

Preliminary Draft Marine Spatial Plan



Sunrise at Rialto Beach

An interagency team of state agencies, including Washington departments of Ecology, Natural Resources and Fish and Wildlife, developed the preliminary draft Marine Spatial Plan with input from local, federal and tribal governments, and stakeholders including the Washington Coastal Marine Advisory Council.

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Marine Spatial Plan for Washington's Pacific Coast

A Marine Spatial Plan (MSP) is currently under development for Washington's Pacific Ocean coast. The MSP provides:

- Guidance for new ocean uses along Washington's Pacific coast, such as renewable energy projects and offshore aquaculture.
- Baseline data on coastal uses and resources to capture current conditions and future trends.
- Requirements and recommendations for evaluating new ocean uses through the different phases of project review consistent with existing laws and regulations.
- Recommendations to protect important and sensitive ecological areas and existing uses like fishing.

Preliminary Review

A preliminary draft is now available for review by key stakeholders and tribes. A more formal draft plan is targeted for release for public comment in May 2017. While not required, a preliminary draft:

- Assists state agencies by getting early input from groups that have been engaged in the process for several years.
- Helps better prepare the draft plan for public comment by refining how plans and regulations fit together, identifying missing information and addressing concerns about recommendations.
- Enables the state meet a target for completing the MSP by June 2017.

Please see instructions for commenting on the preliminary draft MSP in the box at left.

Marine Spatial Plan for Washington's Pacific Coast

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1 **Part I: Introduction**

2 **1.1 Purpose and Need for the Marine Spatial Plan**

3 Washington State's marine waters have abundant natural resources, important biological diversity,
4 and are a source of multiple public uses supporting the economies of nearby communities as well as the
5 entire state. The citizens of Washington, as well as the Native American tribes whom have rich histories
6 along the coast, strongly depend upon marine resources and will continue to do so into the future.
7 Washington's Pacific Coast may be adversely affected by increasing pressures on the resources in this
8 area, conflicts among uses, and proposed new uses. In addition, multiple, overlapping jurisdictions and
9 authorities create challenges for coordinated decision-making and proactive planning.

10
11 Washington State recognizes the value of a coordinated, ecosystem-based approach to planning in
12 marine waters. In March 2010, the Washington State legislature enacted a marine spatial planning law
13 [RCW 43.372] to support integrated coastal decision making and ecosystem-based management. Marine
14 spatial planning is a comprehensive, place-based and ecosystem-based planning tool. It can improve
15 coastal management by creating a plan that reduces conflict, increases certainty, and allows us to
16 balance and maximize the social, economic, and ecological benefits we receive from ocean resources.

17
18 Specifically, the MSP for Washington's Pacific Coast provides the following:

- 19 • Guidance for new ocean uses along Washington's Pacific coast, such as renewable energy
20 projects and offshore aquaculture.
- 21 • Baseline data on coastal uses and resources to capture current conditions and future trends.
- 22 • Requirements and recommendations for evaluating new ocean uses through the different
23 phases of project review consistent with existing laws and regulations.
- 24 • Recommendations to protect important and sensitive ecological areas and existing uses like
25 fishing.
- 26 • A framework and analyses for increased coordination and guidance for decision-making.
- 27 • Activities that enable plan monitoring, evaluation and adaptation.

28
29 With the support of state agencies and the involvement of key stakeholders and the public,
30 Washington created a comprehensive Marine Spatial Plan (MSP) for the Pacific coast. The planning
31 process was led by the State Ocean Caucus, an interagency team. Interagency team members included:
32 Washington Departments of Ecology, Natural Resources, Fish and Wildlife, the Governor's office, State
33 Parks, and Washington Sea Grant.¹ The Washington Coastal Marine Advisory Council (WCMAC), a
34 Governor appointed stakeholder group, created recommendations for the MSP. The plan provides
35 recommendations for a resilient and healthy marine ecosystem on Washington's coast that supports
36 sustainable economic, recreational, and cultural opportunities for coastal communities, visitors, and
37 future generations.

38
39 The Washington State legislature directed that this MSP be submitted to the National Oceanic and
40 Atmospheric Administration (NOAA) for review and approval for incorporation into the State's federally
41 approved coastal zone management program [RCW 43.372.040 (12)]. Washington will benefit from

¹ Governor Gregoire designated Department of Ecology as the overall lead for coordinating the planning process.

42 incorporating the MSP into Washington’s Coastal Program. Once approved, this will improve the state’s
43 ability to review federal actions that have reasonably foreseeable effects on Washington’s coastal
44 resources and uses through federal consistency under the Coastal Zone Management Act (more details
45 are provided in the Management Framework, Section 4.2). In addition, by developing its own plan for
46 the Pacific Coast, Washington will be well positioned to influence and participate in West Coast regional
47 marine spatial planning coordination with other states and the federal government.
48

49 This MSP is a non-regulatory plan. The state law indicates “No authority is created under this
50 chapter to affect in any way any project, use or activity in the state’s marine waters existing prior to or
51 during the development and review of the marine management plan. No authority is created under this
52 chapter to supersede the current authority of any state agency or local government” [RCW 43.372.060].
53 The law also requires the MSP to develop “(a)n implementation strategy describing how the plan’s
54 management measures and other provisions will be considered and implemented through existing state
55 and local authorities” [RCW 43.372.040(6)(f)]. Thus, the MSP creates a framework for integrating
56 existing authorities. It does not supersede existing state laws and must rely on existing state and local
57 authorities to be implemented.
58

59 1.2 Marine Waters Management and Planning Act requirements

60
61 The Marine Waters Management and Planning Act (RCW 43.372) provides the overall intent,
62 purpose, principles and elements for development of a Marine Spatial Plan. For details on specific
63 requirements, please see the full language in RCW 43.372. This section summarizes some of the key
64 principles and requirements of a Marine Spatial Plan from the state law.
65

66 **Key Planning Principles**

67 RCW 43.372.040(4) “The marine management plan must be developed and implemented in a manner
68 that:

- 69 a) Recognizes and respects existing uses and tribal treaty rights;
- 70 b) Promotes protection and restoration of ecosystem processes to a level that will enable long-
71 term sustainable production of ecosystem goods and services;
- 72 c) Addresses potential impacts of climate change and sea level rise upon current and projected
73 marine waters uses and shoreline and coastal impacts;
- 74 d) Fosters and encourages sustainable uses that provide economic opportunity without significant
75 adverse environmental impacts;
- 76 e) Preserves and enhances public access;
- 77 f) Protects and encourages working waterfronts and supports the infrastructure necessary to
78 sustain marine industry, commercial shipping, shellfish aquaculture, and other water-dependent
79 uses;
- 80 g) Fosters public participation in decision making and significant involvement of communities
81 adjacent to the state's marine waters; and
- 82 h) Integrates existing management plans and authorities and makes recommendations for aligning
83 plans to the extent practicable.

84
85 (5) To ensure the effective stewardship of the state's marine waters held in trust for the benefit of
86 the people, the marine management plan must rely upon existing data and resources, but also
87 identify data gaps and, as possible, procure missing data necessary for planning.”

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Requirements

RCW 43.372.040(6) “The marine management plan must include but not be limited to:

(a) An ecosystem assessment that analyzes the health and status of Washington marine waters including key social, economic, and ecological characteristics and incorporates the best available scientific information, including relevant marine data. This assessment should seek to identify key threats to plan goals, analyze risk and management scenarios, and develop key ecosystem indicators. In addition, the plan should incorporate existing adaptive management strategies underway by local, state, or federal entities and provide an adaptive management element to incorporate new information and consider revisions to the plan based upon research, monitoring, and evaluation;

(b) Using and relying upon existing plans and processes and additional management measures to guide decisions among uses proposed for specific geographic areas of the state's marine and estuarine waters consistent with applicable state laws and programs that control or address developments in the state's marine waters;

(c) A series of maps that, at a minimum, summarize available data on: The key ecological aspects of the marine ecosystem, including physical and biological characteristics, as well as areas that are environmentally sensitive or contain unique or sensitive species or biological communities that must be conserved and warrant protective measures; human uses of marine waters, particularly areas with high value for fishing, shellfish aquaculture, recreation, and maritime commerce; and appropriate locations with high potential for renewable energy production with minimal potential for conflicts with other existing uses or sensitive environments;

(d) An element that sets forth the state's recommendations to the federal government for use priorities and limitations, siting criteria, and protection of unique and sensitive biota and ocean floor features within the exclusive economic zone waters consistent with the policies and management criteria contained in this chapter and chapter [43.143](#) RCW;

(e) An implementation strategy describing how the plan's management measures and other provisions will be considered and implemented through existing state and local authorities; and

(f) A framework for coordinating state agency and local government review of proposed renewable energy development uses requiring multiple permits and other approvals that provide for the timely review and action upon renewable energy development proposals while ensuring protection of sensitive resources and minimizing impacts to other existing or projected uses in the area.

(7) If the director of the department of fish and wildlife determines that a fisheries management element is appropriate for inclusion in the marine management plan, this element may include the incorporation of existing management plans and procedures and standards for consideration in adopting and revising fisheries management plans in cooperation with the appropriate federal agencies and tribal governments.

(8) Any provision of the marine management plan that does not have as its primary purpose the management of commercial or recreational fishing but that has an impact on this fishing must minimize the negative impacts on the fishing. The team must accord substantial weight to recommendations from the director of the department of fish and wildlife for plan revisions to minimize the negative impacts.

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137 (9) The marine management plan must recognize and value existing uses. All actions taken to implement
138 this section must be consistent with RCW [43.372.060](#).

139
140 (10) The marine management plan must identify any provisions of existing management plans that are
141 substantially inconsistent with the plan.

142
143 (11)(a) In developing the marine management plan, the team shall implement a strong public
144 participation strategy that seeks input from throughout the state and particularly from communities
145 adjacent to marine waters. Public review and comment must be sought and incorporated with regard to
146 planning the scope of work as well as in regard to significant drafts of the plan and plan elements.

147
148 (b) The team must engage tribes and marine resources committees in its activities throughout the
149 planning process. In particular, prior to finalizing the plan, the team must provide each tribe and marine
150 resources committee with a draft of the plan and invite them to review and comment on the plan.

151
152 (12) The director of the department of ecology shall submit the completed marine management plan to
153 the appropriate federal agency for its review and approval for incorporation into the State's federally
154 approved coastal zone management program.

155
156 (13) Subsequent to the adoption of the marine management plan, the team may periodically review and
157 adopt revisions to the plan to incorporate new information and to recognize and incorporate provisions
158 in other marine management plans. The team must afford the public an opportunity to review and
159 comment upon significant proposed revisions to the marine management plan.”

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161 1.3 Plan goals and objectives

162 To assist with the marine spatial planning process, Washington Sea Grant and the State Ocean
163 Caucus convened a series of workshops in 2013 to develop draft goals and objectives for Washington
164 Coast's Marine Spatial Plan (MSP) and to improve communication and coordination among the groups
165 involved in the MSP planning process. These workshops brought together government officials and local
166 stakeholders with a vested interest or management authority over Washington's marine resources and
167 waters. Representatives from local government, state and federal agencies, tribes and the Washington
168 Coastal Marine Advisory Council (WCMAC) attended. WCMAC is a diverse coastal stakeholder group
169 established by Ecology to provide recommendations to state agencies on ocean policy, including marine
170 spatial planning.

171

172 The draft goals and objectives resulting from the workshops went through a public comment period
173 to give individuals and organizations the opportunity to engage with the plan development process.
174 Comments provided during the public comment period were considered in developing the final goals
175 and objectives for the Marine Spatial Plan. The goals and objectives to guide the Marine Spatial Plan as a
176 result from this process are as follows:

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178 **Overarching Goal:**

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180 To ensure a resilient and healthy marine ecosystem on Washington's coast that supports sustainable
181 economic, recreational, and cultural opportunities for coastal communities, visitors and future
182 generations.

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Goal 1: Protect and preserve existing sustainable uses to ensure economic vibrancy and resource access for coastal communities.

Objective 1: Protect and preserve healthy existing natural resource- based economic activity on the Washington Coast.

- Better understand, define and document all existing marine activities taking place in the study area (commercial, recreational, cultural, ecological) through scientific research and traditional knowledge research. Document context for existing uses and current and future trends of existing uses, including information on present conflicts and potential future conflicts for existing uses.
- Assess economic contributions of existing marine uses to the local and state economy.
- Identify and assess indicators of economic health.
- Following existing laws protect and preserve existing uses by first avoiding and then minimizing significant adverse impacts from potential future activities, including impacts on aquaculture, recreation, tourism, navigation, air quality, and recreational, commercial, and tribal fishing. Identify policies and recommended actions that enable the implementation of the plan.
- Involve individuals and organizations representing existing uses in planning process such as documenting current and future trends of existing uses, reviewing data and maps of their use, understanding potential impacts and evaluating scenarios and plan recommendations.

Goal 2: Maintain maritime coastal communities from now into perpetuity.

Objective 2: Sustain diverse traditional uses and experiences to ensure continuity of WA’s coastal identity, culture, and high quality of life.

- Understand culturally important uses of the marine environment, including documenting areas and uses of historical and cultural significance and current visual resources.
- Provide recommendations for uses that protect and enhance the aesthetic quality of marine environment, maritime activities, marine culture and sense of place.
- Document vulnerability of coastal communities to coastal hazards as they relate to proposed future activities.
- Identify and assess indicators of social well-being within coastal communities.

Goal 3: Ensure that our marine ecosystem is preserved for future generations.

Objective 3: Foster healthy and resilient marine ecosystem functions, biodiversity and habitats.

- Understand current status of the natural resources, ecosystem conditions, and impacts of natural variability and natural stressors on the marine ecosystem over the short and long-term. Where possible, document information on ecosystem services and values.

- 229 • Understand the implications of various human activities to the marine ecosystem including
230 documenting species and habitats that face higher potential risk or impact from proposed
231 activities.
- 232 • Identify and assess areas of ecological importance or particular sensitivity.
- 233 • Identify and assess ecological indicators of ecosystem health on Washington’s Coast.
- 234 • Following existing laws seek to avoid first and then minimize adverse environmental impacts,
235 with special protection provided for the marine life and resources of the Columbia River, Willapa
236 Bay and Grays Harbor estuaries, and coastal areas of Olympic National Park.

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239 **Goal 4:** Develop an integrated decision making process which supports proactive, adaptive and
240 efficient spatial planning.

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242 **Objective 4:** Develop a locally supported and collaborative process that is coordinated with
243 existing authorities for aligning management decisions.

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- 245 • Synthesize information on climate change and predicted impacts to marine resources and
246 existing uses in the study area. Address how climate change may influence plan scenarios and
247 potential impacts of new uses.
- 248 • Engage local, state, federal and tribal governments in all phases of the marine spatial planning
249 process to ensure relevant management information and requirements are integrated into the
250 process. The use or activity must comply with all applicable local, state, and federal laws and
251 regulations.
- 252 • Coordinate with neighboring states and provinces to share technical information across all
253 sectors, enhance management of coastal ecosystems.
- 254 • Recommend approaches for improving the efficiency of the permitting process, where and if
255 appropriate.
- 256 • Involve individuals and organizations representing existing uses and proposed new uses as well
257 as individuals working elsewhere on similar issues in all phases of the planning process.
- 258 • Describe the management and implementation framework, including existing state laws,
259 policies and regulations and how they address existing and proposed uses. The plan will
260 articulate a strategy for ongoing interagency communication, adaptation, implementation and
261 review of the Marine Spatial Plan, including aligning MSP with other state management plans
262 and goals and incorporating it into state plans and processes.
- 263 • Provide opportunities for public engagement and input throughout the planning process
264 including public education, workshops and meetings. Identify barriers to participation and work
265 with local stakeholders to address and reduce barriers to public participation. Document
266 comments and provide responses, as appropriate.
- 267 • Engage scientific experts in review of data and methods. Develop data standards for data
268 collection and analysis.
- 269 • Use best available science and information throughout the planning process and drafting of the
270 plan. Provide a common information base to assist management decisions, including through
271 the use of Geographic Information Systems.

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274 **Goal 5:** Encourage economic development that recognizes the aspirations of local communities and
275 protects coastal resources.

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Objective 5: Enhance sustainable economic opportunities to achieve a resilient economy and improved quality of life.

- Understand potential new uses and their potential benefits and potential significant adverse impacts on existing uses and the environment. Evaluate direct, indirect and cumulative impacts in environmental review documents for the plan.
- Develop coastal decision-making tools, analyses & recommendations to determine appropriate and compatible roles for future activities within the study area, including siting of offshore renewable energy, new locations for dredge disposal or aquaculture, and other potential new activities such as mining and bioextraction.
- Identify appropriate mitigation measures to address significant adverse impacts posed by proposed future uses of Washington’s coastal waters. Develop mitigation measures in accordance with state laws and regulations.

291 1.4 Planning process summary

292 [This section summarizes outreach, engagement and coordination efforts and will be revised with
293 additional planning process efforts currently underway.]

294
295 As described in the introduction, the interagency team coordinated the planning process to develop
296 the MSP. The following describes some of the key activities and groups that the interagency team
297 engaged in the development of the MSP.

298 299 **Plan Scoping**

300 Scoping Workshops (Spring 2013): Washington Sea Grant and state agencies convened a series of
301 marine spatial planning scoping workshops in Aberdeen, WA. Over 50 people attended the workshops
302 representing local government, state and federal agencies, tribes and the Washington Coast Marine
303 Advisory Council. Participants worked together to develop draft goals, objectives and a planning
304 boundary for the Marine Spatial Plan (MSP) for Washington’s Pacific Coast.

305
306 SEPA Scoping: Using the draft language developed by the scoping workshops, Ecology, as lead for
307 developing the plan, issued a scoping notice and comment period for the plan under the State
308 Environmental Policy Act (SEPA). The public comment period ran from July 16, 2013 through September
309 23, 2013, and allowed for broader input and review from interested parties and the public. Ecology
310 received and considered 17 unique comment letters and 28 signed form letters. Based on these
311 comments, Ecology revised the scope of the proposed marine spatial plan and released a summary of
312 SEPA scoping and response document (January 2014).

313 314 **Coastal Marine Resource Committees (MRCs)**

315 From the very initial steps, the Marine Resource Committees have been actively involved in the
316 state’s marine spatial planning process. Some key activities have included:

- Funding priorities and projects (Summer 2012 and Sumer 2013) – State planning staff attended meetings of each of the coastal MRCs in Summer 2012 and Summer 2013 to gather input on their priorities for marine spatial planning.
- Coastal Voices Workshops (Spring 2013) – MRCs worked with the Surfrider Foundation and The Nature Conservancy to host five workshops with over 100 participants to gather input from

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322 coastal residents and stakeholders on interests and goals and inform scoping for the marine
323 spatial plan.

- 324 • MRC Summit (November 2013) – State planning staff presented to MRCs on Marine Spatial
325 Planning at this annual meeting of all the coastal MRCs.
- 326 • Input on MSP Actions (Spring 2014) – Each MRC reviewed a list of draft actions for each of the
327 Marine Spatial Plan goals and provided input. State planning staff used MRC input to further
328 revise the actions, which WCMAC then recommended the state adopt in July 2014.
- 329 • Input on Social Indicators (Spring 2015) – At their regular meetings, coastal MRCs each received
330 a presentation on social indicators work and provided feedback on draft indicators.
- 331 • Each MRC has a representative on the Washington Coastal Marine Advisory Council (WCMAC) to
332 ensure regular communication of their interests and input to the process.

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334 **Washington Coastal Marine Advisory Council (WCMAC)**

335 This is a diverse group of representatives from coastal stakeholder interest groups, coastal MRCs,
336 and state agencies providing ongoing advice on the marine spatial planning process. This has included
337 participating in scoping workshops; reviewing and recommending actions to carry out goals and
338 objectives; identifying data, project and funding priorities; providing input on approaches and
339 deliverables for projects; sharing interests and concerns; and providing recommendations for the
340 analyses and plan development. WCMAC members have also served as liaisons with the interest groups
341 they represent and have identified additional experts for MSP projects consultants to interview for
342 information. The group has met about 5-6 times per year, since the beginning of the planning process.
343 Additionally, a Technical Committee and Steering Committee meet approximately monthly to assist the
344 group with tasks. A contracted facilitator assists the Committees and Council with developing agendas
345 and other meeting materials, facilitating meetings, consensus-building, and tracking and recording
346 discussions and recommendations. More information is available on the Advisory Council website
347 at: <http://www.ecy.wa.gov/programs/sea/ocean/advisorycouncil.html>

348

349 Initially formed by Ecology in December 2011, legislation prompted the reformation of this advisory
350 council under the Governor's office in September 2013, but still staffed by Ecology. A total of 23 advisory
351 council meetings have been held between March 2012 and November 2016.

352

353 **Local Governments**

354 State agency staff have met with coastal planning staff, presented at quarterly Shoreline Planner's
355 meetings and provided updates at work sessions for county commissioners to convey information on
356 Marine Spatial Planning (Spring 2013 – Clallam and Jefferson). Local governments were invited to attend
357 the scoping workshops held in Spring 2013. In addition, Ecology distributed a comprehensive white
358 paper with information on ocean management guidelines, Shoreline Master Programs (SMPs), and
359 Marine Spatial Planning targeted for local planners. More recently, Ecology provided a shorter
360 Frequently Asked Questions to answer specific questions about the relationship among SMPs, Marine
361 Spatial Planning, and the state's Coastal Zone Management Program.

362

363 **MSP 101**

364 Planning staff have provided presentations and workshops providing introductory information on
365 marine planning to a variety of other audiences, including to community members (Forks, summer
366 2012), at conferences (Working Waterfronts Symposium, Tacoma, March 2013) and through learning
367 exchange workshops (Neah Bay and Aberdeen, spring 2012). Washington Sea Grant has provided
368 introductory and update presentations on Marine Spatial Planning to a number of community
369 organizations across the Washington Coast, including economic development councils, council of

370 governments, chambers of commerce, non-profit organizations, and other similar groups. Since fall of
371 2012, Washington Sea Grant has presented to 15 community groups and reached over 230 people.

372

373 **Coastal Events and General Outreach**

374 Washington Sea Grant is attending numerous local events around Washington's coast to raise
375 awareness and engage the broader public on marine spatial planning, including distributing brochures.
376 Washington Sea Grant and the local MRCs co-hosted two local film showings of *Ocean Frontiers* – a film
377 about marine planning in the United States. These efforts reached over 500 people between Summer
378 2014 and June 2015. Washington Sea Grant also distributed Frequently Asked Questions on marine
379 spatial planning to local libraries and community centers across the coast.

380

381 **MSP Project Engagement**

382 Washington Sea Grant organized presentations on specific projects or topics of high interest to
383 target audiences, such as the providing draft results on ecological models and indicators to the Grays
384 Harbor Coalition for Infrastructure and Citizens for a Clean Harbor. Planning staff also organized
385 workshops on the coastal economic analysis to assist contractors in scoping the project and getting
386 input on draft results from a range of stakeholders and agencies. Over 110 people participated in these
387 various events.

388

389 **Tribes**

390 State agency staff have met with technical and policy staff of coastal tribes throughout the planning
391 process. The state and the four coastal treaty tribes – the Hoh, Makah, Quileute tribes and the Quinault
392 Indian Nation have had between 2-4 joint technical and policy staff meetings per year. Depending on the
393 tribe, various tribal staff have participated in workshops, meetings, and forums; reviewed and provided
394 input on MSP project priorities, deliverables, and draft products; provided technical and scientific
395 information and feedback; met with consultants; and partnered on data collection and field work.

396

397 **Federal agencies**

398 State agencies have also involved federal agencies in many ways, such as including them in scoping
399 and technical workshops and meetings; contacting them for specific data and information and to gather
400 input on priorities, needs, and interests; and partnering with them on a number of specific projects (see
401 below for examples). State staff have provided several presentations to the Olympic Coast National
402 Marine Sanctuary's Advisory Council.

403

404 Federal agency staff have also played an important technical and scientific support role in the state's
405 marine spatial planning process. This includes coordinating the science-based development of and
406 assessment of conceptual models and ecological indicators for Washington's coast, creating ecological
407 models for distribution of seabirds and marine mammals, conducting an inventory of and prioritization
408 of seafloor mapping data, creating a seafloor atlas from existing data, and providing GIS data and other
409 information such as satellite vessel traffic data provided by Olympic Coast National Marine Sanctuary.

410

411 **Scientists**

412 In 2013, Washington Sea Grant facilitated a graduate level class that used graduate students and
413 engaged a diverse group of research professors to review available marine spatial planning data and
414 identify data gaps. Washington Sea Grant subsequently set up a Science Advisory Panel with these and
415 other researchers and scientists from academic, state, and federal entities to provide independent
416 review of and feedback on particular data sources, project methods, and data analyses.

417

418 **Data and Tool Development**

419 Throughout the planning process, state agencies have sought input on data and tool development.
420 This included working with The Nature Conservancy and EcoTrust to host a number of training and input
421 sessions on the online data mapping tool with MRCs, planners and other audiences as it was being
422 developed to improve functionality and ease-of-use. Washington also partnered with federal agencies to
423 host participatory human use mapping workshops to map ocean use areas based on expert user
424 knowledge. The 4 workshops involved 65 participants representing all ocean use sectors such as ocean
425 industries, marine operators, and federal, tribal and state resource managers (April 2013). Planning staff
426 have continued to engage representatives from ocean uses and the WCMAC to identify available data,
427 data priorities and projects to fill gaps; and to understand how best to analyze the data on their use to
428 understand potential conflicts with new uses.

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430

431 **1.5 MSP Study Area**

432 The Marine Spatial Plan Study Area consists of marine state and federal waters along the Pacific
433 Ocean². The Study Area extends from ordinary high water on the shoreward side out to 700 fathoms
434 (4,200 feet) depth offshore and from Cape Flattery on the north of the Olympic Peninsula south to Cape
435 Disappointment at the Mouth of the Columbia River (Map 1). The Study Area encompasses estuaries
436 along the coast, including two large estuaries: Grays Harbor and Willapa Bay. This area was chosen
437 because it is where the highest intensity and density of existing coastal uses exist, is ecologically
438 meaningful in terms of connections to Washington’s coastal zone, and maximizes the use of existing
439 data and available information (SEPA scoping document). The area was also chosen based on expected
440 locations for potential new federal activities and this area is where effects from those new uses or
441 activities are reasonably foreseeable on the state’s coastal uses or resources (SEPA scoping document).

442

443 The Study Area covers 7,732 square miles and includes the intertidal, nearshore, continental shelf,
444 and continental slope areas of Washington’s Pacific waters. Adjacent upland areas include the Olympic
445 Peninsula and the southwestern portion of the state. Four counties: Clallam, Jefferson, Grays Harbor,
446 and Pacific Counties border the Study Area, along with five federally recognized American Indian tribes:
447 Makah, Quileute, Hoh and Shoalwater Bay Tribes, and the Quinault Indian Nation (Map 2). At the Study
448 Area’s southern boundary is the Mouth of the Columbia River, the largest river in the PNW with source
449 waters from the Rocky Mountains, and at the northern boundary is the Strait of Juan de Fuca with
450 source waters from Puget Sound and the Fraser River (Canada). A large portion of the Study Area marine
451 environment is a part of the Olympic Coast National Marine Sanctuary. There are also five national
452 wildlife refuges within the Study Area. The Study Area also includes the Washington State Seashore
453 Conservation Area and several state parks, which are managed by the Washington State Parks and
454 Recreation Commission for public recreational use (Map 1).

455

456 The northern coastal portion of the Study Area consists of a mostly rocky coast with several coastal
457 rivers, rocky outcrops, and pocket beaches. Adjacent uplands are rural, consisting mostly of Olympic
458 National Park land and Indian Reservation Land. The southern coastal portion of the Study Area has
459 generally sandy beaches and includes Willapa Bay and Grays Harbor. Several small cities and towns are
460 located along the southern coast. Uplands in the southern area are largely managed private and public
461 timber lands and agriculture.

² Marine Spatial Plans for other marine waters of Washington including the Columbia River, Strait of Juan de Fuca, and Puget Sound is dependent on funding.

462

463 1.6 Pacific Coast Indian Tribes and Treaty Rights

464 The Washington coast has been home to native peoples for at least 6,000 years. These peoples
465 traditionally lived at the water's edge, thriving on the riches of the ocean plants, fish, shellfish, seabirds,
466 and marine mammals. With the settlement of Euro-Americans, native peoples formed into federally
467 recognized sovereign nations with their own governments, procedures, and citizens and maintained
468 their rights to fish, hunt, and exercise their sovereign rights (Olympic Coast National Marine Sanctuary,
469 2011). These sovereign nations were formed prior to Washington statehood and their rights are
470 protected by the United States federal government. Some are recognized by Executive Order and some
471 by treaties with the United States. On the Washington coast, the Makah, Quileute, and Hoh Tribes, and
472 the Quinault Indian Nation are signatories to treaties (Treaty of Neah Bay, Treaty of Olympia). The
473 Shoalwater Bay Tribe is recognized by Executive Order (Map 2).

474 The Washington tribes and tribal citizens continue to live, manage, and rely upon coastal resources.
475 The treaty rights to harvest extend beyond reservation boundaries into the tribes' "usual and
476 accustomed" fishing grounds. Federal courts have ruled that the treaty tribes have the right to 50% of
477 the harvestable ocean resources passing through their respective ocean treaty areas, and that they co-
478 manage the resources with the state of Washington where the state also has jurisdiction (*U.S. v.*
479 *Washington*, 384 F. Supp. 312 (W.D. Wash. 1974), *U.S. v Washington*, 873 F. Supp. 1422 (W.D. Wash.
480 1994)) (0-3 miles; beyond that the tribes work with NOAA). More detail is provided below.

481 The actions of the state of Washington on marine resources affect the tribes and their members just
482 as the actions within the tribal governments affect the state and its citizens (Washington State
483 Department of Ecology, n.d.). The management of the marine environment is crucial to the tribes, as the
484 marine environment is integral to their history, culture, identity, and future; marine resource
485 management as a matter of law is shared with the state. The MSP provides an opportunity for the state
486 of Washington to progressively plan for new ocean uses, while protecting the current uses,
487 environment, and identity of coastal Washington, including respecting the interests of the five federally
488 recognized Indian Tribes adjacent to the Study Area. The state relationship with the tribes is of high
489 importance in the MSP process and for future new use decisions.

490

491 Coastal Tribes

492 The state invited each of the coastal tribes to provide a description of their tribe, including
493 information such as:

- 494 • Uses of marine resources, reliance upon these resources (what it means to them)
- 495 • General insights to their management of these resources; what future activities are
496 important to them...
- 497 • Any main concerns or opportunities, including related to new uses

498

499 To-date, one participating tribe has provided a description, including their main concerns and
500 interests in the Marine Spatial Planning process. Additional descriptions will be added when they are
501 available from tribes. Following individual tribal descriptions is information that describes tribal treaty
502 rights, fishing co-management procedures, government-to-government relationships, and consultation
503 procedures.

504

505 *Makah Tribe*

506

507 *Quileute Tribe*

508 The Quileute Tribe is part of the Treaty of Olympia of January, 1856, with the Quinault Indian Nation
509 and the Hoh Tribe. It is headquartered at La Push, at the mouth of the Quillayute River, but its usual and
510 accustomed fishing grounds under the Treaty of Olympia include marine waters from Cape Alava south
511 to the Queets River and 40 nautical miles west. The Tribe also has freshwater fishing rights to the entire
512 Quillayute River Basin, and north to Lake Ozette (shared with Makah) and south to Goodman Creek
513 (shared with Hoh). Quileute has defined its presence on the Washington Coast as “since time
514 immemorial”. It has been actively fishing for marine mammals, groundfish, salmonids, and shellfish
515 throughout its history. While commercial use of these fisheries—initially through trade and later
516 through more conventional commercial compensation—has long been their tradition, the fisheries are
517 critical to subsistence of their members, and special attention is given to assuring food for elders or
518 other needy persons in the community. Many traditional ceremonies derive from the ancient fishing
519 practices and the appreciation of nature’s bounty and ceremonial events celebrating the fisheries are
520 also part of the tribe’s culture, related in potlatches, traditional songs, and dances. Recent recognition of
521 the full scope of the Quileute’s ocean fishery was provided by the federal court decision in *United States*
522 *v. Washington*, subproceeding 2009-01, of July 9th and September 3rd, 2015.

523 The Quileute Tribe was recognized officially as having self-regulatory capacity by the state, under
524 provisions of the *U.S. v. Washington* court for demonstrated government capacity. The tribe has a
525 modern fleet, with emphasis on the crab, halibut, black cod, and salmon fisheries at present. Tribal
526 representatives participate in intergovernmental processes to determine appropriate harvest levels for
527 the fisheries, such as the Pacific Fisheries Management Council, North of Falcon, Pacific Salmon Treaty,
528 and numerous meetings with NOAA Fisheries, WDFW, and coastal treaty tribe representatives. The Tribe
529 has a commissioner to the Northwest Indian Fisheries Commission.

530 Immediate future concerns are reductions in allowable harvest that may derive from climate, severe
531 weather, harmful algal blooms, or anthropogenic causes such as fishing practices. The tribe is also
532 concerned about access that may be interrupted by naval operations, shipping lanes, or conservation
533 measures, and engages fully in intergovernmental meetings and review of publications on all matters
534 that can impact its fishery operations.

535 The tribe is open to exploring opportunities for energy generation that can be done with respect for
536 the ecosystem and fishing rights, and treaty rights in general.

537 *Hoh Tribe*

538

539 *Quinault Indian Nation*

540

541 *Shoalwater Bay Tribe*

542

543 Treaty Tribes and Treaty Rights

544 Four of the five tribes adjacent to the MSP Study area are Treaty Tribes and include the Makah,
545 Quileute, and Hoh Tribes, and the Quinault Indian Nation.³ The Stevens Treaties were negotiated in the
546 mid-1850s throughout the state of Washington with the Governor of the Washington Territory, Isaac
547 Stevens. The 1855 Treaty of Neah Bay with the Makah Tribe and the 1856 Treaty of Olympia with the
548 Hoh Tribe, Quileute Tribe, and the Quinault Indian Nation govern the relationships between the federal
549 government and the coastal Treaty Tribes. Through signing those treaties, the tribes agreed to allow the
550 peaceful settlement of much of western Washington and provided land to do so, in exchange for their
551 continued right to fish, gather shellfish, hunt, and exercise other sovereign rights off-reservation, to
552 assure access to food after the signing of the treaties. Therefore, the treaties established the right to fish
553 in “usual and accustomed areas” well beyond the reservation’ boundaries. The *United States v.*
554 *Washington* courts have been continuously defining the exact scope of these fishing areas since 1974.

555 Fishing treaty rights co-management

556 In the 1970s the American Indian tribes in the State of Washington sought to have greater access to
557 their treaty resources and uphold their treaty rights in federal court. This arduous process resulted in
558 the seminal case of *United States v. Washington*, written by Judge George Boldt and often referred to as
559 the Boldt decision (*U.S. v. Washington*, 384 F. Supp. 312 (W.D. Wash. 1974)). Judge Boldt upheld the
560 treaty rights, establishing the treaty tribes as resource co-managers and affirming the tribal right to 50%
561 of the harvestable salmon returning to their historic fishing sites. In 1979, the United States Supreme
562 Court upheld the Boldt decision. A court decision in 1994 (*U.S. v Washington*, 873 F. Supp. 1422 (W.D.
563 Wash. 1994)), also known as the Rafeedie decision (named for the judge), recognized the treaty right of
564 Washington treaty tribes to take 50% of all naturally occurring shellfish at all usual and accustomed
565 areas. This decision also established the tribal right to harvest not just shellfish, but also any species of
566 aquatic animal, finned or not finned, in the usual and accustomed area of a tribe. The *United States v.*
567 *Washington* court in subproceeding 09-1 affirmed again in 2015 that “fish” as understood by the parties
568 to the treaties included any aquatic animal, including marine mammals.

569 Because the coastal treaty tribes’ right to fish is held “in common with” the non-Indian citizens of
570 present-day Washington and Oregon, Judge Boldt in 1974 determined the tribes are “co-managers” of
571 the fishery resource (*U.S. v. Washington*, 384 F. Supp. 312, 403 (W.D. Wash. 1974)) and have the right to
572 50% of the harvestable resource passing through their respective treaty areas. Thus, each treaty tribe
573 regulates and controls tribal fishing at its usual and accustomed grounds in accordance with tribal law
574 and judicially prescribed fishery management responsibilities, maintains its own fisheries management
575 and enforcement staff, enters into management agreements with other co-managers, and engages in a
576 wide variety of research, restoration, and enhancement activities to improve the scientific basis for
577 resource stewardship (Olympic Coast National Marine Sanctuary, 2011).

578 The treaty tribes, the state of Washington, specifically the Washington State Department of Fish and
579 Wildlife (WDFW), and United States government (NOAA Fisheries) are co-managers of fisheries
580 resources in Washington. The Pacific Fishery Management Council (PFMC) is the multiparty body that is
581 responsible for implementing the Magnuson Stevens Fishery Conservation Act (Magnuson Stevens Act;
582 16 U.S. 1801 et seq.) and facilitating co-management of fisheries within the Economic Exclusive Zone
583 (out 200 nautical miles, beyond state jurisdictional limits of 0-3 miles) off of Washington, Oregon, and
584 California. Tribal, federal, and state representatives sit on the PFMC and its technical committees, and
585 the PFMC sets annual harvest numbers for salmon, groundfish, coastal pelagic species, and highly

³ The Shoalwater Bay Tribe is a federally recognized tribe but is not party to the Stevens treaties.

586 migratory species fisheries for non-treaty fisheries. Treaty tribes through their co-management role with
587 NOAA Fisheries identify annual harvest needs for treaty fisheries, the result of these discussions are
588 then communicated with PFMC. The PFMC is also involved in international fisheries management, such
589 as negotiating pacific halibut conservation and catch limit with Canada through the International Pacific
590 Halibut Commission (Industrial Economics, Inc., 2014).

591 This tribal/federal/state co-management framework has evolved as a reliable planning forum for
592 multiple aspects of fishery management, including planning harvest time, place, and manner, and
593 constraining fish mortality. The co-managers are charged with the responsibility for managing certain
594 aspects of fishery resources and for coordinating their efforts through the development, adoption, and
595 implementation of fishery management plans under the Magnuson Stevens Act (Olympic Coast National
596 Marine Sanctuary, 2011).

597 The Marine Spatial Plan does not address or attempt to influence the fisheries co-management
598 process or relationship. Fisheries co-management is outlined here to recognize its importance within the
599 Study Area and provide context for fishing and shellfishing industry descriptions provided later within
600 the Plan.

601 Government-to-government relationship

602 Washington state agencies and tribes have government-to-government relationships, meaning that
603 each tribe has an independent relationship with each other and the State and that these relationships
604 recognize and respect the sovereign rights of each party. The State of Washington and the federally
605 recognized tribes created government-to-government agreements through the Centennial Accord and
606 subsequent Millennium Agreement to consult with each other on matters that may affect one another
607 (Governor's Office of Indian Affairs, 2015). In 2012, a state law established state agency procedure
608 requirements for the government-to-government relationship (RCW 43.376).

609 The federal government has a federal trust responsibility to federally recognized tribes, through this
610 obligation, the federal government works directly with tribes as independent governments. The exact
611 implementing procedures may vary between the federal agencies, but the federal trust obligation
612 includes consulting with tribal governments prior to taking actions that may affect federally recognized
613 tribes and treaty rights (The White House, 1994).

614 Consultation procedures

615 Formal consultation in a government-to-government relationship is key and the establishment of
616 the Centennial Accord and Millennial Agreement set the foundation for consultation procedures
617 between the State and the tribes. Consultation goes beyond informing tribes about what the state
618 agencies are planning to do. Consultation between the state and tribe(s) is an agreed upon process by
619 both parties that creates a forum that is respectful, provides effective communication environment and
620 that works toward a consensus before a decision is made or an action is taken, while recognizing that
621 agreement on an outcome is not always possible.

622 The state seeks to cooperatively establish the manner and timeframe for consultation with tribal
623 governments on issues of tribal interest or when the implication of a policy or action has tribal
624 implications as determined by the tribe(s). The state attempts to provide early notification and an
625 invitation for open consultation with affected and interested tribes. The state government-to-
626 government consultations with tribes take place independently and often parallel from the public
627 participation process (e.g., public comment for SEPA) but representatives of tribal governments and
628 tribal members have equal access to public participation processes as well. Communication (less formal

629 than consultation) is also integral to the government-to-government state and tribal relationship. The
630 state attempts to provide regular, informal communication with the tribes on issues and upcoming
631 decisions that may be of interest to the tribes. State agencies maintain the government-to-government
632 communications and consultations by interacting through officials with appropriate stature and
633 authority (Washington State Department of Ecology, n.d.).

634 A description of the State's coordination and consultation process with the five tribes adjacent to
635 the Study Area for the development of the Marine Spatial Plan is provided below. The procedures for
636 tribal and state consultation, coordination, and communication to address specific new use proposals
637 within the MSP Study Area are provided in Section 4: Management Framework.

638 Description of Coordination with Tribes for development of the Plan

639 [This section to be written closer to the completion of the Plan and consultations.]

640

641 1.7 Olympic Coast National Marine Sanctuary

642 Designated in 1994, the Olympic Coast National Marine Sanctuary (Sanctuary) is a place of regional,
643 national, and global significance. The Sanctuary encompasses much of the northern half of the Marine
644 Spatial Plan Study Area (Map 1) and is one of North America's most productive marine regions and
645 pristine, undeveloped shorelines. The Sanctuary is a part of a system of 14 marine protected areas
646 coordinated and administered by National Oceanic and Atmospheric Administration (NOAA).

647 The Sanctuary spans 2,408 square nautical miles of marine waters off of Washington's Olympic
648 Peninsula coast. It extends seaward 32 to 64 kilometers (20 to 40 miles) and to depths of over 1,400
649 meters (4,500 feet). The Sanctuary is located within the northern portion of the California Current Large
650 Marine Ecosystem, is connected to the Big Eddy Ecosystem, and supports high primary productivity. The
651 Sanctuary is home to some of the largest U.S. seabird colonies, at least twenty-nine species of marine
652 mammals, commercially important fish species, deep sea corals, and one of the most diverse seaweed
653 communities in the world.

654 The Sanctuary borders the Olympic National Park and lies within the usual and accustomed areas of
655 four federally recognized American Indian tribes: the Hoh, Makah, and Quileute Tribes, and the Quinault
656 Indian Nation (the four coastal treaty tribes). The Sanctuary also enhances protection of the Washington
657 Maritime National Wildlife Refuge Complex, which includes more than 600 offshore islands and
658 emergent rocks within the Sanctuary. Major ocean activities occur within the Sanctuary, including
659 shipping, tribal and non-tribal commercial fisheries, and research activities.

660 The mission of the Sanctuary is "to protect the Olympic Coast's natural and cultural resources
661 through responsible stewardship, to conduct and apply research to preserve the area's ecological
662 integrity and maritime heritage, and to promote understanding through public outreach and education".
663 The Sanctuary is managed using a unique collaborative framework. In 2007, the four coastal treaty
664 tribes, the state of Washington, and the ONMS created the Olympic Coast Intergovernmental Policy
665 Council (IPC) to provide a regional forum for resource managers to exchange information, coordinate
666 policies, and develop recommendations for resource management within the Sanctuary.

667 In addition, the Sanctuary also works with a Sanctuary Advisory Council (SAC), a stakeholder group
668 with representatives from the coastal treaty tribes, state and federal agencies, local governments, and a
669 variety of local interest groups. The SAC advises the Sanctuary Superintendent on the management and
670 protection of the Sanctuary; and deliberates and provides recommendations on Sanctuary operations,

671 education and outreach programs, regulations and enforcement efforts, and marine policy and
672 management plans.

673 The Sanctuary has several goals and objectives aimed at protecting the ecological resources and
674 cultural uses within the Sanctuary. Examples of their goals and programs include: investigating and
675 enhancing the understanding of ecosystem processes through research, enhancing ocean literacy,
676 conserving natural resources within the Sanctuary, enhancing understanding and appreciation of the
677 Olympic Coast's maritime heritage, and facilitating wise and sustainable uses within the Sanctuary. The
678 2011 Olympic Coast National Marine Sanctuary Management Plan outlines several Action Plans involving
679 topics such as oil spills prevention and preparedness, marine debris, education and outreach, research
680 coordination, and community involvement (Olympic Coast National Marine Sanctuary, 2011).

681 For more information about the Olympic Coast National Marine Sanctuary, please see the 2011 Final
682 Management Plan (Olympic Coast National Marine Sanctuary, 2011) or the Sanctuary website:
683 <http://olympiccoast.noaa.gov/>

684 Authority and Legal Framework

685 Under the National Marine Sanctuaries Act (16 U.S.C. 1431 et seq.), sanctuaries have the authority
686 to prohibit particular activities and permit certain activities if the proposal will not substantially injure
687 Sanctuary resources and qualities and is found to satisfy the Sanctuary's criteria for permitted activities.
688 Activities that would disturb or place a constructed object on the seafloor within the Olympic National
689 Marine Sanctuary would require a Sanctuary permit. The Sanctuary could also consider an application to
690 authorize, and potentially condition, other federal or state authorizations (15 CFR Part 922).

691 The Sanctuary requires a permit when an individual or organization wishes to conduct an activity
692 within the Sanctuary that is prohibited by Sanctuary regulations. Prohibited activities include low
693 altitude overflights, seafloor disturbances, constructing or placing any structure on the seafloor, and
694 discharging or depositing any material. However, whether the Sanctuary chooses to issue a permit or
695 authorization is dependent upon a number of project-specific factors including:

- 696 • Assessment of the potential injury to the Sanctuary resources and qualities
- 697 • Professional qualifications and finances of the applicant
- 698 • Duration of the project
- 699 • Cumulative effects
- 700 • Impacts of the activity on adjacent tribes

701 Permits may be issued for projects that will not substantially injure Sanctuary resources and
702 qualities and will further one of the following:

- 703 • Research related to Sanctuary resources and qualities
- 704 • Education, natural or historical resource value of the Sanctuary
- 705 • Salvage and recovery operations
- 706 • Archeological understanding
- 707 • Tribal self-determination and government functions, exercise of treaty rights, economic
708 development, or other tribal activities

709 The Sanctuary includes conditions in permits and authorizations to ensure that an approved project
710 has minimal negative impacts to the marine environment.

711 Of the potential future uses addressed within the Marine Spatial Plan, mining (methane hydrate
712 mining and sand/gravel mining) as well as new dredge disposal locations⁴ are prohibited activities and
713 may not be permitted by the Sanctuary (15 CFR Part 922.152). Marine renewable energy, offshore
714 aquaculture, and marine product extraction⁵ would require Sanctuary authorization and the Sanctuary
715 may choose to permit these activities if they meet the criteria discussed above.

716 Olympic Coast National Marine Sanctuary Involvement with WA Marine Spatial Planning

717 The Sanctuary has been directly involved with the Marine Spatial Planning process and will continue
718 to be engaged during Plan implementation. The Sanctuary staff recommended that the Olympic
719 National Marine Sanctuary be included within the MSP Study Area and that the Marine Spatial Plan
720 integrate the Sanctuary Management Plan. The Sanctuary staff has assisted the MSP process by
721 participating as technical advisors in projects such as seafloor mapping prioritization and ecological
722 indicator development, assisting in several data gathering and mapping projects, and providing input on
723 overall plan development.

724

⁴ Emergency dredge disposal may be permitted by the Sanctuary.

⁵ Marine product extraction will require permits if benthic organisms were extracted (seafloor disturbance)

725 References

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Marine Spatial Plan for Washington's Pacific Coast

Section 2: Current Conditions and Future Trends

- 2.1 Ecology of Washington's Pacific Coast
- 2.2 Cultural and Historic Resources
- 2.3 Socio-Economic Setting
- 2.4 Commercial, Recreational, and Tribal Fisheries
- 2.5 Aquaculture
- 2.6 Recreation and Tourism
- 2.7 Marine Transportation, Navigation, and Infrastructure
- 2.8 Military Uses
- 2.9 Research and Monitoring Activities
- 2.10 Potential New or Expanded Uses
 - 2.10.1 Marine Renewable Energy
 - 2.10.2 Offshore Aquaculture
 - 2.10.3 Dredging and Dredge Disposal
 - 2.10.4 Marine Product Extraction
 - 2.10.5 Mining
- 2.11 Climate Change

2.1 Ecology of Washington's Pacific Coast

Washington's Marine Spatial Plan (MSP) Study Area¹ is a highly productive, diverse ecosystem. Living resources within this ecosystem are the foundation to Washington's ocean uses. The health and status of the Study Area's species, habitats, and ecosystem are of primary importance to ocean and estuarine users, coastal residents, tribes, and the state of Washington. The Study Area has several federally and state designated protected areas (Map 1) designed to protect and foster the health of important habitats and species off Washington's Pacific coast.

This chapter describes the ecology of the MSP Study Area by summarizing the physical oceanography, water quality status, geomorphology, biology, and ecological stressors of Washington's outer coast. Information presented here can be used to understand not only the ecological context of Washington's ocean and estuaries, but also for considering potential future new uses and how they may affect the ecological status of the Study Area. While climate change is mentioned briefly in this section, a more detailed and thorough explanation of the impacts of climate change on the ecology of the MSP Study Area can be found in Section 2.11: Climate Change.

Physical Oceanography

Washington's coast is influenced by local and regional climate as well as large-scale oceanic forces. The currents, tides, eddies, plumes, temperature, and other physical features of the Washington coast shape habitat, fisheries, and other important services provided by these highly productive waters. The following section discusses the main physical oceanographic features that influence the MSP Study Area.

Currents, Upwelling, and Productivity

The Pacific Northwest (including the outer Pacific coast of Washington) is predominantly influenced by large-scale ocean processes that exhibit seasonal patterns and a highly dynamic ocean environment (Hickey & Banas, 2003). The dominant oceanographic feature of the Pacific Northwest (PNW) is the California Current System (CCS), which has strong interannual, seasonal, and daily variability. The CCS includes the strong southward flowing California Current, which flows year-round offshore from the shelf break, and a California Undercurrent which flows northward along the continental slope. The CCS also includes the northward flowing Davidson Current in the winter and the southward flowing California Coastal Jet Current in the summer. Each current has distinct properties (e.g., temperature, nutrients, oxygen, salinity, etc.) depending upon the source waters, including the Pacific Subarctic, North Pacific Central, and Southern water masses (Hickey & Banas, 2003; Pirhalla et al., 2009).

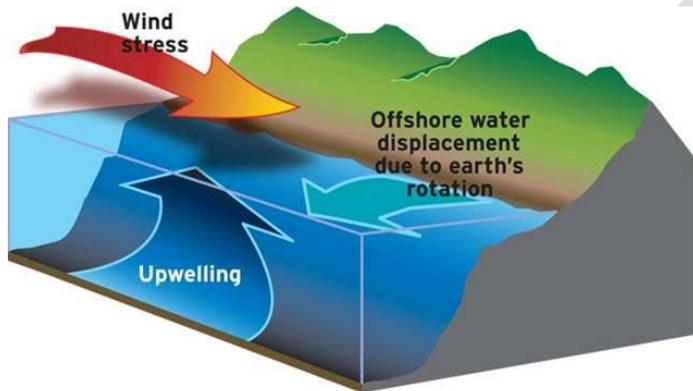
Seasonal circulation patterns bring the water properties from these currents into the region and strongly influence productivity, transportation routes for larval fish and shellfish, plankton, and other important ecological features (Hickey & Banas, 2003, 2008; Pirhalla et al., 2009). The PNW has an upwelling/downwelling seasonal pattern driven by offshore wind. Upwelling occurs mostly during spring and summer when the wind comes from the north, but with important 'conditioning' events occurring in the winter (Black et al., 2011). Upwelling is the process by which currents and southward wind stress, combine with the Coriolis force to push surface water offshore and replace it with deep, cold, salty, nutrient-rich water from below (Figure 2.1-1). Upwelling brings nutrients up into the photic zone (the upper portion of the water column where sunlight penetrates) where nutrients are then available to phytoplankton that form the base of the coastal and ocean food web. Upwelling can be variable on a several day scale, with periods of strong upwelling and periods of relaxed wind and reduced upwelling

¹ The MSP Study Area is defined in Section 1.5.

42 during the spring and summer seasons (Andrews, Harvey, & Levin, 2013; Hickey & Banas, 2003, 2008;
43 Pirhalla et al., 2009).

44 The seasonal pattern generally transitions to downwelling during the fall that persists throughout
45 winter. During downwelling, currents and northward wind stress push water onshore, and this water is
46 typically warmer, less saline, and has fewer nutrients (Hickey & Banas, 2003). Seasonal upwelling and
47 downwelling events are generally well characterized within the literature, and these events can be
48 detected by analyzing parameters such as sea surface height and chlorophyll-a (Pirhalla et al., 2009).
49 Figure 2.1-2 provides a general example of seasonal chlorophyll measurements along Washington's
50 coast corresponding to increases in chlorophyll in spring and summer (upwelling) and decreases in fall
51 and winter (downwelling).

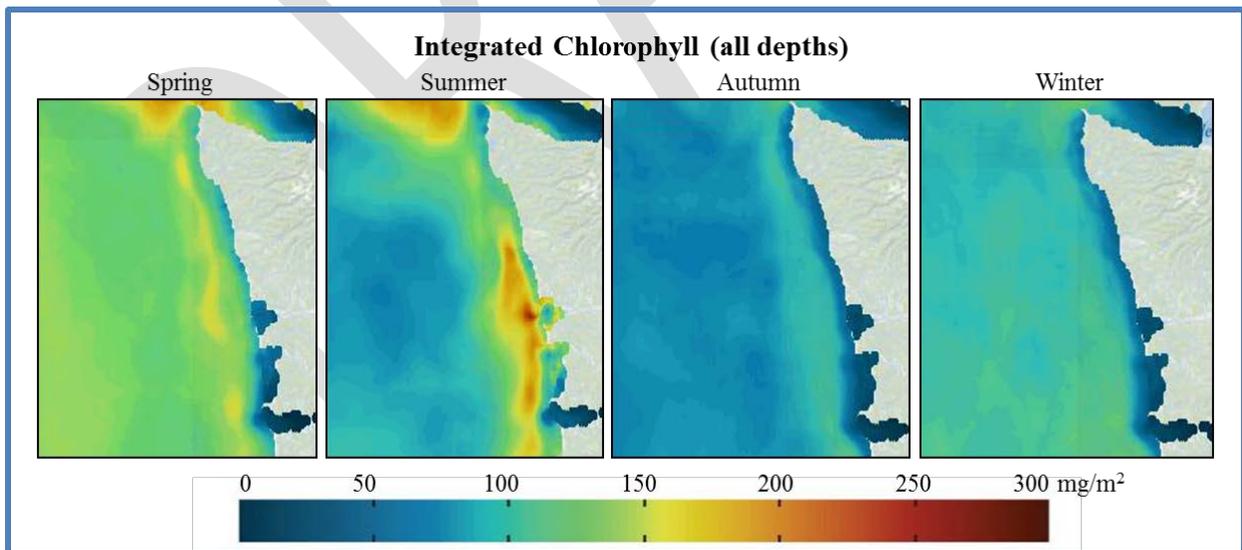
52



53

54 Figure 2.1-1. Schematic of upwelling forces. Source: Northwest Fisheries Science Center as provided in the IEA.

55



56

57 Figure 2.1-2. Integrated chlorophyll (all depths) for 2005-2006. Source: Ocean conditions page.

58 In addition to upwelling, other features influence ocean and coastal productivity along the
59 Washington coast. A significant aspect is the Juan de Fuca Eddy, a semi-permanent feature located off
60 the coasts of northern Washington and southern Vancouver Island of British Columbia. The Eddy forms
61 in the spring, dissipates in the fall, and is formed by the outflow from the Salish Sea through the Strait of

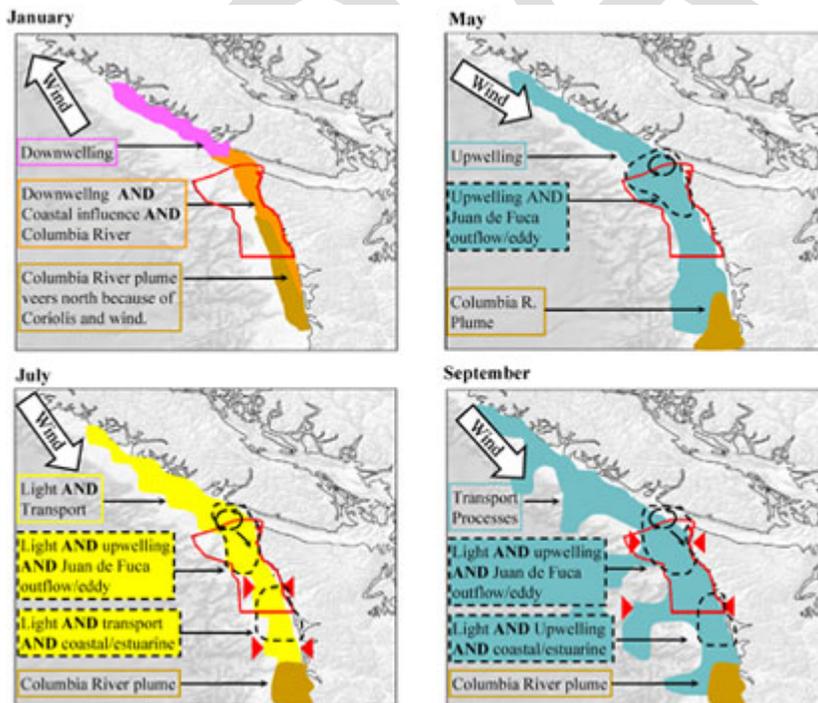
62 Juan de Fuca. The Eddy is characterized by high nutrients, increased productivity and retention, and
63 enhanced higher trophic-level biomass (Andrews et al., 2013; Hickey & Banas, 2008).

64 The Columbia River Plume is another major feature that influences productivity along the
65 Washington coast. The river plume brings freshwater, sediment, nutrients, carbon, and organic matter
66 which increase primary productivity in marine waters. The plume also influences water circulation,
67 retention, and transportation which effect plankton and larval fish. The Columbia River Plume can vary
68 in orientation, but is generally pushed northward along the coast in the winter during downwelling and
69 generally southwestward during the summer, although this may vary during weak upwelling periods
70 (Andrews et al., 2013; Burla, Baptista, Zhang, & Frolov, 2010; Hickey & Banas, 2008). While the Columbia
71 River Plume generally provides fewer nutrients to the ocean during the summer months, Hickey and
72 Banas (2008) suggest the plume may help sustain local ecosystems by providing a nutrient supply during
73 periods of weak to no upwelling or during late spring transitions.

74 Coastal trapped waves, a complex interaction of shelf slope, wind, and angular momentum, are
75 another important physical process feature and can accelerate local alongshore currents. Coastal
76 trapped waves can generate as far south as central California (Hickey & Banas, 2003). Features such as
77 the Juan de Fuca Eddy, the Columbia River Plume, coastal trapped waves, and submarine canyons
78 (described below) are estimated to contribute significantly to the higher productivity of the Washington
79 coast as compared to the rest of the PNW (southern Oregon and northern California) (Hickey & Banas,
80 2008). An illustration of the major physical factors influencing seasonal nutrient availability in
81 Washington waters is provided in Figure 2.1-3.

82

83 **Figure 2.1-3. Schematic of general physical factors limiting nutrient availability and surface response during January, May,**
84 **July, and September. Source: (Pirhalla et al., 2009).**



85

86

87

88 *Estuaries*

89 Several estuaries occur within the MSP Study Area. Estuaries in the northern portion of the Study
90 Area are relatively small outlets from coastal rivers. Two large estuaries in the southern portion of the
91 Study Area, Grays Harbor and Willapa Bay, are significant features of the southern coast. Grays Harbor
92 and Willapa Bay consist of multiple channels surrounded by wide, shallow mudflats. Over half of the
93 surface area in each of these two estuaries is intertidal (Hickey & Banas, 2003). Rivers emptying into
94 Grays Harbor and Willapa Bay are dominated by local rainfall. This leads to higher river flow in the
95 winter, intermittent flows in the spring, and low flows in the summer. The large estuaries within the
96 MSP Study Area are highly influenced by oceanographic forces, including the upwelling/downwelling
97 cycle (Hickey & Banas, 2003).

98 *Tides*

99 Tidal patterns contribute to the high biological diversity of intertidal habitats along the Washington
100 coast. Tides in Washington are mixed semidiurnal, meaning that there are typically two high tides and
101 two low tides per day and the consecutive highs and lows differ in height. The daily tidal range is 2 to 4
102 meters (6.5 to 13 feet) (Ruggiero et al., 2013). In Grays Harbor and Willapa Bay, oceanic waters flush up
103 to half of the water volume twice a day. In the spring and summer, very low tides occur in the morning,
104 when cool temperatures and fog keep the physical stresses (high temperature, desiccation, etc.) on the
105 tidal flats low. Low tides in the winter can cause freezing and mortality of exposed organisms (Hickey &
106 Banas, 2003; Skewgar & Pearson, 2011). Tides contribute to the exchange of water, oxygen, nutrients,
107 heat, and other physical conditions in the estuaries and beaches. This is critical for various organisms
108 occupying different tidal zones, mudflats, rocky shores, and other communities (Andrews et al., 2013).

109 *Climate and Large Scale Influences*

110 Washington has a temperate climate, with high seasonal precipitation mostly from October to
111 March, and dry, warmer conditions during the summer months. This seasonal rainfall and snowfall
112 influences river flows, coastal turbidity and sediment input, temperature, and salinity gradients along
113 the coast and in estuaries. Storms during the winter months also play an important role in shaping the
114 physical environment (Hickey & Banas, 2003; Pirhalla et al., 2009; Skewgar & Pearson, 2011).

115 Large-scale, global processes influence climate from year to year and on an interdecadal scale.
116 These large-scale climatic processes interact in complex ways with significant influence on ocean
117 productivity. The El Niño-Southern Oscillation (ENSO) pattern causes system-wide differences in sea
118 surface temperature, sea surface height anomalies, turbidity, and sediment transport processes (Pirhalla
119 et al., 2009; Ruggiero et al., 2013; Skewgar & Pearson, 2011). For example, within the MSP Study Area,
120 sea surface temperatures are generally warmer during the warm phase (El Niño) and cooler during the
121 cool phase (La Niña) (Pirhalla et al., 2009). Also, during an El Niño phase, storms, large waves heights,
122 and wave angles have been documented to create erosion hotspots in the PNW (Ruggiero et al., 2013).
123 The Pacific Decadal Oscillation (PDO) also influences sea surface temperature and height (Pirhalla et al.,
124 2009) over a longer timescale than ENSO. Another process, the North Pacific Mode (a.k.a. the Blob), has
125 recently resulted in exceptionally warmer waters off the West Coast in 2013-2015 (Kintisch, 2015), and
126 may have influenced marine species ranges and ocean productivity (Bond, Cronin, Freeland, & Mantua,
127 2015; Hartmann, 2015; Kintisch, 2015).

128 *Storms and wave energy*

129 The PNW is known for its severe wave climate, particularly during winter storms. Winter storms
130 create deep-water significant wave heights greater than 10 meters (33 feet) and have generated wave
131 heights up to 15 meters (49 feet). The strongest storms can achieve hurricane wind speeds. High, long-
132 period waves with a west southwest approach characterize the winter months (November through
133 February) and small waves (1 meter or 3 feet) from the west northwest are typical of calmer, summer
134 conditions (May through August) (Ruggiero et al., 2013). Increasing wave heights and intensity of storms
135 have been observed in the PNW over the last half of the 20th century (Ruggiero et al., 2013). Also, the
136 frequency of strong storms has increased, while the frequency of weak to medium strength storms has
137 decreased (Ruggiero et al., 2013). The storm and wave energy of the PNW has a significant influence on
138 the physical conditions of the ocean and coast. Wave and storm energy influences erosion and
139 accretion, sediment transportation, surf zone energy, and flooding.

140 Water quality

141 Water quality is important for species, habitats, and human health. Several water quality
142 parameters are regularly monitored to study the causes, trends, and impacts of water quality. This
143 information is used to develop and adapt management plans to address ecological and public health
144 issues, such as pollution, toxins, and other impacts.

145 For some water quality parameters, the Washington State Department of Ecology (Ecology) has
146 developed enforceable water quality standards to protect beneficial uses including human contact and
147 aquatic life uses (e.g. salmonid migration, rearing, and spawning). The state is also required to use these
148 standards to prepare a list of water quality limited segments under the Clean Water Act and EPA's
149 implementing regulations. The Washington State Department of Health (WDOH) regulates shellfish
150 harvesting under the National Shellfish Sanitation Program. This program designates commercial and
151 recreational shellfish harvest areas and establishes fecal coliform bacteria limits to protect those uses.
152 Water bodies are regularly monitored to evaluate whether or not these standards are met.

153 For Ecology's water quality assessment, all available and credible water quality and fish tissue data²
154 are assessed and waterbody segments are evaluated and categorized into a water quality rating system
155 based on the results (Washington State Department of Ecology, 2012b). Water quality assessment
156 categories are as follows:

- 157 • Category 1: meets tested standards for water quality
- 158 • Category 2: waters of concern where there is some evidence of a water quality problem, but
159 not enough to require production of a water quality improvement project at this time
- 160 • Category 3: insufficient data
- 161 • Category 4: polluted waters that do not require a TMDL
 - 162 ○ Category 4a: polluted waters with an approved total maximum daily load (TMDL)
 - 163 ○ Category 4b: polluted waters with an approved water quality improvement plan
164 that is equivalent to a TMDL
 - 165 ○ Category 4c: is impaired by a non-pollutant
- 166 • Category 5: polluted waters that require a TMDL or another type of water quality
167 improvement project

168 Category 5 listings are commonly referred to as 303(d) listings for impaired waters, in reference to
169 section 303(d) of the federal Clean Water Act, and Ecology is required by EPA to develop and implement
170 TMDLs for all category 5 listings.

² Data must meet the state Credible Data Quality Act.

171 TMDLs or other water quality improvement projects are a management approach to clean up 303(d)
172 listed (polluted) waterbodies so that they meet state water quality standards. Water quality
173 improvement plans allocate pollutant discharges to point and non-point sources so that the loading
174 capacity (the maximum amount of pollutants a waterbody can receive and still meet water quality
175 standards) is not exceeded. Wasteload allocations for point sources are incorporated into National
176 Pollutant Discharge Elimination System (NPDES) permits that set effluent limits and requirements for
177 treatment of their effluent. The implementation of best management practices (BMPs) is intended to
178 reduce nonpoint pollution sources that affect water quality. The current water quality assessment was
179 approved by the federal Environmental Protection Agency (EPA) in 2016.

180 Ecology also conducts water quality monitoring for parameters that are not included in the water
181 quality standards to track changes in overall marine conditions due to human and climatic influences
182 (Washington State Department of Ecology, 2014a, 2014b). Other priority water quality issues are
183 monitored in Washington State by Ecology, other state agencies, and organizations. On tribal lands, the
184 tribes, funded through the EPA and in some cases having established tribal water quality standards (e.g.,
185 Makah), monitor and regulate water quality³. The four coastal treaty tribes also monitor water quality in
186 their respective U&As, using methods first approved by the EPA. The data are uploaded to the EPA
187 STORET program. For the U&A, exceedances are determined using state water quality standards. The
188 following are summaries of main water quality considerations within the MSP Study Area.

189 *Dissolved Oxygen*

190 Dissolved oxygen in the water is essential for all aerobic marine and estuarine life. Dissolved oxygen
191 levels are primarily influenced by temperature, gas exchange with the atmosphere, and water source.
192 Waters with high levels of respiration can become decreased in dissolved oxygen, either from an excess
193 of nutrients producing decaying organic matter, or from deep ocean waters with a prolonged absence of
194 photosynthesis. Colder water holds more dissolved oxygen, and warmer water holds less. Deep waters
195 beyond the continental shelf naturally have low oxygen concentrations. Hypoxia (low dissolved oxygen
196 concentrations) in Washington shelf and coastal waters is related to upwelling. Upwelling delivers
197 oxygen-depleted water up from the bottom to the surface, periodically causing hypoxic or even anoxic
198 (no oxygen) conditions. The layer of deep water along the upper continental slope extending to depths
199 greater than 1,000 meters (3,280 feet) that has persistently low oxygen is called the oxygen minimum
200 zone. Historical data suggests that this normally hypoxic layer is showing trends of increased
201 temperature and even lower oxygen (Office of National Marine Sanctuaries, 2008).

202 Decreased oxygen levels in already low-oxygen deep waters or the intrusion of low-oxygen waters
203 into shallower areas towards shore (via upwelling) can stress communities and kill marine organisms
204 (Office of National Marine Sanctuaries, 2008). In 2006, hypoxic conditions were severe enough to cause
205 widespread fish and invertebrate mortality along Washington and Oregon coasts (Chan et al., 2008;
206 Office of National Marine Sanctuaries, 2008). Data indicate that the frequency, intensity, and extent of
207 hypoxic conditions off of Oregon's shelf waters has been increasing since 2000, and anoxic conditions
208 had never been recorded before 2006 (Chan et al., 2008).

209 In Willapa Bay, one water quality segment at the mouth of the Willapa River has been listed as
210 Category 4a for dissolved oxygen, and other segments are listed as Category 2 towards the southern
211 part of the bay near the mouth of the Naselle River and just west of Long Island (Washington State
212 Department of Ecology, 2012a). The Willapa River Dissolved Oxygen TMDL study found that point
213 sources were the primary negative influence on dissolved oxygen levels in the Willapa River. A TMDL

³ The State does not address 303(d) listings on tribal lands but does for the tribal U&As off-reservation.

214 established wasteload allocations for wastewater treatment facilities and seafood processors that
215 discharge to the Willapa River (Washington State Department of Ecology, 2006). Grays Harbor currently
216 has no TMDLs for dissolved oxygen. Grays Harbor and Willapa Bay are strongly influenced by large
217 oceanographic forces on the coast, and may experience low dissolved oxygen levels during upwelling
218 events (C. Krembs, personal communication, May 7th, 2015).

219 *Nutrients*

220 Nutrients, like nitrogen and phosphorus, are essential to plant and animal nutrition, but in high
221 concentrations can lead to a decline in water quality. Excess nutrients in water can lead to
222 eutrophication, which can result in algae blooms, declines in submerged aquatic vegetation, depletion of
223 dissolved oxygen, and mortality of fish and invertebrates. Nutrient concentrations can vary between
224 location and systems, and are a result of complex natural and human-influenced sources. Anthropogenic
225 sources of nutrients can come from point sources, such as sewage treatment plants and urban
226 stormwater, or non-point sources such as failing septic systems and agricultural runoff (Andrews et al.,
227 2013).

228 Nutrient concentrations can be naturally quite high along the Pacific Coast of Washington due to
229 upwelling of nutrient-rich water and also from the Juan de Fuca outflow and Columbia River Plume,
230 which drive the high productivity along the coast (Hickey & Banas, 2003). In general, human-caused
231 increases in nutrients from point or nonpoint sources are not a concern for the northern coast of
232 Washington since there are no significant population centers in the area (Office of National Marine
233 Sanctuaries, 2008). Furthermore, determining the contributions of regional nutrient influences to the
234 Pacific Coast from human sources is very difficult given the strong oceanographic influence through
235 upwelled waters and high variability (C. Krembs, personal communication, May 7th, 2015).

236 Grays Harbor and Willapa Bay are strongly influenced by oceanographic forces such as currents and
237 upwelling (Hickey & Banas, 2003), as well as riverine supply from the Chehalis River or Columbia River
238 during downwelling winds from the south. Nutrient monitoring data from Ecology's Environmental
239 Assessment Program show no significant trends in nutrient changes from 1999-2013 within Grays
240 Harbor or Willapa Bay for nitrogen or phosphorus parameters (Washington State Department of
241 Ecology, 2014a), and there are currently no TMDLs related to nutrients for either Grays Harbor or
242 Willapa Bay (Washington State Department of Ecology, 2012a).

243 *Carbon dioxide and ocean acidification⁴*

244 Carbon dioxide (CO₂) dissolved in seawater decreases the pH of the water, making the ocean more
245 acidified, resulting in a corrosive environment for some shell-forming organisms. The decline in pH is
246 known as ocean acidification. CO₂ in the ocean can come from several sources. The primary driver of
247 ocean acidification is from the ocean absorbing atmospheric CO₂, which is currently at significantly
248 elevated levels compared to historic conditions from the burning of fossil fuels. On the Washington
249 coast, low ocean pH is also a result of upwelled high-CO₂ ocean waters. Decomposition (respiration) of
250 organic material releases CO₂, and these cold bottom waters, which have been out of contact with the
251 ocean surface for up to a few decades, bring cold, CO₂-rich waters to the surface. This is a natural
252 phenomenon. Other sources of ocean acidification include nutrients, which can increase algal blooms
253 and in turn, increased decomposition of organic matter when the algae die, decreasing pH. Freshwater
254 river inputs may also be more acidic than ocean water and therefore influence the acidity of estuarine
255 and coastal waters (Feely, Klinger, Newton, & Chadsey, 2012).

⁴ Ocean acidification is also discussed in Section 2.11: Climate Change.

256 When the oceans take up CO₂, the pH is lowered and the availability of carbonate (CO₃²⁻) is also
257 reduced. The reduced pH and carbonate availability lowers the saturation state of the calcium carbonate
258 (CaCO₃) biominerals: aragonite and calcite, which are used in shell and exoskeleton formation of many
259 marine species. When the saturation state is lowered, it can become more difficult for shell forming
260 organisms, such as oysters, crabs, corals, pteropods, and phytoplankton, to build their shells necessary
261 for survival. Ocean acidification has the potential to affect populations, species distributions, food webs,
262 and disease prevalence (Feely et al., 2012).

263 The Washington coast is particularly vulnerable to ocean acidification because upwelling naturally
264 brings low pH waters to the coast. Effects of low aragonite saturation states have already been observed
265 in the oyster industry, where PNW oyster hatcheries were experiencing mass mortalities when raising
266 oyster larvae in the mid-2000s. Natural oyster recruitment was also low during these years. CO₂ and
267 saturation state monitoring revealed that the water intake during those failure events was low in pH and
268 saturation state. The industry has utilized monitoring equipment and pH buffering to adapt to the acidic
269 conditions and increase hatchery success (Feely et al., 2012). Pteropods are an important component of
270 the marine food web in Washington as they are consumed by fish, seabirds, and whales, and are a key
271 prey for salmon. Studies have shown that pteropod species suffer decreases in calcification and growth
272 rates with declining pH (Feely et al., 2012).

273 Scientists anticipate that ocean acidification conditions and effects will increase in the future,
274 causing more challenges for the oyster industry and resulting in unknown effects to PNW species,
275 habitats, and ecosystem. These impacts could extend to fisheries, human health, and the economy.
276 Ongoing research and monitoring is focused on understanding this phenomenon to better prepare
277 industry response and resource management actions (Feely et al., 2012).

278 *Harmful algal blooms*

279 Phytoplankton concentrations can become quite high in areas with sufficient nutrients, light, and
280 water retention. Some types of phytoplankton produce toxins which can be harmful to marine
281 organisms and humans at concentrated levels. For example, the diatoms of *Pseudo-nitzschia spp.* can
282 produce the neurotoxin domoic acid, which causes amnesic shellfish poisoning, while the dinoflagellate
283 *Alexandrium cantenella* produces the neurotoxin saxitoxin, which causes paralytic shellfish poisoning,
284 and the dinoflagellates of the *Dinophysis spp* produce okadaic acid, which causes diarrhetic shellfish
285 poisoning. When consumed by humans, these toxins can result in illness and even death (Office of
286 National Marine Sanctuaries, 2008; Washington State Department of Fish and Wildlife, 2015b).

287 When levels of phytoplankton with toxins reach a particular threshold, the event is termed a
288 harmful algal bloom (HAB). Shellfish that filter the organisms, such as clams and mussels, can
289 concentrate the toxins exposing harmful levels to human consumers. The Olympic Region Harmful Algal
290 Blooms Partnership (ORHAB), as well as coastal tribes cooperating with ORHAB, such as Quileute,
291 regularly monitors phytoplankton levels in water and toxin levels in water and in shellfish tissue. The
292 partnership is coordinated by the Olympic National Resources Center and consists of the Washington
293 State Department of Health, Department of Fish and Wildlife, the Quinault Indian Nation, and others.
294 The Quileute Tribe operates with separate funding, sends samples to WDOH, and results are posted
295 through WDFW. When toxin concentrations reach a particular threshold, state beaches are closed to
296 shellfish harvest to protect human health (Olympic Regional Harmful Algal Bloom Partnership, 2015;
297 Washington State Department of Fish and Wildlife, 2015b). The Quileute Tribe posts advisories for its
298 members on high levels of HAB at its website, on a hotline, and at trailheads for shoreline access.

299 The occurrence of HABs on the coast is considered to be a natural phenomenon. Nutrients and
300 water retention in the Juan de Fuca Eddy create conditions for high productivity and can result in HABs.

301 Variable winds and upwelling/downwelling forces can push the Eddy closer to shore, bringing the HABs
302 along the coast and contaminating shellfish harvest beaches, with higher toxin levels in the northern
303 portion of the Study Area generally occurring during summer and fall. Southern WA coast beaches are
304 also affected by HABs, with the Juan de Fuca Eddy and Heceta Bank (Oregon) suggested as possible
305 primary sources of toxic phytoplankton (Hickey et al., 2013). The Columbia River Plume may act as a HAB
306 barrier to southern WA beaches during the summer/fall, which can prevent accumulation of toxins in
307 shellfish, but may also act as a HAB conduit during winter/spring resulting in shellfish closures (Hickey et
308 al., 2013).

309 Suspected increases in the frequency of HABs along the Study Area could be related to the reduced
310 outflow of the Columbia River Plume from dams and water removals, as well as climate related
311 phenomena (Office of National Marine Sanctuaries, 2008). In 2015, the United States West Coast
312 experienced possibly the largest HAB in recorded history, with HABs extending from central California to
313 British Columbia and possibly as far north as Alaska. Unusually warm waters of the Pacific Ocean are
314 thought to have contributed to this massive HAB (Doughton, 2015).

315 *Chemical contaminants*

316 Chemical contaminants such as metals, persistent organic pollutants, hydrocarbons, PCBs, etc. are
317 also potential pollutants that can affect the health of marine waters. At present levels, these pollutants
318 are not a concern within Sanctuary waters, and monitoring suggests that water quality is currently good
319 throughout the Olympic Coast (Office of National Marine Sanctuaries, 2008). Grays Harbor is surrounded
320 by commercial forestry and agriculture and has municipal and commercial point source discharge
321 facilities. Water quality is monitored for various contaminants including metals, pesticides, and organic
322 pollutants. In 1992 a TMDL was established for dioxin, a contaminant released into Grays Harbor as a by-
323 product of pulp and paper bleaching from paper mills, and wasteload allocations for 2,3,7,8, TCDD
324 (dioxin) were made for two facilities in Grays Harbor, one of which has since ceased operation. Dieldrin,
325 a legacy pesticide, is listed as a Category 5 for a segment near Westport based on tissue samples from
326 mussels (Washington State Department of Ecology, 2016).

327 Willapa Bay's surrounding watershed is mostly rural except for the cities of Raymond and South
328 Bend. City industries include lumber mills and seafood processing and the river valley is dominated by
329 agriculture with the surrounding area being mostly forestry. Willapa Bay is monitored for contaminants,
330 including several pesticides and other pollutants. Chrysene, a compound from creosote for preserving
331 wood, as well as Benzo(a)anthracene and Benzo(b)fluoranthene, both polycyclic aromatic hydrocarbons,
332 are listed as Category 5 in limited segments of Willapa Bay based on results from mussel tissue samples.
333 Willapa Bay has no other water or fish tissue contaminant TMDL listings (Washington State Department
334 of Ecology, 2016).

335 *Fecal Coliform Bacteria*

336 Bacteria from human and animal waste can pose a threat to human health. Bacteria can enter the
337 water from malfunctioning wastewater treatment plants, improperly functioning septic systems, and
338 from livestock, pets, wildlife, and humans. As bacteria levels increase, so does the risk of humans
339 becoming sick. When bacteria levels in water become high enough, swimming beaches and shellfish
340 harvesting areas along state beaches are closed to protect human health (Washington State Department
341 of Ecology, 2014c). Bacteria in shellfish growing areas and swimming beaches are routinely monitored
342 by the Washington State Department of Health (DOH) in coordination with the Washington State
343 Department of Ecology, tribes, and local partners.

344 A particular area of concern is the Pacific Coast Growing Area in Grays Harbor County, which extends
345 north from Ocean Shores to Point Grenville. This area is approved for commercial shellfish harvest⁵, and
346 the portion from Moclips to Ocean Shores is a tourist destination and popular spot for recreational
347 harvest of razor clams. Fecal coliform bacteria levels became high enough for the DOH to close two
348 sections of the Mocrocks razor clam beach in the summer beginning in 2011, and a portion of the
349 Copalis beach at Oyhut was closed year round to shellfish harvesting starting in 2013. Three zones
350 within this area are listed as Category 5 on the state Water Quality Assessment (Washington State
351 Department of Ecology, 2016). The Washington Department of Ecology is working with DOH, Grays
352 Harbor County, and the Quinault Indian Nation to identify the source(s) of fecal coliform bacteria
353 contamination within the area of concern. Potential sources of contamination in this area include
354 stormwater, wastewater treatment plants, failing on-site septic systems near beaches and creeks, pet
355 and horse waste, human waste from recreation activities, and wildlife waste (Swanson & Anderson,
356 2014).

357 Segments within Grays Harbor are listed as Category 4A on the state Water Quality Assessment for
358 fecal coliform bacteria and there is a TMDL to address this issue. Bacteria levels have resulted in
359 repeated temporary shellfish harvest closures for commercial shellfish growers in the central and
360 western areas of the harbor that is approved for commercial shellfish harvest. The Grays Harbor
361 Bacteria TMDL includes waste allocations for NPDES permitted sources of bacteria into the Harbor
362 including: two seafood processors in Westport, Ocean Spray Cranberries, two pulp mills, discharges from
363 sewage treatment plants in Aberdeen, Hoquiam, Ocean Shores, and Westport, and stormwater runoff
364 from the cities of Hoquiam and Aberdeen. Load allocations were also established for nonpoint source
365 pollution reductions for all tributaries to Grays Harbor including: the Chehalis River, Hoquiam River,
366 Humptulips River, and the numerous smaller watersheds surrounding the harbor (Rountry & Pelletier,
367 2002).

368 Segments of Willapa Bay are listed as Category 5 in the state Water Quality Assessment for fecal
369 coliform bacteria. The section of the bay at the mouth of the Willapa River is listed as 4a and is
370 associated with the Willapa River Bacteria TMDL. The TMDL established wasteload allocations for NPDES
371 discharges to the Willapa River and load allocations for nonpoint source reductions throughout the
372 watershed including tributaries to Willapa River (Ahmed & Rountry, 2007). There is a prohibited
373 commercial shellfish harvest area of the Bay at the mouth of and including the lower part of the Willapa
374 River because of the WWTP, and an area at Bay Center is prohibited for commercial shellfish because of
375 high fecal coliform samples in that area (Office of Environmental Health and Safety, 2015). Recent
376 construction of a regional wastewater treatment plant (WWTP), and closure of the South Bend and
377 Raymond sewage treatment plants, is expected to help improve bacteria and DO conditions in the
378 Willapa River.

379 North of the Pacific Beach Growing Area ending at Point Grenville, monitoring efforts along the
380 coast within the Sanctuary and in tribal U&As indicate that there is reduced concern for bacteria in these
381 waters (Office of National Marine Sanctuaries, 2008).

382 *Temperature*

383 The Pacific Ocean and Washington coastal water temperatures are driven by large-scale
384 oceanographic forces, upwelling, currents, and climatological factors. Average sea surface temperature
385 ranges from about 8°C to 16°C (46°F to 61°F) annually. Sea surface temperature varies across the shelf

⁵ There is no public access north of the Moclips River. Commercial harvest of razor clams is conducted by the Quinault Indian Nation.

386 (nearshore to offshore) due to local upwelling/downwelling forces (Pirhalla et al., 2009). At a larger
387 scale, ocean temperature is influenced by climatic forces such as El Niño-Southern Oscillation and the
388 Pacific Decadal Oscillation. In recent years, warm temperature anomalies ranging from 1°C to 4°C (2°F to
389 7°F) have been observed (the North Pacific Mode, aka “the Blob”) in the Pacific Ocean along the West
390 Coast and are attributed to decreased cooling during the winter months (Bond et al., 2015; Hartmann,
391 2015). Ocean temperature is important to track because it influences species distributions, interactions,
392 and survival, and changes in temperature may have important implications for commercially important
393 and sensitive species (Andrews et al., 2013)

394 The shallow estuaries of Grays Harbor and Willapa Bay are influenced by upwelling/downwelling but
395 are also subject to solar heating during the summer (Hickey & Banas, 2003). Both Grays Harbor and
396 Willapa Bay are monitored for temperature water quality standards and have Category 2 (waters of
397 concern) water segments, yet there are currently no temperature TMDLs for these estuaries. Grays
398 Harbor segments with temperature increases beyond the water quality standards have been attributed
399 to natural conditions (Washington State Department of Ecology, 2012a). Willapa Bay has several
400 Category 2 temperature segments, and it is unclear to what extent natural conditions and human
401 actions are influencing the temperature increases (Washington State Department of Ecology, 2012a).

402 Geomorphology

403 Washington’s coast resides in a tectonically active region, where the Juan de Fuca oceanic plate is
404 subducting under the North American continental plate in what is known as the Cascadia Subduction
405 Zone. This geologic activity has resulted in the creation of the Olympic Mountain range, the Cascade
406 Mountain range, and the dynamic coastal cliffs along the northern coast. Up until about 5 million years
407 ago, much of the material forming the present coastal mountain ranges and western Washington was
408 under the ocean, at which time they began to be uplifted, as the oceanic plate slid under the continental
409 plate. Today’s coastline is the result of erosion processes acting on the uplifted material over the past 5
410 million years, and is considered to be a relatively young landscape (Ruggiero et al., 2013).

411 Washington’s shoreline has a diverse physical landscape with dramatic coastal cliffs, rocky outcrops,
412 expansive beaches, dunes, and pocket beaches separated by headlands (Map 3). The northern portion
413 of the Washington coastline, from Neah Bay to Point Grenville, is dominated by rocky shores with short
414 stretches of pocket beaches. Wave erosion has formed steep cliffs at various locations. In many places,
415 wave cut platforms inundated by tides contain small islands, sea stacks, and rocks protruding from the
416 platform surface (Olympic Coast National Marine Sanctuary, 2011; Ruggiero et al., 2013).

417 From Point Grenville south to Cape Disappointment on the Columbia River, the southern boundary
418 of the Study Area, the coastline is dominated by broad sandy beaches, dunes, and ridges (Olympic Coast
419 National Marine Sanctuary, 2011; Ruggiero et al., 2013). Coastal dunes are derived from sand carried by
420 longshore drift and wind erosion (Skewgar & Pearson, 2011), and wetlands have formed behind the
421 dunes in many areas (Hruby, 2014). The large estuaries in the southern portion of the Study Area, Grays
422 Harbor and Willapa Bay, are fronted by large barrier spits, and have large expanses of wetlands. The
423 Long Beach Peninsula, which consists mostly of the barrier spit separating Willapa Bay from the Pacific
424 Ocean, is about 28 miles long.

425 Sediment is transported along the coast and nearshore areas by waves and currents. Winter storms
426 generate large waves that push the sediment in a northerly direction, while calm summer waves
427 transport sediment to the south. In the Columbia River Littoral Cell, which extends from Tillamook Head,
428 Oregon to Point Grenville, Washington, the net sediment transport is to the north, particularly in the
429 subcells north of the Columbia River (Washington’s coast). Storm events have caused localized, short
430 term erosion in some areas. Anthropogenic changes such as jetties and dams have resulted in erosion

431 and accretion changes to the beaches. Some locations are subject to chronic erosion, most notably the
432 North Cove area just north of the mouth of Willapa Bay. This area has seen long term erosion rates (100
433 years) of about 30 meters (100 feet) per year, and short term erosion rates (20-40 years) of 56 meters
434 (180 feet) per year. However, erosion areas like this are fairly limited and the vast majority of
435 Washington's shoreline is currently stable or accreting over time (Ruggiero et al., 2013).

436 Washington's continental shelf is relatively narrow and extends about 7 to 35 nautical miles from
437 the coast to the shelf break. The continental shelf is composed primarily of soft sediments and glacial
438 deposits of gravel, including cobble and boulders, punctuated by rocky outcrops (Olympic Coast National
439 Marine Sanctuary, 2011). The northernmost portion of the MSP Study Area south to the Hoh River
440 consists of largely hard and mixed substrate, with rocky reefs and outcrops. From the Hoh River south to
441 the Columbia River there is mostly soft, sandy substrate. Throughout the Study Area, outcrops may form
442 rocky reefs scattered among the soft substrate (Map 3). Most notable is Grays Bank, a large rocky reef
443 about 9 miles across the inner and middle shelf characterized by high habitat diversity. Seafloor
444 modeling predicts that an unknown number of rocky outcrops could be scattered throughout the
445 presumably mostly soft substrate of the Washington continental shelf (Goldfinger, Henkel, Romsos,
446 Havron, & Black, 2014).

447 Empirical seafloor mapping within the Study Area is limited. Modeling efforts have attempted to
448 create regional maps of geology and habitats to estimate the primary features and makeup of the
449 seafloor. Data quality, confidence, and predictability vary by location and site specific mapping is
450 recommended to accurately assess substrate and habitat features on a local scale (Goldfinger et al.,
451 2014).

452 NOAA completed a seafloor mapping prioritization process for the Washington Marine Spatial Plan
453 in 2015. This process evaluated existing seafloor data and prioritized locations within the Study Area
454 where resource managers, scientists, and other stakeholders identified as being important for informing
455 future management decisions. Two offshore and three nearshore priority areas were identified and
456 represent opportunities to focus limited resources on key mapping needs. Ecosystem-based
457 management, living resource management, coastal inundation & natural coastal hazards, "other
458 regulatory", sediment management, and research were identified as the most important management
459 issues for these areas (NCCOS, 2015). The final prioritization report can be found
460 at http://www.msp.wa.gov/wp-content/uploads/2015/03/NCCOS_SeafloorMappingReport.pdf.

461 The Study Area also includes the shelf break and slope (a.k.a. coastal margin), a transition zone
462 between the oceanic plate and the continental plate, which rapidly increases in depth toward the
463 abyssal plain. Several submarine canyons cut into Washington's continental slope and shelf, including
464 the Nitinat, Juan de Fuca, Quinault, Gray's, Guide, Willapa, and Astoria Canyons (Hickey, 1995) (Map 3).
465 The canyons vary in size, with the Juan de Fuca canyon trough transecting the northern portion of the
466 Study Area angling toward the Strait of Juan de Fuca. Submarine canyons are regions for massive
467 submarine landslides and act as channels for coastal sediment to reach the deep seafloor (Olympic
468 Coast National Marine Sanctuary, 2011). Submarine canyons are also noted to be habitats with high
469 biological activity and diversity (Hickey, 1995). Canyons can enhance coastal upwelling by providing a
470 conduit for deep, cold, nutrient rich seawater to reach the bottom boundary layers of shelf water,
471 where it can be upwelled by local wind forcing, contributing to the high productivity of Washington's
472 ocean (Hickey & Banas, 2008).

473 **Earthquakes and tsunamis**

474 The Cascadia Subduction Zone (CSZ), located along the West Coast, from northern Vancouver Island
475 down to northern California, is a region full of active earthquake faults. The Juan de Fuca Plate is

476 subducting underneath the North American Plate, which causes friction and stress. Scientists believe the
477 two plates are currently locked, so that a major earthquake has not occurred. Eventually when the stress
478 becomes too great, the major faults will rupture, causing significant earthquakes. There are three
479 different types of earthquakes: deep, shallow, and subduction zone.

480 In the 1980s, scientists became aware of the risk of “great” subduction zone earthquakes in the
481 Cascadia region. Geologic records revealed that in 1700, an approximate magnitude 9.0 (Richter scale)
482 earthquake occurred in the CSZ, and further investigations revealed that a similar great earthquake
483 occurs on average every 500 years in the Cascadia region (Cascadia Region Earthquake Workgroup,
484 2013). Smaller CSZ earthquakes are thought to occur off the northern California and Oregon coasts
485 (Goldfinger et al., 2012).

486 The next great CSZ earthquake is anticipated to be a magnitude of 8.0 to over 9.0. It will cause
487 substantial damage, particularly to coastal areas, and may result in several large tsunamis. During a CSZ
488 earthquake, a portion of the seafloor is suddenly thrust upwards, which displaces the entire ocean
489 above it, resulting in long period waves radiating outward from the source. Multiple waves can be
490 generated, and travel up to about 500 miles per hour through the deep ocean. Recent examples of
491 subduction earthquakes and associated tsunamis in other areas of the world include the 2011
492 magnitude 9.0 Tohoku, Japan earthquake and the 2010 magnitude 8.8 Maule, Chile earthquake
493 (Cascadia Region Earthquake Workgroup, 2013).

494 Biology

495 MSP Study Area waters have high biological productivity and support a diversity of habitats and
496 species, many of which are important ecologically, culturally, and economically to Washington, the
497 United States, and the world⁶. Habitats are where organisms live, eat, shelter, and reproduce. A living
498 ecosystem is the collection of habitats, and healthy marine habitats are the foundation of healthy
499 communities of marine life. The MSP Study Area is comprised of many habitats which support numerous
500 species of fish, mammals, and birds. This section describes the key habitats and species found within
501 Study Area waters to tell the story of marine life off of Washington’s Pacific coast and to emphasize the
502 importance of protecting these biological resources now and into the future.

503 As a part of the marine spatial planning process, scientists at NOAA developed conceptual models of
504 the key ecological components, physical drivers, and human activities in the MSP Study Area. They also
505 evaluated and selected a portfolio of indicators for the key components and quantified the status and
506 trends of the indicators. The results are presented in the following two reports, which are used as
507 frequent references for this section. Readers are encouraged to consult the reports for references to
508 the original research.

- 509 • Andrews, K. S., Coyle, J. M., & Harvey, C. J. (2015). Ecological indicators for Washington
510 State’s outer coastal waters. Seattle, WA: Northwest Fisheries Science Center. Report to the
511 Washington Department of Natural Resources. Retrieved from [http://www.msp.wa.gov/wp-
512 content/uploads/2015/03/NWFSC_EcosystemIndicatorReport.pdf](http://www.msp.wa.gov/wp-content/uploads/2015/03/NWFSC_EcosystemIndicatorReport.pdf).
- 513 • Andrews, K. S., Harvey, C. J., & Levin, P. S. (2013). Conceptual models and indicator selection
514 process for Washington State’s marine spatial planning process. Conservation Biology
515 Division, Northwest Fisheries Science Center, National Marine Fisheries Service, National
516 Oceanic & Atmospheric Administration. Retrieved from [http://www.msp.wa.gov/wp-
517 content/uploads/2013/07/NOAA_NWFSC_ConceptualModel_FinalReport.pdf](http://www.msp.wa.gov/wp-content/uploads/2013/07/NOAA_NWFSC_ConceptualModel_FinalReport.pdf).

⁶ Olympic National Park is a UNESCO World Heritage Site.

518 *Habitats*

519 Several habitats occur within the MSP Study Area. For the purposes of this MSP, six major habitat
520 types are described: pelagic, seafloor, kelp forest, rocky shores, sandy beaches, and large coastal estuary
521 habitat. These habitat categories were chosen by the National Marine Fisheries Service Northwest
522 Fisheries Science Center for the Indicators for Ecological Assessment reports (Andrews, Coyle, & Harvey,
523 2015; Andrews et al., 2013) produced for the WA MSP and were derived from categories used in
524 WDFW's "State of the Washington Coast" (Skewgar & Pearson, 2011) and the Olympic Coast National
525 Marine Sanctuary "Condition Report" (Office of National Marine Sanctuaries, 2008). The indicators and
526 report are discussed in further detail in Section 3.

527 *Pelagic*

528 The pelagic zone represents all water column habitats from the surface to near-bottom in MSP
529 Study Area waters. Physical drivers important to the pelagic habitat include currents, eddies and plumes,
530 wind-driven upwelling, climatic forces, and solar energy. These forces create a dynamic pelagic zone,
531 which in turn affects primary productivity, pelagic community composition, and species survival. For
532 more information on these forces in the MSP Study Area, please see the Physical Oceanography section.

533 Phytoplankton are the base of the food web for the entire marine community. The phytoplankton
534 community off the Washington coast is highly productive due to strong upwelling of nutrient-rich waters
535 and the influence of the Juan de Fuca Eddy and the Columbia River plume. Diatoms and dinoflagellates
536 generally dominate the phytoplankton communities (Andrews et al., 2013).

537 Many zooplankton migrate vertically in the water column from near the seafloor to the surface to
538 feed on phytoplankton. Zooplankton are key links in the food chain, connecting primary production to
539 upper trophic levels. Shifts in zooplankton species composition can be correlated with regional climate
540 and seasonal patterns. Cold water zooplankton species tend to be lipid-rich, providing a key energy
541 source to pelagic fishes, while warm water zooplankton have a lower lipid concentration and can be a
542 lower quality food source. Cold water species typically dominate the zooplankton community during the
543 summer upwelling season, while the warm water species usually dominate during winter. Climate forces
544 such as El Niño events, the 'Blob', and the Pacific Decadal Oscillation can alter these seasonal patterns
545 (Andrews et al., 2015, 2013).

546 The pelagic zone provides important habitat and food for a variety of fishes. Forage fish species,
547 including smelt, Pacific herring, northern anchovy, and Pacific sardine, live and feed in the upper pelagic
548 zone and are key links in the food web by transferring energy from plankton to larger predatory fish,
549 marine mammals, and seabirds. Salmon also spend much of their time in the pelagic zone after their
550 initial entry into the ocean, feeding on zooplankton (e.g. pteropods) and forage fish. Albacore tuna are
551 seasonal visitors to the MSP Study Area. Midwater rockfish, such as adult widow rockfish (*Sebastes*
552 *entomelas*), Pacific ocean perch (*S. alutus*), yellowtail rockfish (*S. flavidus*), and black rockfish (*S.*
553 *melanops*), spend a large portion of their time above the seafloor substrate and feed primarily on large
554 zooplankton. Pacific whiting (a.k.a. hake) are one of the most abundant fish species in the California
555 Current. They also feed in pelagic waters on prey items similar to salmon, rockfish, and other groundfish
556 species (Andrews et al., 2013). Myctophids (a.k.a. lanternfishes) may be the most abundant pelagic
557 family of fishes. Like many zooplankton, they occupy deeper waters during the day and rise to feed on
558 phytoplankton providing an important trophic link between primary production and deeper waters
559 (Davison, Checkley Jr., Koslow, & Barlow, 2013).

560 Many species of seabirds and marine mammals feed and transit through the pelagic habitat of the
561 MSP Study Area. At least 29 species of marine mammals inhabit or transit through Washington coastal

562 and offshore waters, and numerous species of marine birds live, reproduce, feed, and transit through
563 the MSP Study Area, some migrating thousands of miles to “winter” in MSP waters. These animals feed
564 on zooplankton, forage fish, salmon, and other fishes (Andrews et al., 2013; Olympic Coast National
565 Marine Sanctuary, 2011). Occasionally, leatherback sea turtles also feed in the pelagic habitat of the
566 MSP Study Area, preying mainly upon jellyfish (Washington State Department of Fish and Wildlife,
567 2013).

568 Primary existing human pressures within this habitat include fishing, atmospheric deposition of
569 pollutants, and commercial shipping activities (Andrews et al., 2013).

570 Seafloor

571 Seafloor habitat represents all bottom habitats below 30 m (98 feet) depth in the MSP Study Area⁷.
572 Physical seafloor habitat can consist of soft/mixed substrates or rocky/mixed substrates. Empirical
573 mapping of the entire MSP Study Area seafloor habitat is not available. However, direct seafloor
574 mapping of limited areas along with models suggest that the majority of seafloor habitat is soft/mixed
575 substrates (Goldfinger et al., 2014). Rocky/mixed seafloor substrates mainly occur in the northern
576 portion of the Study Area (Map 3). Biogenic seafloor habitat made up of deep-sea corals, sponges, and
577 anemones has also been observed in the Study Area, with fishes and invertebrates congregating in these
578 areas. In the MSP Study Area, while the entire area has not been surveyed to date, the highest density of
579 biogenic habitat has been observed in the canyon areas such as the northernmost region in the Juan de
580 Fuca Canyon area, although many areas with biogenic habitat have been observed throughout the Study
581 Area (Andrews et al., 2015).

582 Large zooplankton such as euphausiids (a.k.a. krill) are an important component to the seafloor
583 habitat food web as they are a large portion of the diet for many groundfish. The abundance of
584 predominant krill species has been observed to be much higher during high upwelling conditions than
585 low upwelling conditions. Sinking microscopic aggregates of organic and inorganic particles such as
586 bacteria, phytoplankton, detritus, fecal pellets, and bio-minerals, are also an important component of
587 the seafloor food web. Aggregates of this material fall from the pelagic zone to the seafloor as “marine
588 snow”, where they become food for detritus-feeding invertebrates and deposit feeders. Peaks in marine
589 snow are commonly observed following large diatom blooms (Andrews et al., 2013).

590 Deposit feeders live and feed on the seafloor. Species include several benthic invertebrates
591 including amphipods, isopods, small crustaceans, snails, sea cucumbers, worms, polychaetes, sea slugs,
592 and hermit crabs. They feed primarily on detritus on the seafloor, and are key links in the food web.
593 Deposit feeders are prey for several commercially or recreationally valuable species, including Dover
594 sole (*Microstomus pacificus*) and Pacific halibut (*Hippoglossus stenolepis*). Other benthic invertebrates
595 include bivalves, corals, sea urchins, and sea stars, which make up significant proportions of some
596 flatfish and rockfish diets. The seafloor is also important habitat for Dungeness crab (*Metacarcinus*
597 *magister*), a highly valuable commercial fishery and important prey for sharks, large rockfish, and
598 octopus. Spot prawns (*Pandalus platyceros*) and pink shrimp (*P. eous* and *P. jordani*) are also commercial
599 harvest species associated with the seafloor habitat (Andrews et al., 2013).

600 Groundfish provide one of the primary fisheries for Washington coastal communities. The
601 groundfish assemblage consists of many different families, including rockfish, roundfish, flatfish, and
602 elasmobranchs. These species rely on seafloor habitat and their diets consist of many benthic

⁷ This seafloor depth cutoff was chosen in the Ecological Indicators report. For more details, please see Andrews et al., 2015.

603 invertebrates and other fishes. Commercial fishing and associated seafloor habitat modification from
604 trawls and other bottom gear are key human pressures in this habitat.

605 A physical stressor to the seafloor habitat includes low dissolved oxygen events (hypoxia and anoxia)
606 that can cause stress and mortality of organisms along the seafloor, especially immobile or slow-moving
607 benthic invertebrates that are unable to leave the area during low oxygen conditions. This may affect
608 the seafloor food web and possibly impact the groundfish assemblage (Andrews et al., 2013).
609 Monitoring suggests that hypoxic conditions have been increasing in frequency and intensity since 2000
610 (Chan et al., 2008). For more information, please see the Dissolved Oxygen section.

611 Kelp forest

612 Kelp forest habitat includes floating kelp canopies of bull kelp (*Nereocystis leutkeana*) or giant kelp
613 (*Macrocystis pyrifera*), submerged kelp beds (e.g., *Laminaria* spp. and *Pterogohora californica*), and
614 rocky reefs that occur at depths of less than 30 meters (98 feet). Rocky reefs are included in the kelp
615 forest habitat category because many animal species that inhabit kelp forests also inhabit shallow rocky
616 reefs without canopy-forming kelp. In addition to the two conspicuous species of canopy-forming kelp,
617 more than 20 species of kelp that do not form floating canopies occur on rocky reefs in the region,
618 comprising one of the most diverse kelp communities in the world (Mumford, 2007). This habitat occurs
619 primarily along the northern coast of the MSP Study Area (Map 4)(Andrews et al., 2015).

620 Kelp forests form diverse communities providing physical structure and energy to the food web.
621 Kelp provides surface area, creating habitat for sessile organisms. The complex structural component of
622 kelp serves as a nursery, refuge, and forage area for a variety of fishes, especially rockfish, sculpins,
623 greenling, lingcod, perch, juvenile salmon and others, including many fish on Washington's list of Species
624 of Concern. Floating kelps provide surface habitat that dampens waves, and these semi-protected areas
625 are used as foraging habitat for seals and several species of birds. Sea otters feed in kelp habitats and
626 rest among floating kelp beds (Andrews et al., 2013).

627 Kelp forests and other macroalgae also play a key role in supplying particulate organic matter and
628 dissolved organic matter to the food chain. Decomposing kelp supports a strong bacterial community
629 that fuels phytoplankton and benthic filter-feeder growth in the nearshore environment. In addition,
630 sections or entire plants break loose during storms and sink to the bottom or wash up on beaches,
631 where they are scavenged by small crustaceans, insects, and other scavengers (Mumford, 2007).

632 The total extent of surface canopy, area, and density of kelp beds affects the species assemblages
633 found in this habitat. Trends in kelp bed characteristics thus provide insight into ecosystem condition
634 and also provide important information for trends in fish and invertebrate populations. Kelp populations
635 fluctuate seasonally and inter-annually depending upon reproductive cycles, oceanographic conditions,
636 and herbivore pressure. Strong storm events and nutrient-poor waters associated with El Niño events
637 can decrease kelp coverage, while cold, nutrient-rich La Niña events provide extraordinary growth
638 conditions. Disturbance from storm-driven waves is, however, a natural process and provides an
639 important opportunity for bull kelp and macroalgae recruitment. Years with suppressed cold water
640 upwelling can negatively affect kelp forests, as bull kelp is particularly sensitive to warm temperatures.
641 Light penetration is also an important physical factor, and events with increased sediment runoff due to
642 heavy rains or landslides may reduce densities of bull kelp (Andrews et al., 2013).

643 In the northern hemisphere, the most widespread and herbivore-induced kelp deforestations have
644 resulted from sea urchin grazing (Steneck et al., 2002). Three common sea urchin species: red
645 (*Mesocentrotus franciscanus*), purple (*Strongylocentrotus purpuratus*), and green (*S. droebachiensis*)
646 graze upon kelp in Washington. Sea urchin abundance is controlled by predation, and the most notable

647 predators of sea urchins are sea otters, seastars, humans, and crabs. Sea urchin removal by sea otters
648 can promote the growth of kelp and kelp-associated communities. Sea otters have ecosystem-level
649 effects across the nearshore marine communities they inhabit, and this sea urchin/sea otter/kelp
650 trophic interaction has been well documented in the Pacific Ocean (as cited in Andrews et al., 2013). In
651 Washington waters, sea otter reintroduction and range extension was followed by decreases in sea
652 urchin densities and increases in algal abundance (Kvitek, Iampietro, & Bowlby, 1998; Laidre & Jameson,
653 Ronald J., 2006).

654 Existing human pressures identified in the Ecological Indicators report for MSP for kelp forest habitat
655 include recreational fishing, pollutants, and excess nutrient inputs (Andrews et al., 2015). Increases in
656 water temperature have been shown to negatively impact kelp (Dayton, 1985; Tegner, Dayton, Edwards,
657 & Riser, 1996), and anthropogenic climate change is expected to negatively affect kelp communities
658 (Harley et al., 2012). Turbidity and sedimentation profoundly affect kelp communities by changing light
659 availability, scouring plants or burying hard substrate (Shaffer & Parks, 1994) (Branch et al. 1990, Airoldi
660 2003).

661 Rocky shores

662 The rocky shores habitat represents rocky and mixed intertidal shorelines in the MSP Study Area.
663 This habitat generally occurs north of Point Grenville (Map 3) (Andrews et al., 2015). Rocky shores cover
664 a broad range of substrate types, from bedrock to boulder fields to cobble and gravel. Tide pools,
665 boulder size, and proximity to sand can influence the communities within this habitat (Andrews et al.,
666 2013).

667 The variety in substrate type, tidal elevation gradient, productivity, and local physical disturbances
668 (storms, drift wood, etc.) lead to a wide diversity of macrophytes in this habitat. Over 120 species of
669 macrophytes (macroalgae, surfgrass, etc.) have been documented to occur in rocky habitats within the
670 Olympic Coast National Marine Sanctuary (OCNMS). Macrophytes not only provide food, but also
671 provide microhabitats for fauna, protecting them from stressors such as waves, desiccation (drying out),
672 and temperature changes. This habitat also supports a large biomass of sessile, suspension-feeding
673 benthic invertebrates. Suspension-feeding taxa include barnacles, mussels, sponges, tubeworms,
674 tunicates, and others. The upper and lower distribution limits within the intertidal zone for each species
675 depends upon their resilience to physical factors such as desiccation and temperature, along with
676 competition and predation. Suspension feeders provide habitat for macroalgae, invertebrates, and fish,
677 can influence nutrient concentrations in intertidal waters, and provide food for predators including
678 humans (Andrews et al., 2013).

679 Dozens of grazing invertebrates occur along the rocky shores of Washington's outer coast, most
680 notably snails, limpets, chitons, and small crustaceans. Grazers are also stratified in their vertical
681 distribution limits within the intertidal zone. As a group, grazers feed on a variety of organisms including
682 benthic microalgae, coralline algae, macroalgae, and algal detritus. Predators within the rocky shores
683 habitat include the ochre seastar (*Pisaster ochraceus*), whelks, anemones, worms, and crabs. *Pisaster* is
684 considered a keystone predator and its presence helps to maintain the diversity of intertidal rocky
685 communities. Zonation and microhabitat preferences are also exhibited by predators on rocky shores
686 (Andrews et al., 2013).

687 Several fishes live within rocky shores, moving in and out with the tides and residing in tide pools.
688 Common species include small sculpins and gunnels. Many seabirds, shorebirds, raptors, and general
689 foraging bird species use rocky shores. Oystercatchers, gulls, and crows forage within the rocky intertidal
690 zone. Species such as petrels, cormorants, gulls, and murre nest in colonies on offshore rocky islands
691 and sea stacks. Harbor seals (*Phoca vitulina*) are common in rocky intertidal habitats along the outer

692 coast, and are year-round residents. Rocky islands are also used as haul-outs for Steller sea lions
693 (*Eumetopias jubatus*) and California sea lions (*Zalophus californianus*). Northern elephant seals
694 (*Mirounga angustirostris*) have been observed occasionally at some rocky islands (Andrews et al., 2013).

695 Several important physical drivers influence the rocky shores habitat. The intertidal zone is defined
696 by the tides. Geomorphology and tidal elevation determine which zones are exposed to various
697 stressors and the length of time they are exposed. Stressors include exposure to air, temperature
698 changes, predation, and changes in freshwater inputs, wave action, and light. Organisms that tolerate
699 similar conditions and tidal exposures will group together (aka zonation). The upper limit of a species
700 distribution is often determined by their tolerance to physical extremes, while the lower limit is often
701 determined by forces such as competition and predation. Rocky intertidal organisms are also subject to
702 wave energy, which can cause physical disturbance, particularly during severe storms. It is also
703 suggested that wave energy increases the productivity of rocky intertidal systems by providing
704 competitive advantages for wave tolerant organisms, replenishing nutrients, and enhancing light uptake
705 by algae. Upwelling provides nutrients, plankton, and larval recruits to the rocky intertidal system
706 (Andrews et al., 2013).

707 Rocky shores along the coast of Washington appear to be healthy. There are, however, several
708 existing human pressures that could impact the health of rocky shores. Specific activities include
709 trampling and harvest by human visitors, competition from non-native species, and pollution, including
710 but not limited to oil spills, marine debris, and untreated discharge from land or marine facilities or
711 activities (Andrews et al., 2013).

712 Sandy beaches

713 Sandy intertidal beach habitat stretches mainly along the southern shorelines of the MSP Study
714 Area, south of Point Grenville, making up about half of Washington's outer coastline. Sandy pocket
715 beaches between headlands and near estuaries occur also north of Point Grenville (Map 3). Physical
716 drivers for sandy beach habitats are sediment deposition, wave energy, beach slope, upwelling, and
717 climate variability. Upwelling provides nutrients and food to the beach habitat. Weather and climate,
718 such as hot sunny days and strong winter storms, create variable conditions for organisms living in sandy
719 habitats (Andrews et al., 2013).

720 Physical forces are central to the ecology and functioning of sandy beaches. Wave energy, the size of
721 sand grains, and the elevation gradient interact to shape sandy beach systems. Washington's southern
722 beaches are generally characterized as dissipative, meaning they are relatively flat, and have fine sand,
723 large tide ranges, and broad surf zones (Andrews et al., 2013; Skewgar & Pearson, 2011). The wave
724 energy reaching and shaping a particular stretch of beach will vary depending upon factors such as
725 proximity to headlands and bays, winds during storms, and offshore structures such as islands, reefs, or
726 sea stacks (Andrews et al., 2013).

727 Primary producers within sandy habitats are surf zone phytoplankton, benthic diatoms, and other
728 small autotrophs. The razor clam (*Siliqua patula*) is an invertebrate commonly associated with
729 Washington's sandy beaches. Razor clam digging is a popular recreational activity along the coast,
730 providing significant economic benefits. Razor clams are also likely important ecologically, as they
731 recycle ammonium into the nearshore water, promoting primary production. Other invertebrate
732 macrofauna within Washington's sandy beach habitat include several crustaceans such as shrimp, crabs,
733 and amphipods, along with polychaetes, snails, and isopods that live in the middle to lower tidal
734 elevations. Higher on the beach near the drift line are crustacean scavengers such as beach hoppers and
735 isopods, as well as terrestrial arthropods. Sandy beaches are also habitat for several meio- and
736 microfaunal invertebrates (e.g. small worms, mollusks, cnidarians, and unicellular heterotrophs),

737 although not many studies have been conducted to characterize these communities on Washington's
738 beaches (Andrews et al., 2013).

739 An important ecological interaction in the sandy beach habitat is the importation of phytoplankton,
740 particulate organic matter, and detritus. Organic matter brought in by waves and currents provide
741 substantial support for the food chain. In addition, detached kelps and other macrophytes wash up as
742 wrack on the beach and provide habitat for invertebrates and fish as well as food sources for foragers.
743 Habitat structure of sandy beaches (beach zonation, grain size, wave energy, and moisture content) also
744 heavily influences community composition. It is hypothesized that dissipative beaches (like those in
745 Washington) support a greater diversity of microhabitats and niches than intermediate and reflective
746 (steep slopes, coarser sand, no surf zones, etc.) beaches (Andrews et al., 2013).

747 Dozens of species of fish inhabit subtidal waters along sandy beaches in Washington. Some, such as
748 surf smelt, spawn in intertidal sand substrate. Common fish include sculpins, sand lance, surf perches,
749 juvenile tomcod, and flatfish. Birds, including gulls, diving birds, wading birds, shorebirds, and crows,
750 forage on sandy beaches at high and low tides. Sandy beaches are also visited by foraging terrestrial
751 mammals (Andrews et al., 2013; Skewgar & Pearson, 2011).

752 Sand dunes occur along many of the sandy beaches of Washington's outer coast. Vegetated dunes
753 are colonized by native or introduced dunegrasses and various small shrubs and trees. Dunes provide
754 habitat for shorebirds such as sanderlings and snowy plover (*Charadrius nivosus*) (Skewgar & Pearson,
755 2011). The beaches north of Kalaloch are often characterized by the buildup of large logs that have
756 either eroded off of adjacent forested cliffs, or been carried down river systems to the coast. Dunes also
757 provide important protection to the shoreline from wave and storm erosion.

758 Many existing human activities may affect Washington sandy beaches, including clamming and
759 recreation, shoreline development, non-native species, sediment changes, oil spills, and pollution. Sandy
760 beaches south of Point Grenville receive most of their sand from the Columbia River; therefore, dams
761 and disposal of dredged sand from the mouth of the Columbia River into offshore waters have greatly
762 decreased the sediment source from the Columbia River to these beaches (Andrews et al., 2013). This is
763 adversely affecting beach habitat north of the Columbia's mouth, since materials removed by erosive
764 action are not replaced.

765 [Large coastal estuaries](#)

766 Coastal estuaries are semi-enclosed, brackish bodies of water that form where rivers meet the
767 ocean. They are highly productive ecosystems that support a wide range of species at different life
768 history stages, along with numerous ecosystem services. They are also important transitional systems
769 that are linked to freshwater, terrestrial, and marine processes. In particular, this habitat discussion
770 focuses on Willapa Bay and Grays Harbor, the two largest coastal estuaries in the MSP Study Area
771 (Andrews et al., 2015).

772 Large coastal estuaries have varying sediment types (gravel, sand, mud, or silt). Grays Harbor and
773 Willapa Bay have vast areas of mudflats below salt marshes or terrestrial vegetation, cut with multiple
774 tidal channels. Wave exposure varies by location, with sand flats replacing mud flats in areas more
775 exposed to coastal wave energy. Washington's large coastal estuaries are significantly influenced by
776 ocean upwelling and downwelling. Salinity varies with proximity to rivers and bay mouths, and ocean
777 forces and tides can break up the stratification of freshwater on the surface and saltwater below.
778 Freshwater inputs are highest in the winter and lowest in the summer. Tidal mixing is a key driver in this
779 habitat, as over 50% of Willapa Bay and Grays Harbor is intertidal (Hickey & Banas, 2003; Skewgar &

780 Pearson, 2011). Other physical drivers include sediment dynamics, river plumes, large-scale climate
781 patterns, and weather (Andrews et al., 2015).

782 Estuaries are critical habitat for a variety of marine and terrestrial organisms. Primary producers
783 include phytoplankton, benthic microalgae, macroalgae, and macrophytes, such as eelgrass, kelp, salt
784 marsh plants (Map 4), and terrestrial plants. Salinity and tidal elevation influence the distribution of
785 plants throughout the estuaries, with the upper estuarine habitat host to a variety of plants, and
786 mudflats being mostly unvegetated. Invertebrates include insect larvae, amphipods, polychaetes,
787 burrowing shrimp, and others (Skewgar & Pearson, 2011)

788 Shellfish and fish are abundant here. Specific shellfish species include the Olympia oyster (*Ostrea*
789 *lurida*)⁸, non-native Pacific oyster (*Crassostrea gigas*), non-native manila clam (*Venerupis philippinarum*),
790 Dungeness crab, and others. Numerous listed and commercially important fishes spend at least some
791 part of their life-cycle within estuaries. Specific fish species include six species of salmon (*Oncorhynchus*
792 spp.), herring, three-spined stickleback (*Gasterosteus aculeatus*), sturgeon (*Acipenser* spp.), sevengill
793 sharks (*Notorynchus cepedianus*), and many others. Estuaries provide crucial nursery habitat for many
794 species of juvenile fishes and crabs. Some studies have evaluated the spatial and temporal use of the
795 estuaries by juvenile salmon (Sandell, Fletcher, McAninch, & Wait, 2013). Estuaries are also important
796 foraging areas for visiting wildlife, such as migratory shorebirds, ducks, and geese, as well as terrestrial
797 animals, such as deer and elk. Harbor seals also reside within coastal estuaries, hauling out on rocks,
798 reefs, beaches, and docks, and feed on invertebrates and fishes in marine, estuarine, and occasionally
799 fresh waters (Andrews et al., 2015; Skewgar & Pearson, 2011).

800 Biogenic habitats are an important part of the coastal estuarine ecosystem. Eelgrass beds and oyster
801 reefs are two types of biogenic habitats that are very common in Grays Harbor and Willapa Bay. Native
802 and non-native eelgrass (*Zostera marina* and *Z. japonica*, respectively) form patchy beds covering
803 thousands of hectares in these coastal estuaries (Map 4). Non-native eelgrass grows on shallow,
804 intertidal areas whereas native eelgrass typically grows deeper. Eelgrass beds provide primary
805 production to the nearshore food web, and creates a physical habitat that provides three-dimensional
806 structure to otherwise bare mudflats, slows water currents, dampens waves, and traps sediments
807 (Abdelrhman, 2003; Skewgar & Pearson, 2011). Eelgrass is a key part of the estuarine food web, for
808 several species, including birds, invertebrates, and fish. For example, Brant geese (*Brant bernida*) are
809 one of the few large animals that are direct consumers of eelgrass, and these plants are an important
810 food source during their twice-annual migration on the Pacific flyway (Ganter, 2000; Skewgar & Pearson,
811 2011). Seagrass provides habitat for epiphytes, microalgae, macroalgae, and invertebrates that attach to
812 its leaves and are preyed upon by fish and marine-associated birds. Eelgrass habitat is also vital for
813 several highly important commercial species, such as Dungeness crab, Pacific herring, salmonids, shrimp,
814 and flatfishes at some point in their life-cycle (Skewgar & Pearson, 2011).

815 Oysters also create a three-dimensional biogenic habitat in the lower intertidal and subtidal zones.
816 Fish and invertebrates live within oyster shell accumulations, and the oysters provide ecosystem
817 functions by circulating and clarifying water, reducing hypoxia, and filtering nutrients. Historically,
818 Willapa Bay and Grays Harbor supported large populations of Olympia oysters in the low intertidal zone
819 and the shallow subtidal zone (Skewgar & Pearson, 2011). After overharvest led to commercial
820 extinction by 1930, recovery of the Olympia oyster has been hindered by removal of shell
821 accumulations, the preferred habitat of Olympia oyster larvae, and competition with non-native oyster
822 species. Recent aquaculture has focused on the non-native Pacific oyster (Ruesink et al., 2005; Skewgar
823 & Pearson, 2011).

⁸ The Olympia oyster is also a Washington State Candidate Species on the Species of Concern List

824 Several existing human pressures occur within Washington’s large coastal estuaries including fishing,
825 pollution (both physical, such as suspended sediment or temperature increases, and chemical, including
826 by not limited to acidification), dredging, shellfish aquaculture, non-native species, watershed activities,
827 port development, and commercial shipping (Andrews et al., 2015). While the estuaries provide valuable
828 habitat functions and ecosystem services, there is an extensive history of human activities and
829 management within Willapa Bay and Grays Harbor, which has significantly altered habitats and functions
830 from their original state.

831 Estuaries are highly valuable ecosystems. While the MSP has spatial data for some estuarine species
832 and habitats (e.g. green sturgeon critical habitat, marine mammal haulout locations, seabird colonies,
833 dunegrass, kelp, seagrass, and saltmarsh), up-to-date spatial data for many estuarine species is not
834 available. However, given the context that estuaries are known to be vital habitat for many
835 commercially and recreationally valuable species, wildlife, endangered and threatened species, and
836 support key human uses, the State has determined that Willapa Bay and Grays Harbor estuaries are
837 highly important ecological areas, and therefore will be subject to the strictest evaluation if proposals
838 for new uses are suggested within these estuaries. For more information on the Ecologically Important
839 Areas analysis please see Part 3.

840 *Species*

841 The MSP Study Area is home to many species of marine animals and plants. Various species are
842 important for commercial and recreational fisheries, are key links in the marine and estuarine food web,
843 are popular for wildlife viewing, may be state and/or federally protected, or are simply important to the
844 quality and character of the region’s ecosystem. This section highlights animals: key fishes, marine
845 mammals, birds, and sea turtles that occur within the MSP Study Area to help tell the biological story of
846 Washington’s ocean and estuaries. Many other taxonomic groups such as invertebrates, zooplankton,
847 phytoplankton, algae, and plants are also important to the MSP Study Area. While these taxa are not
848 specifically described here, many are mentioned briefly within the Habitat Section.

849 *Fishes*

850 The MSP Study Area is habitat for a variety of fishes. Fishes are important both ecologically and
851 economically to the state of Washington. Key groups of fishes discussed here are pelagic fishes,
852 groundfish, and salmonids and other anadromous fish.⁹ Map 5 shows the Ecologically Important Areas
853 (EIA) for the fish subsector.¹⁰

854 *Forage fish, migratory species, and pelagic fishes*

855 Forage fish are important links in the ocean food web, connecting primary and secondary trophic
856 levels to larger predatory fish, marine mammals, and seabirds. Several species of forage fish inhabit the
857 MSP Study Area (Table 2.1-1). Forage fish tend to be present in high abundance, feed on plankton for a
858 portion of their life cycle, and form dense schools or aggregations. Forage fish often feed in pelagic
859 waters, and certain species such as smelt and sand lance spawn on coastal intertidal sandy beaches
860 (Map 6). Forage fish are prey for a variety of commercially important and legally protected fish (i.e.
861 salmon), marine mammals, and birds and can be of interest for commercial, recreational, and
862 subsistence fishing (Andrews et al., 2013; Langness, Dionne, Masello, & Lowry, 2015).

863 **Table 2.1-1. Forage fish species**

⁹ Information on fishing is in Section 2.4: Commercial, Recreational, and Tribal Fisheries.

¹⁰ Details of the EIA analysis and maps are provided in Part 3: Spatial Analyses.

Common name	Species name
Surf smelt	<i>Hypomesus pretiosus</i>
Night smelt	<i>Spirinchus starksi</i>
Whitebait smelt	<i>Allosmerus elongates</i>
Pacific sand lance	<i>Ammodytes hexapterus</i>
Pacific herring	<i>Clupea pallasii</i>
Northern anchovy	<i>Engraulis mordax</i>
Pacific sardine	<i>Sardinops sagax</i>

864 Many migratory fish species travel through and feed within the pelagic waters of the MSP Study
 865 Area including species such as common thresher shark and albacore tuna. These species feed at a
 866 variety of levels on the food chain, from plankton, to fishes, to mammals. Migratory species are
 867 important commercial, recreational, and tribal fisheries and because of their migratory nature can be
 868 fished by vessels from multiple nations (Olympic Coast National Marine Sanctuary, 2011; Pacific Fishery
 869 Management Council, 2015). Pelagic fish species are susceptible to climate variations, such as upwelling,
 870 source waters, and El Niño/La Niña events (Andrews et al., 2013).

871 *Groundfish*

872 The groundfish (a.k.a. bottomfish) assemblage consists of dozens of species including rockfish,
 873 lingcod, dogfish, halibut, whiting, flatfish, skates, and sablefish. Rockfish consists of numerous species,
 874 with 30 species identified by NOAA in MSP waters. Over 15 species of flatfish have been identified in
 875 OCNMS waters. Groundfish occupy several habitats, including rocky bottoms, kelp, seafloor, and even
 876 pelagic areas. Groundfish prey on a variety of organisms such as euphausiids, plankton, deposit feeders,
 877 benthic invertebrates, forage fish, and other small groundfish (Andrews et al., 2015, 2013; Olympic
 878 Coast National Marine Sanctuary, 2011).

879 Fishing has been a human pressure affecting groundfish and many species were subject to
 880 overfishing, especially during the 1980s and 1990s. Some rockfish species like Yelloweye Rockfish are
 881 particularly sensitive to fishing pressure because of long-lived, low productivity life history
 882 characteristics. A few stocks of rockfish within MSP Study Area waters have been declared overfished
 883 since 2000, but recent fishery management measures appear to have been successful at rebuilding most
 884 groundfish stocks, with only two stocks still classified as ‘overfished’ (yelloweye rockfish and pacific
 885 ocean perch) (Garfield & Harvey, 2016; Pacific Fishery Management Council, 2014a). Essential fish
 886 habitat and rockfish conservation area closures for groundfish bottom trawling have been established
 887 and are being reconsidered in several areas within the MSP Study Area to protect habitat and aid in
 888 stock recovery. The status of groundfish populations is monitored and assessed by NOAA Fisheries,
 889 tribes, and state fisheries management agencies. However, there are data gaps in monitoring of rockfish
 890 populations due to the difficulty and cost of conducting routine, scientific surveys in rocky reef habitats
 891 which are difficult or not possible to access with bottom trawl gear used for stock assessments.

892 *Salmon and other anadromous fishes*

893 Salmonids (salmon and related species) and other anadromous fishes are of high ecological and
894 economic importance in Washington. Anadromous species spawn in freshwater systems, migrate to
895 nearshore and offshore marine areas to feed and grow, then return to home rivers and streams upon
896 maturity to start the cycle again. Seven salmonids, Pacific eulachon, green sturgeon, white sturgeon, and
897 Pacific lamprey occur within the MSP Study Area (Table 2.1-2). American shad is a non-native
898 anadromous species that was introduced to the West Coast in the late 1800s and has thrived. Eight of
899 the twelve anadromous species in the MSP Study Area are listed under the federal Endangered Species
900 Act (ESA) or Washington State species of concern lists (Washington State Department of Fish and
901 Wildlife, 2015d).

902 Salmon in particular are a cultural icon to Washington residents, both tribal and non-tribal. After
903 leaving freshwater, salmon rely on estuarine (Sandell et al., 2013), nearshore, and pelagic waters and
904 prey on a variety of animals including euphausiids, amphipods, larval decapods, and forage fish
905 (Andrews et al., 2015, 2013).

906 Salmon have been and continue to be impacted by numerous pressures: fishing, loss of freshwater
907 habitat, hydropower dams, and poor ocean conditions, which collectively can include changes in
908 chemical or physical conditions, with accompanying loss of food supply (NOAA Fisheries, 2014c).
909 Salmonids are considered for listing and recovery under the ESA below the species level as Evolutionary
910 Significant Units (ESUs). The MSP Study Area provides habitats for several listed (e.g. Puget Sound
911 Chinook) and non-listed (e.g. Washington Coast Chinook) ESUs. Much of the critical habitat designated
912 for each of the listed salmon ESU's lies outside of the Study Area. Lake Ozette sockeye salmon and some
913 Columbia River salmon ESUs, and critical habitats are directly adjacent to the Study Area. Essential Fish
914 Habitat has been designated within the Study Area for Chinook, Coho, and Pink salmon under the
915 Magnuson-Stevens Act (Map 7). (Pacific Fishery Management Council, 2014b).

916 Ocean conditions have been used to forecast returns of Chinook and Coho salmon, including the
917 Pacific Decadal Oscillation, sea surface temperature anomalies, coastal upwelling, spring transition date,
918 and copepod biomass anomalies (Andrews et al., 2015; Burke et al., 2013; Peterson et al., 2015). Salmon
919 recovery management measures in Washington include hatchery programs, habitat improvement, and
920 fisheries management (Washington State Department of Fish and Wildlife, 2008).

921 Green sturgeon are believed to spend the majority of their lives in nearshore oceanic waters, bays,
922 and estuaries. The southern distinct population (SDP) of green spawns only in the Sacramento River, CA
923 and is listed under the Endangered Species Act as threatened (Adams et al., 2007). Adult sturgeon from
924 the SDP enter Willapa Bay during the late spring and early summer months and feed on burrowing
925 shrimp (*Neotrypaea californiensis*) (Dumbauld, Holden, & Langness, 2008; Moser & Lindley, 2007). It is
926 conjectured that they also feed on mollusks, and amphipods, and even small fish (NOAA Fisheries,
927 2014b). Green sturgeon ESA critical habitat is within much of the Study Area occurring along the entire
928 coast, including Grays Harbor and Willapa Bay (Map 7) (NOAA Fisheries, 2014b).

929 Pacific eulachon (aka "candlefish" or "smelt") are small anadromous fish that typically spend three
930 to five years in saltwater before returning to freshwater to spawn. While in the ocean, eulachon typically
931 spend their time in nearshore waters and up to 1,000 feet (300 meters). Eulachon populations declined
932 dramatically in the past 20 years, and the fish was listed as Threatened under the ESA in 2008 (NOAA
933 Fisheries, 2014a). The MSP Study Area is important habitat for eulachon, and eulachon ESA critical
934 habitat is directly adjacent to the Study Area (Map 7). Eulachon are an important cultural fishery for
935 many tribes in Washington.

936 Table 2.1-2. Anadromous fish species occurring within the MSP Study Area. Source: (Washington State Department of Fish
937 and Wildlife, 2015d).¹¹

Common name	Species name	Federal status	State status
Chinook salmon	<i>Oncorhynchus tshawytscha</i>	Threatened/Endangered	State Candidate
Chum salmon	<i>Oncorhynchus keta</i>	Threatened	State Candidate
Coho salmon	<i>Oncorhynchus kisutch</i>	Threatened	none
Pink salmon	<i>Oncorhynchus gorbuscha</i>	none	none
Sockeye salmon	<i>Oncorhynchus nerka</i>	Threatened/Endangered	State Candidate
Steelhead	<i>Oncorhynchus mykiss</i>	Threatened	State Candidate/none
Coastal cutthroat trout	<i>Oncorhynchus clarki</i>	none	none
Pacific eulachon	<i>Thaleichthys pacificus</i>	Threatened	State Candidate
Green sturgeon	<i>Acipenser medirostris</i>	Threatened	none
White sturgeon	<i>Acipenser transmontanus</i>	none	none
Pacific lamprey	<i>Entosphenus tridentatus</i>	Species of concern	State monitored
American shad	<i>Alosa sapidissima</i>	none	none

938 **Marine mammals**

939 At least 29 species of marine mammals inhabit or transit through the MSP Study Area at some point
940 in their lives. Species include baleen and toothed whales, seals and sea lions, and sea otters. Many
941 marine mammals are top predators within the ecosystem, while some large baleen whales are primarily
942 filter or bottom feeders (e.g. Humpback and Gray whales). Diets vary from krill, invertebrates, forage
943 fish, salmon, other fishes, and even other marine mammals. About 20,000 Gray whales migrate through
944 the Study Area, with the abundance of Gray whales at any time influenced by environmental variability
945 within the Arctic feeding grounds and the timing of migration (Olympic Coast National Marine
946 Sanctuary, 2011). In southern Washington, a visual survey of marine mammals was conducted over eight
947 trips between July 2008 and June 2009 in the area between Grays Harbor, the Quinault Canyon, and
948 Grays Canyon. This survey found the Harbor porpoise to be the most commonly sighted marine
949 mammals in nearshore waters, and Dall’s porpoise was the mostly commonly sighted marine mammal in

¹¹ Salmon are listed and managed as ESU’s, some species with several ESU’s. Therefore, at the species level, there may be multiple and differing ESA listings.

950 offshore waters (Oleson & Hildebrand, 2012). A visual survey in June 2008 within the OCNMS found
951 that humpback whales were the most commonly sighted cetacean (Oleson & Hildebrand, 2012).

952 Orcas (aka killer whales) are also found in the MSP Study Area.¹² Orcas are divided into four
953 populations based on ecology, genetics, diet, behavior, and social interactions. Three populations are
954 described as “resident” orcas: northern, southern, and offshore. Resident orcas are fish-eating, with
955 northern and southern populations mainly feeding on salmonids and occasionally bottom fish. Transient
956 orcas in Washington waters are mammal-eating, preying mainly upon harbor seals. All four populations
957 of orcas occur within the MSP Study Area, although their distribution, abundance, and temporal use of
958 the area varies by population. The distribution of the populations is best known during summer when
959 the most monitoring has occurred. During this time, the northern resident population has a core range
960 in inshore British Columbia, the southern residents population is centered in the inshore waters near the
961 border of Washington and British Columbia, and the offshore population is generally found on the
962 continental shelf from southern California to the Aleutian Islands (Lance, Calambokidis, Baird, & Steiger,
963 2011). Population sizes are well established for northern and southern resident orcas, with less
964 precision around population estimates of offshore resident and transient orcas. Southern resident orcas
965 are listed as Endangered under the ESA, and all killer whales are listed as Endangered in the State of
966 Washington (Table 2.1-3) (Lance et al., 2011).

967 The National Centers for Coastal Ocean Science (NCCOS) developed relative density models for four
968 cetaceans to inform the likely distributions of these animals for the MSP. Species were chosen by
969 Ecology and WDFW because they were species of management concern. The maps were created by
970 using associative models linking at-sea mammal observations with environmental covariates. Maps were
971 produced for Dall's porpoise (*Phocoenoides dalli*), harbor porpoise (*Phocoena phocoena*), gray whale
972 (*Eschrichtius robustus*), and humpback whale (*Megaptera novaeangliae*). These maps do not include
973 cetacean use of the estuaries. Cetaceans, especially gray whales and harbor porpoises, are known to use
974 the estuaries. More details on the NCCOS modeling effort and available maps are in Section 3: Spatial
975 Analyses.

976 DNR worked to identify ecologically important areas (EIAs). EIAs are defined as areas where
977 animals, especially those of interest to fisheries and wildlife management, are shown through existing
978 data to use the MSP Study Area the most. More information about the EIA analysis process and
979 additional maps are available in Section 3: Spatial Analyses. An EIA hotspot map was created for the
980 marine mammal subsector (Map 8) and for humpback whales (Map 9).

981 Harbor and elephant seals, and California and Steller sea lions aggregate and haul out on rocky
982 islands, coastal areas, and estuaries of the MSP Study Area (Map 10). Harbor seals and California sea
983 lions use the coastal estuaries frequently. Northern fur seals also transit through and forage within the
984 MSP Study Area (Lance et al., 2011). Similar to cetaceans, NCCOS developed relative density models for
985 the harbor seal (*Phoca vitulina*) and Steller sea lion (*Eumetopias jubatus*) to inform the likely
986 distributions of these animals in the MSP Study Area (excluding their use of the estuaries) (See Part 3).

987 A population of sea otters also occurs in the Study Area, favoring rocky habitats and kelp forests
988 along the Olympic Peninsula coast from Destruction Island northward to Tatoosh Island (Map 10).
989 Extirpated by fur trade hunters in 1911, sea otters were reintroduced to the outer coast in 1969 and
990 1970 (Lance et al., 2011). The population in 2015 was approximately 1,394 animals (Jeffries, Lynch, &
991 Thomas, 2016). Population growth in the state has been slower than anticipated in the past few years,

¹² Orcas are found in all oceans and seas of the world, with their density being greatest in colder waters within 800 km of major continents. Off the west coast of North America they are found in relatively high density in near-shore waters from Alaska to central California (Lance, Calambokidis, Baird, & Steiger, 2011).

992 possibly because the sea otter population has reached carrying capacity within its current range, and has
 993 not yet expanded to other anticipated areas (Lance, Richardson, & Allen, 2004). Sea otters are a
 994 keystone species that help maintain kelp forest habitat structure by predateding on sea urchins (Andrews
 995 et al., 2013; Olympic Coast National Marine Sanctuary, 2011).

996 Ten marine mammal species listed under the federal ESA or Washington species of concern list
 997 occur within the MSP Study Area (Table 2.1-3). Stressors for marine mammals include collisions with and
 998 other boat interactions (e.g. noise), entanglement in fishing gear and marine debris, contaminants, oil
 999 spills, alterations in habitat and prey, and oceanographic conditions (Andrews et al., 2013; Olympic
 1000 Coast National Marine Sanctuary, 2011). All marine mammals, whether listed under the ESA or state
 1001 species of concern, are currently protected by the Marine Mammal Protection Act (16.U.S.C. §§1631 et
 1002 seq).¹³

1003 **Table 2.1-3. Marine mammals on the federal or state species of concern lists within the MSP Study Area. Source (Washington**
 1004 **State Department of Fish and Wildlife, 2015d).**

Common name	Species name	Federal status	State status
Blue whale	<i>Balaenoptera musculus</i>	Endangered	State Endangered
Fin whale	<i>Balaenoptera physalus</i>	Endangered	State Endangered
Gray whale	<i>Eschrichtius robustus</i>	None	State Sensitive
Harbor porpoise	<i>Phocoena</i>	None	State Candidate
Humpback whale	<i>Megaptera novaeangliae</i>	Endangered	Endangered
Killer whale	<i>Orcinus orca</i>	Endangered ¹⁴	Endangered ¹⁵
North Pacific right whale	<i>Eubalaena japonica</i>	Endangered	Endangered
Sea otter	<i>Enhydra lutris</i>	Species of Concern	Endangered
Sei whale	<i>Balaenoptera borealis</i>	Endangered	Endangered
Sperm whale	<i>Physeter macrocephalus</i>	Endangered	Endangered
Steller sea lion	<i>Eumetopias jubatus</i>	Species of Concern	None

1005

¹³ There are some exceptions to the Marine Mammal Protection Act, including small takes of incidental harvest such as harvest by Alaskan natives.

¹⁴ This listing is for the Southern Resident Orca population, the other three populations (northern, offshore, and transient) are not listed under the ESA.

¹⁵ The State of Washington lists all Killer Whales in the state as Endangered.

1006 **Birds**

1007 Numerous bird species use and transit through the MSP Study Area. Many species of birds, including
1008 seabirds, raptors, marshbirds, waterbirds, and shorebirds, forage and nest in sea stacks, rocky offshore
1009 islands, cliffs, bluffs, dunes, marshlands, estuaries, tidal flats, coastal beaches, and old-growth forests.
1010 Seabird and shorebird populations occur throughout the outer coast of Washington, with the majority
1011 located along the west coast of the Olympic Peninsula (Map 11). Washington is also along the Pacific
1012 Flyway, a migratory pathway for millions of waterbirds, shorebirds, and raptors. Some seabird species
1013 migrate thousands of miles to forage in MSP offshore waters, such as albatross and shearwaters
1014 (Kaplan, Beegle-Krause, French McCay, Copping, & Geerlofs, 2010; Olympic Coast National Marine
1015 Sanctuary, 2011). Estuaries are also crucial habitat for several resident and migratory bird species. Five
1016 National Wildlife Refuges have been established in or directly adjacent to the MSP Study Area (Map 1)
1017 to protect land-based resources where large concentrations of birds occur and where seabirds nest.

1018 DNR developed EIA maps for some of bird species, additional information and maps can be found in
1019 Section 3: Spatial Analyses.

1020 **Marshbirds**

1021 The term marshbird broadly encompasses birds that feed, nest, or otherwise utilize tidal or
1022 freshwater marshes (includes herons, egrets, rails, and passerines). They do not swim, rather forage on
1023 sandy beaches, marshes, and other coastal areas. Examples of marshbirds in Washington include the
1024 great blue heron (*Ardea Herodias*), marsh wren (*Cistothorus palustris*), great egret (*Ardea alba*), and
1025 American bittern (*Botaurus lentiginosus*). Marshbirds are associated with estuaries such as Grays Harbor
1026 and Willapa Bay. Marshbirds are sensitive to human disturbance and nesting sites can be abandoned
1027 due to land development, wetland loss, logging, and human intrusions (Kaplan et al., 2010; United
1028 States Department of the Navy, 2015).

1029 **Ducks and geese**

1030 Ducks and geese (Family Anatidae) are generally present along protected shores, bays, and
1031 estuaries. Large numbers occur during the winter, and the birds migrate north or east to summer
1032 breeding grounds. Most species of ducks and geese feed by diving, dabbling, or foraging from the
1033 surface and have diverse diets ranging from mollusks and fish eggs to vegetation. Species include black
1034 brant (*Branta bernicla*), greater scaup (*Aythya marila*), green-winged teal (*Anas crecca*), tundra swan
1035 (*Cygnus columbianus*), bufflehead (*Bucephala albeola*), and others. Willapa Bay is an important stopover
1036 for wintering black brant. The Columbia River estuary provides habitat for swans and wintering ducks.
1037 Harlequin ducks (*Histrionicus histrionicus*) winter along the Pacific Coast and forage for crustaceans,
1038 mollusks, and aquatic insects within rocky substrate and kelp beds (Kaplan et al., 2010; United States
1039 Department of the Navy, 2015).

1040 **Shorebirds**

1041 Shorebirds include species such as sandpipers, plovers, oystercatchers, avocets, and stilts.
1042 Shorebirds can migrate long distances (up to thousands of miles) between wintering and breeding
1043 grounds. Coastal estuaries and wetlands are used during the migratory stopovers to rest, feed, and
1044 replenish their fat reserves needed for the continuing migration primarily to the high arctic where they
1045 nest. Shorebirds can congregate in high concentrations, sometime numbering in the millions. Shorebirds
1046 mainly feed on invertebrates present in shallow waters and associated wetlands, beaches, mudflats, and
1047 other tidelands. Grays Harbor and Willapa Bay represent important stopover sites for many species,
1048 such as dunlin (*Calidris alpina*). At the same time, there are a couple of species that breed locally. The

1049 Western snowy plover (*Charadrius alexandrinus nivosus*) breeds on sandy beaches adjacent to the MSP
1050 Study Area in Grays Harbor and Pacific Counties. Black oystercatchers (*Haematopus bachmani*) also
1051 breed adjacent to and within the MSP Study Area along the rocky coast and offshore rocks and islands.
1052 Coastal development and human activities have degraded shorebird stopover and colony habitat
1053 (Kaplan et al., 2010; Olympic Coast National Marine Sanctuary, 2011; United States Department of the
1054 Navy, 2015).

1055 *Seabirds*

1056 Several species of seabirds (albatrosses, petrels, shearwaters, and alcids) occur within the MSP Study
1057 Area. Examples include murrelets, puffins, albatrosses, fulmars, shearwaters, gulls, murrelets, cormorants,
1058 terns, and others. Seabird use of the area varies seasonally and influenced by physical and biological
1059 processes. Some species travel vast distances across the globe to forage in MSP waters during summer,
1060 such as the sooty shearwater (*Puffinus griseus*), which breeds in New Zealand. Several species of
1061 seabirds breed on coastal islands within the Study Area, such as Tatoosh and Destruction Islands. Some
1062 seabirds forage far offshore over the continental shelf and oceanic waters, while others, such as the
1063 common murre and marbled murrelet forage in fairly nearshore environments. Diets vary by species,
1064 but mainly consist of fishes and invertebrates. Seabird abundance and reproductive success is
1065 influenced by short-term and long-term oceanographic conditions, oil spills, disturbance of breeding
1066 colonies, fisheries bycatch, and predators such as raptors (Kaplan et al., 2010; Olympic Coast National
1067 Marine Sanctuary, 2011; United States Department of the Navy, 2015).

1068 Unlike most seabirds that nest on offshore islands and rocks, marbled murrelets nest in old growth
1069 forests, up to 55 miles inland in Washington. Marbled murrelets are listed as threatened on the federal
1070 and state species lists and are subject to many pressures. Reduction of appropriate nesting habitat is
1071 one of the primary pressures for these birds. Marbled murrelets are monitored annually in Washington
1072 (Washington State Department of Fish and Wildlife, 2013).

1073 Seabirds are often considered indicators for ocean conditions because they forage across multiple
1074 habitats and trophic levels. Because of their behavior of life histories, seabirds can be difficult to
1075 monitor. Some species are monitored as indicators for other seabird populations. The National Centers
1076 for Coastal Ocean Science (NCCOS) developed models to predict relative density (using environmental
1077 covariates) from survey data to inform the MSP. Species were chosen to represent different habitat uses
1078 that ranged from nearshore species like the marbled murrelet to pelagic species like the northern fulmar
1079 and black-footed albatross. Species that are locally rare or declining were also included (e.g., pink-footed
1080 shearwater and tufted puffin). These maps do not include seabird use of the estuaries because surveys
1081 largely did not occur in the estuaries. Maps were produced for marbled murrelet (*Brachyramphus*
1082 *marmoratus*), tufted puffin (*Fratercula cirrhata*), common murre (*Uria aalge*), black-footed albatross
1083 (*Phoebastria nigripes*), northern fulmar (*Fulmarus glacialis*), pink-footed shearwater (*Puffinus*
1084 *creatorpus*), and sooty shearwater (*Puffinus griseus*) (Menza, Battista, & Dorfman, 2013). See Section 3:
1085 Spatial Analyses for more information and maps.

1086 The EIA hotspot map for the Seabirds subsector is Map 12.

1087 *Raptors*

1088 A few species of raptors forage within and adjacent to the MSP Study Area, including bald eagles
1089 (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*). Bald eagles and peregrine falcons
1090 nest along the outer coast; the eagles prey upon seabirds, waterfowl, and salmon, and the falcons prey
1091 upon shorebirds, seabirds, ducks, and other birds (Washington State Department of Fish and Wildlife,

1092 2013). These birds also prey upon common murre and other surface nesting birds during the breeding
 1093 season (Olympic Coast National Marine Sanctuary, 2011).

1094 *Birds with Special Protection*

1095 Several species of birds occurring adjacent to and within the Study Area have federal or state special
 1096 protection (Table 2.1-4). Seabirds, raptors, shorebirds, waterbirds, marshbirds, and terrestrial birds are
 1097 included in this list. A terrestrial bird, the streaked horned lark, nests and forages on sandy beaches
 1098 along the southern outer coast and islands of the lower Columbia River (See Section 3: Spatial Analyses
 1099 for the EIA map) (Washington State Department of Fish and Wildlife, 2013). Common reasons for bird
 1100 population declines include oceanographic factors (e.g. El Niño), which can affect their food source,
 1101 habitat degradation, pollution and oil spills, and predation (Kaplan et al., 2010; Olympic Coast National
 1102 Marine Sanctuary, 2011). National Wildlife Refuges, Olympic Coast National Marine Sanctuary, WDFW,
 1103 and WDNR implement management measures to help protect and recover populations of listed species
 1104 in Washington.

1105 **Table 2.1-4. Birds on the federal or state species of concern lists occurring within or directly adjacent to the MSP Study Area.**
 1106 **Source: (Washington State Department of Fish and Wildlife, 2015d)**

Common name	Species name	Federal status	State status
Bald eagle	<i>Haliaeetus leucocephalus</i>	Species of Concern	State Sensitive
Brand's cormorant	<i>Phalacrocorax penicillatus</i>	None	State Candidate
Brown pelican	<i>Pelecanus occidentalis</i>	Species of Concern	State Endangered
Cassin's auklet	<i>Ptychoramphus aleuticus</i>	None	State Candidate
Clark's grebe	<i>Aechmophorus clarkii</i>	None	State Candidate
Common loon	<i>Gavia immer</i>	None	State Sensitive
Common murre	<i>Uria aalge</i>	None	State Candidate
Marbled murrelet	<i>Brachyramphus marmoratus</i>	Threatened	State Threatened
Peregrine falcon	<i>Falco peregrinus</i>	Species of Concern	State Sensitive
Purple martin	<i>Progne subis</i>	None	State Candidate
Sandhill crane	<i>Grus canadensis</i>	None	State Endangered
Short-tailed albatross	<i>Phoebastria albatros</i>	Endangered	State Candidate
Snowy plover	<i>Charadrius nivosus</i>	Threatened	State Endangered

Streaked horned lark	<i>Eremophila alpestris strigata</i>	Threatened	State Endangered
Tufted puffin	<i>Fratercula cirrhata</i>	None	State Endangered
Western grebe	<i>Aechmophorus occidentalis</i>	None	State Candidate

1107

1108 **Sea turtles**

1109 Three species of sea turtles occur within the MSP Study Area: leatherback, loggerhead, and green
 1110 sea turtles. All three of these turtles are listed under the federal ESA and Washington State species of
 1111 concern (Table 2.1-5). These sea turtles feed and migrate through MSP waters; no nesting sites occur
 1112 within Washington State (they nest in tropical regions). The leatherback sea turtle is the only sea turtle
 1113 regularly found in Washington waters. Leatherbacks feed primarily on jellyfish, which are found in the
 1114 upper part of the water column. Leatherbacks are found in MSP waters during the summer and fall,
 1115 especially in the Columbia River Plume and in other areas where the oceanographic conditions tend to
 1116 aggregate jellyfish (Washington State Department of Fish and Wildlife, 2013).

1117 Designated critical habitat for leatherback sea turtles occurs throughout the MSP Study Area. A
 1118 primary stressor within the Study Area is pollution, particularly plastic bags which leatherbacks mistake
 1119 for jellyfish and ingest. Entanglement in fishing gear can also be a stressor, but the drift gillnet and
 1120 pelagic longline fishing gears that primarily affect leatherbacks are no longer permitted in the Study
 1121 Area and therefore the risk of entanglement is now quite low (Washington State Department of Fish and
 1122 Wildlife, 2013). Sightings of loggerhead and green sea turtles are rarely recorded off the Washington
 1123 coast. Only four strandings of green sea turtles and no strandings of loggerheads were recorded
 1124 between 2002 and 2012 (Washington State Department of Fish and Wildlife, 2013).

1125

1126 **Table 2.1-5. Sea turtles within the MSP Study Area and their federal and state species of concern status. Source: (Washington**
 1127 **State Department of Fish and Wildlife, 2015d).**

Common name	Species name	Federal status	State status
Green sea turtle	<i>Chelonia mydas</i>	Threatened	State Threatened
Leatherback sea turtle	<i>Dermochelys coriacea</i>	Endangered	State Endangered
Loggerhead sea turtle	<i>Caretta caretta</i>	Endangered	State Threatened

1128 **Stressors**

1129 The MSP Study Area is subject to many stressors from human activities (aka anthropogenic
 1130 stressors). These stressors may harm wildlife, alter water quality, and degrade habitat. This section
 1131 presents summaries of some of the key anthropogenic stressors in the MSP Study Area: invasive species,
 1132 oil spills, marine debris, vessel discharge, fishing pressures including habitat modification related to
 1133 bottom gear, shoreline development, human disturbance and trampling, ocean noise, and vessel

1134 strikes.¹⁶ While this is not meant to be an exhaustive discussion of various human stressors to ocean
1135 ecology, these topics are presented here to acknowledge the major identified impacts that
1136 Washington's ocean environment currently faces.

1137 *Invasive species*

1138 Invasive species are non-native organisms that harm or pose a risk of harming the state's
1139 environmental, economic, or human resources.¹⁷ Invasive species including diseases, parasites, plants,
1140 invertebrates, and vertebrates occur along the Washington coast in a variety of habitats. Invasive
1141 species can be intentionally or unintentionally introduced through a variety of ways, including ballast
1142 water discharge, use of organisms for packing material, fouling on aquaculture shipments, aquarium
1143 trade with subsequent release into the environment, recreational boating, range expansion due to
1144 climate change, and floating debris (e.g. biofouling on debris arriving from 2011 Japanese tsunami)
1145 (Andrews et al., 2015, 2013; Office of National Marine Sanctuaries, 2008; Skewgar & Pearson, 2011).

1146 Invasive species can have a profound impact on the habitat, trophic interactions, and ecology of an
1147 area, which can also lead to significant social and economic burdens, particularly for recovery of species
1148 such as salmon, and fishery and aquaculture industries (Office of National Marine Sanctuaries, 2008).
1149 Statewide, there are 94 known marine invasive species recorded, 59 of which occur on Washington's
1150 Pacific coast (Davidson, Zabin, Ashton, & Ruiz, 2014). The MSP Study Area has been subject to impacts
1151 from invasive species, with some of the more well-known invasions occurring in the coastal estuaries.
1152 Examples include Atlantic cordgrass (*Spartina alterniflora* and *S. densiflora*), Japanese eelgrass (*Zostera*
1153 *japonica*), and European green crab (*Carcinus maenus*). The brown alga (*Sargassum muticum*) is an
1154 example of an invasive species that has been found in rocky shores and mixed substrate sites on the
1155 Pacific Ocean coast, yet little is currently known on its impacts to native species or other algae in WA
1156 (Skewgar & Pearson, 2011).

1157 The prevention and control of invasive species is a complex task and depends upon the vector as
1158 well as effective treatments for each species. Resource managers consider prevention to be the best and
1159 most cost-effective way to manage invasive species (Cusack, Harte, & Chan, 2009). Recreational vessel
1160 cleaning, ballast water management, vessel inspections, biofouling management, and prohibiting the
1161 release of non-native species are some of the primary ways Washington attempts to prevent the
1162 introduction and spread of aquatic invasive species (Washington State Department of Fish and Wildlife,
1163 2015a).

1164 In the cases of established, invasive populations, Washington may take direct action to control
1165 populations and prevent further spread of species that are significant threats to native habitat and/or
1166 natural resource industries. The types of management applied in these situations, ranging from physical
1167 removal to application of herbicide and pesticide chemicals, depends on multiple factors including the
1168 species, extent of establishment, degree of containment possible, and urgency of the threat to
1169 Washington's environmental, economic, or human resources. For example, management of invasive
1170 species on Japanese tsunami marine debris was primarily by physical removal (Washington State
1171 Department of Fish and Wildlife, 2015c); whereas in Willapa Bay and Grays Harbor, herbicides were
1172 ultimately the best management tool used to control invasive Atlantic cordgrass (Washington State
1173 Department of Agriculture, 2015).

¹⁶ Climate change is discussed in Part 2.11 of the MSP

¹⁷ Management of native species which become harmful is handled by the State differently, and are not discussed here.

1174 Multiple agencies are involved with decisions related to invasive species control. The Washington
1175 Invasive Species Council coordinates among state agencies to support a comprehensive strategy for
1176 making effective investments to protect Washington from invasive species (Washington Invasive Species
1177 Council, 2014). Washington also has specific programs related to the prevention and control of invasive
1178 species.¹⁸ These programs focus on various aspects of outreach, education, reporting, prevention,
1179 enforcement, and treatment related to invasive species.

1180 Invasive species will continue to be a stressor into the future with a significant risk of impact within
1181 the MSP Study Area and Washington State. It is possible that potential new uses, such as marine
1182 renewable energy, offshore aquaculture, or other activities could become vectors for invasive species.

1183 *Oil spills*

1184 Oil is routinely transported through the MSP Study Area on many types of vessels as fuel, lubricating
1185 oil, hydraulic fluid, and as a byproduct from fish processing. Crude oil and refined products are also
1186 carried as cargo on tankers and oil barges. Vessels of all types transit through the study area, including
1187 vessels entering and exiting the Strait of Juan de Fuca, Grays Harbor, and the Columbia River. Larger
1188 vessels, including tankers and oil barges typically travel 25 to 50 nautical miles off the coast (City of
1189 Hoquiam & Washington State Department of Ecology, 2015a, 2015b; Washington State Department of
1190 Ecology et al., 2015).

1191 Oil spills in the marine environment can negatively affect water quality and directly injure plants,
1192 animals, and habitat. An oil spill may also negatively impact human activities and interests such as
1193 recreation, cultural resources, tribal resources, human health, fisheries, and aquaculture. The extent of
1194 impact to these resources depends on the location and volume of the spill and type of oil; a large oil spill
1195 would likely have a significant negative impact on many or all of the above listed resources (City of
1196 Hoquiam & Washington State Department of Ecology, 2015a, 2015b). While rare, large oil spills have
1197 occurred on the Washington Coast, including the 1988 *Nestucca* barge spill (231,000 gallons of fuel oil)
1198 off Grays Harbor and the 1991 *Tenyo Maru* fishing vessel spill (100,000 gallons of diesel fuel) off the
1199 north end of the Pacific Coast (Office of National Marine Sanctuaries, 2008). Smaller spills occur more
1200 frequently than large spills, and sources for spills reported off the coast between 2011 and 2015 include
1201 fishing vessels, recreational vessels, and a tank vessel (Washington State Department of Ecology, 2015).

1202 The Washington Department of Ecology has a Spills Program that seeks to protect Washington's
1203 environment, public health and safety through comprehensive spill prevention, preparedness, and
1204 response. When a spill does occur, the program responds in a rapid, aggressive, and well-coordinated
1205 manner. Day-to-day program work includes prevention inspections (vessels, oil transfers, and facilities)
1206 contingency planning, geographic response plan development, and worst case drills and exercises with
1207 industry. Response drills and exercises ensures the major parties, including industry, are able to respond
1208 in a unified manner through an Incident Command System, as required by industry contingency plans
1209 and the State Area Plan¹⁹. Recent legislation has directed the Spills program to look at the risks imposed

¹⁸ Some examples include including the Washington State Aquatic Invasive Species Prevention and Enforcement Program co-administered by WDFW and Washington State Patrol, the Washington State Noxious Weed Control Board that advises the WSDA on noxious weed control, the Washington Department of Ecology's Aquatic Weeds Program, and others.

¹⁹ The state has adopted the Northwest Area Contingency Plan (NWACP) as the state's Oil and Hazardous Substance Spill Prevention and Response Plan, which applies to the activities of all state and local agencies involved in managing oil and hazardous substance spills. Ecology is the state's lead agency to oversee prevention, abatement, response, containment and cleanup efforts with regard to an oil or hazardous substance spill to waters of the state. Ecology coordinates with federal, state, and tribal members of the Region 10 Regional Response Team

1210 by the changing energy transportation picture and develop countering measures, geographic response
1211 plan expansion, improvements in response equipment caches, and rail contingency planning.

1212 Changes in oil supply in the U.S. and Canada are likely to influence the movement of crude oil in
1213 Washington State to refineries in the Puget Sound area and also in Vancouver, British Columbia. Alaskan
1214 crude oil, transported by tankers and pipelines, has been decreasing and is expected to continue to
1215 decline. However, increased supply of crude oil from the Bakken formation in North Dakota has
1216 substantially increased the amount of crude oil entering the state by train and has stimulated project
1217 proposals for updating existing refineries and for crude oil storage and transfer facilities in Grays Harbor
1218 and along the Columbia River (Washington State Department of Ecology et al., 2015). Heavier tar sands
1219 crude oil from Canada may also be transported in Washington by existing and proposed pipeline
1220 facilities.

1221 There are currently two proposed projects in Grays Harbor to increase crude-by-rail capacity by
1222 adding new offload stations and storage tanks. If these proposed projects were to move forward, there
1223 would be an increased risk of oil spills in Grays Harbor due to the increased volume of oil transported
1224 and the increased frequency of vessel traffic. A large oil spill in Grays Harbor could also affect the outer
1225 coast of Washington. Through Environmental Impacts Statements (EISs) for the proposals, the Contanda
1226 (formerly Westway Terminal Company) Terminal expansion and the Renewable Energy Group (formerly
1227 Imperium Renewables Inc.) Terminal expansion, the City of Hoquiam and the Washington Department
1228 of Ecology have identified potential significant impacts to the environment and have identified
1229 mitigation measures to avoid and minimize some impacts. Ecology and the City of Hoquiam have also
1230 identified that while the likelihood of a large spill is low, it would likely result in unavoidable and
1231 significant adverse environmental impacts and that no mitigation measures would completely eliminate
1232 the possibility of a large spill or the adverse consequences of such an incident (City of Hoquiam &
1233 Washington State Department of Ecology, 2015a, 2015b; Washington State Department of Ecology et
1234 al., 2015).

1235 In addition, projects have been proposed along the Washington side of the Columbia River that
1236 would increase crude-by-rail capacity, build new storage tanks for the storage and marine transport of
1237 oil and build a new refinery that could handle crude oil. Similar to Grays Harbor, if these proposed
1238 projects were to move forward, there would be an increased risk of oil spills in the Columbia River due
1239 to the increased volume of oil transported, risk due to transfer of oil between rail cars, storage facilities,
1240 and/or vessels, and the increased frequency of vessel traffic.

1241 Olympic Coast National Marine Sanctuary (OCNMS) recognizes the potential accidental release of oil
1242 into the marine environment as the greatest threat to sanctuary resources and qualities. Prevention of
1243 spills is one of OCNMS' highest priorities, along with preparation and response to spills. OCNMS initially
1244 promoted and currently monitors compliance with the Area to be Avoided.²⁰ The ATBA is a voluntary
1245 measure that routes large vessels offshore and decreases risk of vessel groundings and spills reaching
1246 the shore with greater than 95% compliance (Olympic Coast National Marine Sanctuary, 2011). Oil spill
1247 response and prevention is also a key concern for tribes and several federal and state agencies.

and the Northwest Area Committee to prevent and respond to oil and hazardous substance spills. For more information on the Region 10 Regional Response Team and NWACP, please go to <http://www.rrt10nwac.com/Default.aspx>

²⁰ The Area to be Avoided is a boundary where all vessels above 400 gross tons and all ships and barges carrying petroleum and hazardous materials in bulk as cargo or cargo residue are advised to maintain a 25 mile buffer from the coast. The ATBA compliance rate has consistently been very high and was estimated to be over 97% in 2014 (Olympic Coast National Marine Sanctuary, 2015).

1248 Representatives from these governments and agencies participated in the Region 10 Regional Response
1249 team and Northwest Area Committee activities focused on oil spill prevention, planning, and response.

1250 *Marine debris*

1251 Marine debris is known to have both ecological and economic impacts worldwide, and is a notable
1252 stressor in the MSP Study Area. One of the most visible impacts of marine debris is wildlife
1253 entanglement in debris, which can lead to injury, illness, and death. Ingestion of marine debris is also a
1254 harmful impact to wildlife. Sea turtles, seabirds, and marine mammals have been known to ingest
1255 marine debris, often mistaking debris items for food. Economic impacts include negative impacts on
1256 tourism, cost of cleanup, degradation of beaches and habitat, vessel damage, and navigation hazards.
1257 Marine debris can also be vectors for non-native species, which can have both ecological and economic
1258 impacts (NOAA Office of Response and Restoration, 2015).

1259 Marine debris is present along the entire Washington coast of the MSP Study Area and comes from
1260 a variety of sources. Human trash from direct beach recreation activities, upland sources, as well as
1261 trash generated from locations around the Pacific Rim is found on Washington's beaches. Debris from
1262 fishing, aquaculture, and shipping activities is also found on the shore. Plastics make up approximately
1263 92% of the debris on outer coast beaches in Washington. Debris from the Japanese tsunami has also
1264 been arriving on Washington's ocean beaches since the event in 2011. Tsunami debris has included a
1265 variety of objects such as construction materials, boats, a large dock, and some hazardous materials,
1266 such as propane tanks. Non-native species have often been found attached to this debris and required
1267 removal. Tsunami debris has been intermittent and widely scattered, sometimes in significant
1268 quantities, but by 2017 contributes very little to shoreline debris loading. Efforts have been coordinated
1269 by NOAA, the State, and others to safely remove tsunami debris. NOAA continues to work with other
1270 federal, state, and local partners to monitor and remove tsunami debris (Barnea, 2015; NOAA Office of
1271 Response and Restoration, 2015).

1272 Several marine debris volunteer cleanup events occur yearly on beaches in the Study Area.
1273 Currently, the majority of these cleanups are coordinated through the Washington CoastSavers with
1274 many participating nonprofit, business, and government organizations. While CoastSavers has been
1275 coordinating cleanup events since 2007, community groups have been holding cleanup events on the
1276 Washington coast since as early as 1971. Significant annual marine debris collection events include the
1277 Washington Coast Cleanup held in April near Earth Day, the International Coast Cleanup held in late
1278 summer, and the July 5th cleanup held on several southern beaches to clean up trash and fireworks from
1279 4th of July celebrations. The amount of marine debris collected from these events can be quite large.
1280 CoastSavers estimates over 320 tons of marine debris have been collected during the April Washington
1281 Coast Cleanup events from 2000-2012, ranging from 15 to 40 tons collected per year. The July 4th, 2015
1282 cleanup from Moclips to Long Beach collected 115 tons of debris (Washington CoastSavers, 2015).

1283 Efforts are also underway to remove derelict fishing gear from Washington's ocean. Derelict
1284 (abandoned or lost) gear can continue to catch fish and harm wildlife (aka ghost fishing). Tribes, the
1285 State (particularly DNR's Restoration Program and Derelict Vessel Program), and The Nature
1286 Conservancy are working to remove lost crab pots off the Washington coast, which benefits the crab,
1287 the fishermen, and the environment (Miller, 2015).

1288 While cleanup remains an important part of addressing marine debris as a stressor for Washington's
1289 beaches and waters, programs also focus on prevention education and outreach to reduce the amount
1290 of marine debris on the beach and in the ocean. Potential new ocean uses may generate new sources of
1291 marine debris, unless their gear and waste activities are effectively managed to prevent entry into the
1292 environment.

1293 *Vessel discharges*

1294 All types of vessels generate wastewater. The type and amount of wastewater generated depends
1295 on the vessel, passenger load, vessel size, function, and condition. Examples of wastewater include
1296 sewage, graywater (e.g. water from showers, dishwashing, etc.), bilgewater (a mixture of engine water,
1297 cleaning agents, and many other sources), and ballast water (i.e. water for stability). Sewage can be
1298 directed to a marine sanitation device to either treat the materials prior to discharge or to hold it until it
1299 can be pumped to a land based facility. The amount of wastewater discharged into the MSP Study Area
1300 is unknown, however some estimations have been performed for the OCNMS area. In 2009, cruise ships
1301 (i.e. passenger vessels >1,600 GT with an average of about 3,000 passengers) were estimated to
1302 contribute approximately 63% of all sewage discharges and approximately 75% of all graywater
1303 discharges within OCNMS waters, making cruise ships the largest potential contributor of vessel
1304 discharges (Olympic Coast National Marine Sanctuary, 2011).²¹ OCNMS regulations implemented in
1305 2011 now prohibit all cruise ship wastewater discharges within sanctuary waters (15 CR §922.152).

1306 While the OCNMS water quality condition was rated as “good” in the 2008 OCNMS condition report
1307 (Office of National Marine Sanctuaries, 2008), there are concerns surrounding what water quality
1308 impacts vessel discharges could have within ocean waters. Vessel discharges could contain pathogens,
1309 elevated nutrient contents, or toxic substances which may harm wildlife or human health. Regulatory
1310 and voluntary measures for vessel discharge within State, OCNMS, and federal waters are currently in
1311 place to address many types of vessel discharges. Regulations and agreements are complex, and depend
1312 upon the vessel type, vessel size, discharge type, location of discharge, and other factors. One example
1313 is that in the U.S., all non-recreational vessels 79 feet or greater in length may not discharge substances
1314 to marine waters without a National Pollutant Discharge Elimination System Vessel General Permit
1315 (VGP)²². The VGP contains restrictions on the discharge to OCNMS waters, and Flattery Rocks and
1316 Willapa National Wildlife Refuge’s waters in the MSP Study Area, as well as several other waters within
1317 the state²³.

1318 Vessel discharges must meet state water quality standards. However, many onboard treatment
1319 systems do not meet these standards, and so vessels are guided to onshore pumpout facilities or to
1320 withhold discharges until outside of state waters. A memorandum of understanding between the North
1321 West & Canada Cruise Association, Port of Seattle, and the Washington Department of Ecology
1322 restricting sewage and graywater discharge in state waters (3 nm) and OCNMS is in place for cruise ships
1323 not utilizing advanced wastewater treatment systems (Olympic Coast National Marine Sanctuary, 2011).

1324 Washington State agencies, OCNMS, the Environmental Protection Agency, and vessel users will
1325 continue to work together to address vessel wastewater discharge to protect the marine ecosystem and
1326 human health.

1327 *Fishing pressures and bottom gear*

1328 The MSP Study Area is important for commercial, tribal, and recreational fishing. Several fisheries
1329 occur within the MSP Study Area and are managed by the Pacific Fisheries Management Council,

²¹ This assessment did not include estimates from offshore fish processors.

²² Certain discharge and vessel types are not covered or are exempt from the general permit. For more information please see <http://www.ecy.wa.gov/programs/wq/permits/VGP/index.html>

²³ For a list of Washington water bodies affected by the Vessel General Permit, please see Appendix G of the VGP available at <http://www.epa.gov/npdes/vessels-incident-discharge-permitting-3>

1330 Washington State, and treaty tribes.²⁴ The MSP Study Area has a long history of fishing activity, with
1331 some periods of unsustainable and habitat damaging practices. One of the most prominent examples is
1332 the use of bottom trawl gear for groundfish fishing. Bottom trawl gear can directly damage seafloor
1333 habitat, particularly hard bottom habitats and areas with biogenic habitat such as deep sea coral reefs
1334 and sponges. These biogenic habitats are slow growing, and may take decades to recover. While the
1335 exact extent of biogenic and hard bottom habitats within the MSP Study Area is unknown, the extensive
1336 bottom trawl fishing spanning several decades likely damaged some of this habitat (Office of National
1337 Marine Sanctuaries, 2008).

1338 Governments and fishermen are working together to sustainably utilize the valuable fishery
1339 resources within the area. For example, the groundfish fishery has been rationalized and reduced
1340 through a buyback program, and groundfish and rockfish conservation closure areas have been created
1341 as part of fishery management. Gear restrictions and closure areas to non-tribal commercial fishermen
1342 are expected to aid in the recovery of depleted groundfish stocks as well as to allow the critical, slow
1343 growing biogenic seafloor habitat to recover (Office of National Marine Sanctuaries, 2008).

1344 *Shoreline development*

1345 Shoreline development such as jetties, groins, and residential structures near beaches can degrade
1346 habitat through changes to sediment supply and loss of beach habitat. These changes represent a
1347 potential increasing stressor to the natural system as the coastal population continues to grow. The
1348 northern half of the MSP Study Area coast (Clallam and Jefferson Counties) is largely undeveloped and
1349 new coastal development will likely remain limited in the foreseeable future. The southern MSP Study
1350 Area coast (Grays Harbor and Pacific Counties) has a higher population with more cities and towns along
1351 the shoreline. The current primary driver for development on southern beaches is construction for
1352 vacation and retirement homes; however, development pressure is relatively low compared to other
1353 marine shorelines in the State (e.g. Puget Sound). Through Washington's Shoreline Management Act,
1354 local governments and the Washington State Department of Ecology have regulations and standards for
1355 shoreline development in order to protect habitat, facilitate water dependent and preferred uses, and
1356 provide public access ([RCW 90.58.020](#)). Local governments and the State will continue to evaluate
1357 coastal development projects to allow for coastal population growth and use of shoreline resources
1358 while protecting the marine environment.

1359 *Human disturbance and trampling*

1360 Human visitors to the coast can have varying impacts on shore habitats and wildlife, depending on
1361 the habitat types, types of activities, and intensity of use. Many of Washington's southern beaches are
1362 visited frequently by beach combers, razor clammers, beach drivers, and other users. Sandy beaches are
1363 relatively resilient to these types of human activities, although there are potential impacts to birds
1364 through disturbance of nesting and foraging habitats (Skewgar & Pearson, 2011).

1365 Harvest and trampling of intertidal organisms on rocky shores can harm these habitats. Non-tribal
1366 harvest from rocky areas is generally focused on gooseneck barnacles and mussels. WDFW, the tribes,
1367 and Olympic National Park regulate intertidal harvest, although effective enforcement along the coast is
1368 limited. Trampling and souvenir collecting by visitors can have direct, localized impacts on rocky shore
1369 habitat and organisms, but the extent of this activity on the outer coast is not well documented
1370 (Skewgar & Pearson, 2011). The OCNMS condition report (2008) and management plan (2011) stated

²⁴ For more information on fisheries and management, please see the Commercial and Recreational Fisheries Chapter.

1371 that while select habitat loss and degradation has occurred from human visitation activities, cumulative
1372 activities are unlikely to cause substantial or persistent harm to intertidal areas along the OCNMS
1373 shoreline.

1374 *Ocean noise*

1375 Many marine animals use sound to hear, communicate, find food, avoid predators, navigate, select
1376 mates, and more. Marine mammals in particular rely on sound for communication, navigation, and
1377 detecting food. Noise within the ocean can be natural: generated from animals, as well as waves, wind,
1378 storms, and other physical processes. Ocean noise can also be created by humans, through activities
1379 such as shipping and other vessel traffic, drilling, mining, and many other activities. Noise can even
1380 travel across ocean basins (Hatch & Broughton, 2015).

1381 Coastal and ocean waters are getting noisier, and anthropogenic ocean noise (from humans) is a
1382 growing problem for marine ecosystems with increasing and more varied human activities taking place.
1383 Anthropogenic noise can either be acute (intense noise, generally for relatively short time periods) or
1384 chronic (lower intensity background noise). Acute noise can cause adverse physical and behavioral
1385 impacts, while chronic noise can limit marine animal communication range and ability to sense their
1386 environment (e.g. predator avoidance in eels and foraging time in bats). The frequency of noise (i.e.,
1387 high pitch versus low pitch tones) has different effects on different animals, depending on their hearing
1388 sensitivity thresholds. NOAA and the U.S. Navy are actively researching noise in the ocean, with NOAA's
1389 focus on recording noise in marine sanctuaries to better understand the potential effects of human
1390 noise on our nation's marine protected areas (Hatch & Broughton, 2015).

1391 The MSP Study Area has many acoustically active whale species, many of which are listed under the
1392 ESA and all of which are protected under the Marine Mammal Protection Act. Study Area waters are
1393 impacted by both chronic and accumulated acute anthropogenic noise sources, primarily from shipping
1394 as well as Navy training and testing activities. However, in the pelagic habitat, ocean noise pollution
1395 (cumulative acoustic signature of human activities) is currently not well characterized or evaluated for
1396 potential impacts on wildlife (Hatch & Broughton, 2015; Olympic Coast National Marine Sanctuary,
1397 2011). Therefore, noise pollution remains a concern, yet more information is needed to assess the
1398 actual impacts to the Washington marine ecosystem, as well as any potential noise impacts a potential
1399 new use may have on wildlife.

1400 *Vessel strikes*

1401 Collisions between vessels and marine mammals, in particular large whales, is a known stressor
1402 throughout the world, particularly in areas where high ship traffic and whale populations intersect.
1403 Whales are vulnerable to strikes from all vessel types. Vessel strikes can lead to animal injury and death.
1404 Large vessel crews may not even notice when a strike has occurred, injured whales may not be noticed,
1405 and whale carcasses may not wash up on shore, so the number of whale strikes is greater than the
1406 documented incidents (National Marine Sanctuaries, 2015). In Washington, Blue whales, Fin whales, and
1407 Gray whales have been struck and killed by ships (Lance et al., 2011). OCNMS attempts to identify the
1408 degree of risk posed to whales and other marine mammals from ship strikes in the sanctuary by
1409 coordinating with the Northwest Marine Mammal Stranding Network to identify potential increases of
1410 incidents and supporting efforts to examine overlap areas of high marine mammal density and shipping
1411 lanes (Olympic Coast National Marine Sanctuary, 2011).

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2.2 Cultural and Historic Resources

Cultural and historic resources are an important part of the modern context and uses of the Washington coast and MSP Study Area. Washington's coastal area is rich with cultural resources including archaeological sites providing prehistoric records of native peoples' marine-oriented uses and traditional cultural properties for cultural practices, traditions, beliefs, lifeways, arts, crafts, or social institutions of a living community. Maritime history is embedded along Washington's coast, with many existing historic resources representing Euro-American maritime culture and shipwrecks.

American Indian archaeological resources

People have lived along Washington's shoreline and used the marine environment for thousands of years (United States v. Washington, No. C70-9213 (W.D.WA. 2015)). One of the earliest dated archeological sites on the Washington coast occurs within the boundaries of the Treaty of Neah Bay, establishing human presence for at least the last 6,000 years (Olympic Coast National Marine Sanctuary, 2011). It is likely that human presence along the west coast may have started as early as before 14,500 BP (ICF International, Southeastern Archeological Research, & Davis Geoarchaeological Research, 2013).

The native peoples of the Washington coast relied heavily on ocean and coastal resources and continue to do so today. Archeological sites, traditional oral histories, and ethnographies provide records for the types of marine-oriented uses the outer coast tribes participated in during prehistoric times and up to the signing of the treaties. These marine resources not only provided subsistence, but also played an integral role in culture, ceremonies, and economy. Native peoples harvested several species from the ocean, estuaries, and fresh waters including, but not limited to: salmon, steelhead, halibut, cod, sea bass, sole, and crabs. They also harvested shellfish, and were hunters of seal, sea lions, sea otters, and whales. These communities developed specialized gear for fishing, sealing, and whaling, including various types of seaworthy canoes optimized for hunting specific types of animals; dried kelp for fishing lines; and specialized hooks (United States v. Washington, No. C70-9213 (W.D.WA. 2015)).

Records of this activity can be found in various types of coastal archaeological sites and numerous anthropological reports. Sites include shell middens, villages, petroglyphs, burial grounds, fish weirs, canoe runs, traditional cultural properties, and others (ICF International et al., 2013). The modern shoreline and uplands adjacent to the MSP Study Area contain dozens of late prehistoric archeological sites. Some of these sites are known to occur within the intertidal zone, directly above the intertidal zone, and up to several kilometers inland. Specific examples of Native American sites listed in the National Register of Historic Places are: Ozette Indian Village Archaeological Site, Tatoosh Island, and Wedding Rock Petroglyphs (Olympic Coast National Marine Sanctuary, 2011). Enormous middens have also been discovered in La Push connecting native peoples to extensive use of the ocean (United States v. Washington, No. C70-9213 (W.D.WA. 2015)). There are likely undiscovered coastal archaeological sites in the area, Map 13 displays the output of a predictive model for upland archaeological sites developed by DAHP.

Due to changes in sea level since humans first arrived on the west coast, it is very possible that submerged prehistoric Native American archeological sites exist beneath the ocean. At about 19,000 BP, sea level was at its lowest, up to about 30 miles offshore from the present-day shoreline in some locations. Since then, sea level rose at various rates, pushing possible prehistoric occupants farther and farther inland (ICF International et al., 2013). BOEM modeled paleoshorelines from 19,000 BP to 1,000 BP in federal waters to illustrate how shoreline location changed over time (Map 13). Further analysis by BOEM indicates that much of the Study Area has a moderate likelihood of preserved submerged

44 prehistoric sites, with a somewhat higher likelihood of preservation toward the south (ICF International
45 et al., 2013).

46 Historic Resources

47 The Washington coast has a rich, maritime history. Europeans first laid eyes on the Washington
48 coast possibly as early as 1579, yet mapping of this area began in the late 1700s. Sustained Euro-
49 American settlement in Washington began in the 1850s, and the territory was declared a state in 1889.
50 Maritime trade and commerce, processing, and resource extraction quickly became growing, profitable
51 industries. Maritime trade and the foggy, dangerous conditions of the coast necessitated the
52 establishment of lighthouses. Cape Disappointment light house at the mouth of the Columbia River,
53 built in the 1850s, was one of the first lighthouses to be constructed along the Washington coast.
54 Lifesaving stations operated by the U.S. Lifesaving Service (predecessor to the United States Coast
55 Guard) were also established to assist mariners. Many lighthouses along the Washington coast remain
56 intact and open to visitors (Washington State Department of Archaeology and Historic Preservation,
57 2011).

58 Communities sprouted and thrived along Washington's shoreline, using access to water for
59 transporting natural resources such as fish, shellfish, and timber. Working waterfronts hosted canneries
60 and seafood packers, lumber mills, pulp mills, and shipyards. As the region's sea-based commerce
61 became increasingly profitable, recreational boating and tourism also thrived. The natural beauty of
62 rugged shorelines drew people looking for waterfront vacations, and resulted in the construction of
63 marine-oriented resorts, hotels, and campgrounds. These activities and industries shaped the history
64 and culture of coastal communities, and many continue today, particularly shipping, fishing,
65 aquaculture, seafood processing, timber, recreation, and tourism (Washington State Department of
66 Archaeology and Historic Preservation, 2011).

67 Historical places along the coast provide a link to the past of the Washington coast. Historical
68 resources include buildings, structures, sites, districts, and objects. Examples include light stations,
69 historic districts, hotels, and architecturally distinct buildings. There are several historical resources
70 listed on the National Register of Historic Places and the Washington Historic Register adjacent to the
71 MSP Study Area (Map 14). Many more historical sites are listed in the Washington Historic Property
72 Inventory (Washington State Department of Archaeology and Historic Preservation, 2015).

73 Shipwrecks

74 The Washington coast is home to perilous waters. Fog, waves, storms, strong currents, sand bars,
75 and a rugged coastline made historical navigation a challenge. Over 180 ships were reported wrecked or
76 lost at sea in or near Olympic Coast National Marine Sanctuary waters between 1808 and 1972. Ship
77 types ranged from clippers and steam freighters to fishing boats and barges. Several wrecks are famous
78 in local lore (as cited in (Olympic Coast National Marine Sanctuary, 2011). The Columbia River bar at the
79 southern end of the MSP Study Area is reported to be the second most dangerous bar crossing in the
80 world (Oregon Solutions, Cogan Owens Cogan, & Oregon State University Institute of Natural Resources,
81 2011), and thus many shipwrecks have occurred there. Discovered archaeological shipwreck sites
82 represent just a small portion of known losses at sea (Map 14), and many more sites may remain
83 undiscovered within the MSP Study Area.

84 Potential impacts to archaeological and historic resources

85 Historical places, archaeological sites, and traditional cultural properties include areas important for
86 maintaining cultural identities, places with spiritual power, healing, or associated with origins or

87 important events, and areas with aesthetic significance for people today. These sites could be disturbed
88 by new uses that impact the seafloor, and also may be subject to various levels of visual disturbance
89 from new ocean uses.

90 Some historical resources and traditional cultural properties may also be subject to various levels of
91 visual disturbance sensitivity from new ocean uses, such as offshore wind. Washington analyzed how far
92 offshore different height objects would be visible from shore (Map 15). This coarse assessment is useful
93 to understand what may be visible from the coast, yet specific assessments for individual projects will be
94 needed to evaluate the full potential visual impact from each new use proposal.

95 Understanding and integrating cultural landscapes into marine use decisions is important. In an
96 effort to meaningfully integrate the nation's cultural heritage into marine management decisions, the
97 Department of Commerce and the Department of the Interior, through the Marine Protected Areas
98 Federal Advisory Committee (MPA FAC), developed a Cultural Landscapes Approach (CLA). The CLA
99 provides a means for developing new levels of information about marine areas and their resources by
100 including integration of knowledge, memories, and empirical observations of tribal indigenous cultural
101 groups and other resource users. The CLA aims to make cultural resources and human relationships with
102 the environment visible across time and culture (Marine Protected Areas Federal Advisory Committee,
103 2011). This approach may be useful for Washington State when making decisions for new ocean and
104 coastal uses.

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- 133

1 2.3 Socioeconomic Setting

2 Washington's coastal communities adjacent to the MSP Study Area are generally rural, with natural
3 resources playing an important part in the economy and cultural character of these communities. Parks,
4 forests, and natural areas cover much of the land area of the four coastal counties: Clallam, Jefferson,
5 Grays Harbor, and Pacific (Maps 1 and 16). The Pacific coastal areas of Clallam and Jefferson counties
6 are quite remote and sparsely populated, while Grays Harbor and Pacific Counties have several small
7 incorporated and unincorporated communities along the coast (Map 16). Key industries include natural
8 resource-based industries (fishing, aquaculture, and timber), tourism, manufacturing, and government
9 services. The five federally recognized tribes: Makah, Quileute, Hoh, Quinault Indian Nation, and
10 Shoalwater Bay (Map 2), are also an integral part of the socioeconomic character of the coast. All
11 except Shoalwater Bay have treaties with the United States that extend their fishing rights as much as 40
12 nautical miles west into the Pacific. Coastal communities are exposed to several natural hazards and
13 unique coastal challenges such as powerful winter storms, tsunami events, and resulting inundation.
14 Continued participation in marine-resource based industries, a healthy marine ecosystem, and a future
15 with a sustainable local economy are among commonly shared visions of many coastal residents (Butler
16 et al., 2013; Kliem, 2013).

17 Funding through the Marine Spatial Planning process was provided to gather social and economic
18 information for coastal counties and tribes adjacent to the MSP Study Area. This socioeconomic chapter
19 briefly summarizes the extensive information provided through these projects¹. Readers are encouraged
20 to consult these reports and other references for further details on the socioeconomic context of
21 Washington's coastal communities.

- 22 • *Economic analysis to support marine spatial planning in Washington.* The purpose of this
23 project was to develop the tools and data to characterize existing economic conditions on
24 the Washington coast. This report provides economic information for each of the coastal
25 counties and tribes adjacent to the MSP Study Area. Available
26 at: http://www.msp.wa.gov/wp-content/uploads/2014/02/WMSP_2015_small.pdf.
- 27 • *Social indicators for the Washington coast integrated ecosystem assessment.* This report
28 documents the development and assessment of social indicators of human wellbeing for the
29 four coastal counties. The social indicators assessment is part of the Washington integrated
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- 33 • *Washington's working coast: An analysis of the Washington Pacific coast marine resource-*
34 *based economy.* This project provided baseline economic information and assembled
35 qualitative marine resource-based economic information through a narrative of interviews
36 with a representative group of coastal stakeholders. Available
37 at: http://media.wix.com/ugd/e2eea5_7a4796fc90c3f86ff0ae22e675bd6b55.pdf.

38 County profiles

39 Primary socioeconomic measures for the four coastal counties are presented in Table 2.3-1. The four
40 coastal counties are rural along the Pacific coast, and in Clallam and Jefferson Counties the majority of

¹ Economic information specific to each marine industry is provided under the relevant chapters within Part 2 of this MSP.

41 their population centers are in areas not adjacent to the Pacific Coast². The median household income
 42 for each county is below the state average, and the unemployment rates are higher than the state
 43 average for each county.

44 The ocean economy represents a significant portion of the total economy for the four coastal
 45 counties. Pacific County has the highest percentage with over a quarter of total jobs (26%) within ocean
 46 industries (i.e., living resources, marine transportation, tourism and recreation, ship and boat building,
 47 offshore mineral extraction, and marine construction), and Grays Harbor County has the lowest
 48 proportion at 13%, yet it still represents a significant element of total employment (Table 2.3-2). Ocean
 49 economy gross domestic product (GDP) represents approximately 10% of the total GDP for Clallam,
 50 Jefferson, and Grays Harbor Counties, and about 18% of the total GDP for Pacific County (National
 51 Oceanic and Atmospheric Administration, 2016).

52 **Table 2.3-1. Socioeconomic parameters for the four coastal counties³ and Washington state.**

	Clallam County	Jefferson County	Grays Harbor County	Pacific County	Washington State
Population ⁴	72,500	30,700	73,300	21,100	7,061,530 ⁷
Median household income ⁵	\$46,033	\$46,320	\$42,405	\$39,830	\$59,478
Gross regional product ⁶	\$2,033 million	\$ 703 million	\$2,038 million	\$519 million	\$408,049 million
Industry diversity index ^{5,6} (0 = more diverse, values closer to zero indicate higher diversity)	0.7340 (increase over time)	0.6609 (increase over time)	0.5848 (increase over time)	0.4647 (slight increase over time)	0.5220 (increase over time)
Unemployment ⁵	9.2%	9%	11.8%	10.6%	7%
% of individuals below the poverty level ⁷	14.6%	13.3%	19.0%	17.2%	13.4%

² Clallam County's major cities are on the Strait of Juan de Fuca; Jefferson County's major cities are on Puget Sound.

³ These numbers are county-wide, and are not limited to just the Pacific Ocean coastal portion of the counties.

⁴ Estimated for 2014. Source Taylor et al., 2015.

⁵ As of 2013. Source Poe et al., 2015.

⁶ This value is from the Ogive index, an index for economic diversity. A value of 0 on the Ogive index would mean that employment is equally distributed among the sectors, and would be the most diverse. Therefore, an increase in the Ogive index means that employment is unequal and that there is a larger concentration in fewer sectors.

⁷ 2009-2013 five year estimate. Source: United States Census Bureau, 2013.

53 **Table 2.2-2. Ocean economy⁸ of individual counties, the Pacific Coastal counties combined, and Washington State.**

Ocean-related industries	Countywide - 2013 ⁹				Statewide – 2013 ⁹	
	Clallam County	Jefferson County	Grays Harbor County	Pacific County	4 Pacific Coastal County Total (2011)	Washington State (2011)
Employment	3,098	1,262	2,702	1,651	8,713	121,131
Self employment	179	201	327	278	985	6,936
% of total jobs	14%	16%	13%	27%	8% of WA ocean jobs	4% of total WA jobs
Total wages	\$78.7 million	\$26.2 million	\$72.3 million	\$39.5 million	\$216.7 million	\$4.9 billion
Gross Domestic Product (GDP)	\$185.1 million	\$63.4 million	\$171.6 million	\$98.9 million	\$519 million	\$11.8 billion
% of total economy GDP	9.1%	9.1%	8.4%	19%	4.4% of WA ocean economy	2.9% of total WA economy

54

55 *Clallam County*

56 Clallam County extends along the northernmost portion of the Olympic Peninsula and makes up the
 57 northwestern most corner of the state. It covers 1,739 square miles (1.11 million acres). Much of Clallam
 58 County is under public ownership. Federal lands, primarily Olympic National Park (325,047 acres) and
 59 Olympic National Forest (197,782 acres) make up 47% of the county’s acreage. State Forest Lands
 60 account for another 92,525 acres (Taylor, Baker, Waters, Wegge, & Wellman, 2015). The County is
 61 bordered by the Pacific Ocean to the west and the Strait of Juan de Fuca to the north. The shoreline

⁸ Ocean related industries included in the NOAA ENOW data are: living resources, marine transportation, tourism and recreation, ship and boat building, offshore mineral extraction, and marine construction. For more information on methods and specific industry codes please see: <https://coast.noaa.gov/digitalcoast/tools/enow>.

⁹ Online ENOW explorer data from 2013. (National Oceanic and Atmospheric Administration, 2016)

62 adjacent to the MSP Study Area (Pacific Ocean) is almost entirely within Olympic National Park (Map 1)
63 or Indian reservation land (Makah and Quileute reservations) (Map 2).

64 The industries in Clallam County with the highest employment are government (32.7%); wholesale
65 and retail trade (17%); health care and social assistance (10.7%); and accommodation and food services
66 (10.1%) (Taylor et al., 2015). Government is a significant source of employment in Clallam County, with a
67 location quotient of 1.7 times more concentration in government sector as compared to the rest of the
68 state (Butler et al., 2013). Economic development strategies focus on manufacturing, marine services,
69 natural resources, renewable energy, tourism, and others. The Port of Port Angeles is a major port in
70 Clallam County, and significantly contributes to the county's economy with marine terminals, marinas,
71 airports, and log yards; the Port is not located within MSP Study Area (Taylor et al., 2015).

72 A zip code based analysis revealed that the Pacific Coast-based businesses accounted for only 4% of
73 Clallam County's ocean-dependent activity, while the Strait of Juan de Fuca ocean-dependent activity
74 accounts for the remaining 96% (NOAA Coastal Services Center, 2014).

75 *Jefferson County*

76 Jefferson County is located on the Olympic Peninsula south of Clallam County. The county is about
77 1,800 square miles (1.15 million acres) with most of the land in public ownership. Federal lands,
78 primarily Olympic National Park (538, 849 acres) and Olympic National Forest (166,299 acres) make up
79 about 61% of the county's total area, while State Forest Lands account for 14,703 acres (Taylor et al.,
80 2015). The County is bordered by the Pacific Ocean on the west and Puget Sound, Hood Canal, and the
81 Kitsap Peninsula on the east. The shoreline adjacent to the MSP Study Area (Pacific Ocean) is almost
82 entirely Olympic National Park or Indian reservation land, including the Hoh reservation and the
83 northwest corner of the Quinault Indian Nation reservation (Maps 1 and 2).

84 The industries with the highest employment include government (27.1%); wholesale and retail trade
85 (14%); accommodation and food services (12.8%); and health care and social assistance (10.7%) (Taylor
86 et al., 2015). Economic development strategies are focused on industries such as manufacturing, arts
87 and culture, education, healthcare, marine trades, and others. The Jefferson County Economic
88 Development Council is working to increase access to investment capital in the county (Taylor et al.,
89 2015).

90 A zip code based analysis revealed that the Pacific Coast-adjacent businesses accounted for 14% of
91 Jefferson County's ocean-dependent activity, while the Puget Sound ocean-dependent activity accounts
92 for the remaining 86% (NOAA Coastal Services Center, 2014).

93 *Grays Harbor County*

94 Grays Harbor County is the largest of the four coastal counties covering an area of about 1,900
95 square miles (1.22 million acres). Grays Harbor County is bordered by the Pacific Ocean on the west, and
96 has topography of mountains, foothills, and river valleys. Grays Harbor estuary covers 58,000 acres and
97 extends inland about 25 miles. Federal lands make up about 12% of the county, including Olympic
98 National Forest (138,724 acres) and a small part of Olympic National Park (6,662 acres). The Washington
99 Department of Natural Resources (DNR) manages about 31,300 acres of State Forest Lands within the
100 county. The majority of the Quinault Indian Nation reservation is within Grays Harbor County, however
101 the community of Queets is located in Jefferson County and has hundreds of residents (Map 2) (Taylor
102 et al., 2015).

103 More than 60% of the county's population lives in incorporated areas. The county has nine
104 municipalities, five of which are adjacent to the MSP Study Area: Aberdeen, Cosmopolis, Hoquiam,

105 Ocean Shores, and Westport (Taylor et al., 2015). The industries with the highest employment include
106 government (27.4%); wholesale and retail trade (14%); manufacturing (12.7%); and health care and
107 social assistance (10.8%) (Taylor et al., 2015).

108 The Columbia Pacific Resource Conservation and Economic Development District, which Grays
109 Harbor County is a part of, identified four natural resource-related industrial clusters considered integral
110 to the Columbia-Pacific region economy: forest products; fishing, fish processing, and related
111 aquaculture; agriculture; and food products. Grays Harbor County has highlighted recent success in the
112 tourism industry cluster, with increased hotel/motel tax revenues and taxable retail sales. The Port of
113 Grays Harbor is located within Grays Harbor County and plays a major role in the coastal economy
114 (Taylor et al., 2015).¹⁰

115 *Pacific County*

116 Pacific County is about 933 square miles (596,902 acres) in size. It is bordered on the west by the
117 Pacific Ocean, and the Columbia River to the south. Pacific County includes the Long Beach Peninsula,
118 which separates Willapa Bay from the Pacific Ocean. Less than 1% of the county is under federal
119 ownership, yet DNR-managed State Forest Lands account for 23,340 acres, about 4% of the county.
120 More than 70% of the county, close to 420,000 is forested (Taylor et al., 2015). The Shoalwater Bay Tribe
121 is located along the northern shoreline of Willapa Bay (Map 2).

122 A vast proportion (98.8%) of the county is unincorporated. The county has four municipalities:
123 Ilwaco, Long Beach, South Bend, and Raymond. The industries with the highest employment include
124 government (29.9%); manufacturing (12.3%); accommodation and food services (11.9%); and wholesale
125 and retail trade (10%) (Taylor et al., 2015). The agriculture, forestry, fishing, and hunting industry also
126 makes up a significant portion of employment in Pacific County (9.2%), with a location quotient of more
127 than 2.7 times more concentration in this sector as compared to the rest of the state, and more than 9.4
128 times more concentration in this sector as compared to the rest of the country (Butler et al., 2013). In
129 fact, the Brookings Institute ranked Pacific County as the fourth most fishing-intensive local economy in
130 the U.S. by share of total 2012 earnings (Kearney et al., 2014).

131 Pacific County's vision for their economic future includes maintaining and enhancing a rural lifestyle
132 by promoting long-term development of viable agricultural, aquaculture, forest, and fisheries resources;
133 promoting economic development that is compatible with the area's resources; and promoting the
134 safety and general welfare of all residents (Taylor et al., 2015). Four Port Authorities are located in
135 Pacific County: the Port of Willapa Harbor, Port of Peninsula, Port of Ilwaco, and Port of Chinook.¹¹

136 *Tribal socioeconomic profiles*

137 There is considerable economic interaction among the tribes, tribal members, and the non-Indian
138 communities on Washington's coast. Economic activity is often intertwined, as tribal members work and
139 shop off-reservation, non-Indians are employed by the tribes, and many tourists and local residents visit
140 tribally-owned businesses, which include resorts and marinas. In addition, commercial and subsistence
141 fishing activities occur off-reservation in Usual and Accustomed Fishing Grounds (U&A) for treaty

¹⁰ For more information on the Port of Grays Harbor, see 2.7: Marine Transportation, Navigation, and Infrastructure.

¹¹ For more information on the ports of Pacific County, see 2.7: Marine Transportation, Navigation, and Infrastructure.

142 tribes¹², both on the ocean and in freshwater bodies (rivers and lakes). Yet each tribe has its own
143 socioeconomic identity. Available socioeconomic information for each of the five federally recognized
144 tribes adjacent to the MSP Study Area is summarized below.

145 *Makah Tribe*

146 The Makah Reservation is located on the northwestern most tip of the Olympic Peninsula and covers
147 about 44 square miles (30,142 acres), including Tatoosh and Waadah Islands and the Ozette Reservation
148 (Map 2). Physically isolated from Washington and even other parts of Clallam County, the primary
149 community on the Makah Reservation, Neah Bay, is 60 miles from Forks and 75 miles from Port Angeles.
150 Harsh natural conditions accompany the rural setting of this area. The area receives over 100 inches of
151 rain per year and is subject to high winds. Over 40% of the reservation is on slopes exceeding 30% grade
152 and only 6% of the roads are paved (Taylor et al., 2015).

153 In 2010, 1,414 individuals were living on the reservation, and in 2005 tribal enrollment was at 2,534.
154 During a period from 2009-2013, the main industries of employment were public administration
155 (30.7%); agriculture, forestry, fishing and hunting, and mining (18.6%); and educational services, and
156 health care and social assistance (17.7%). The U.S. Census Bureau estimates that almost 55% of these
157 jobs were government positions, including tribal employees, and other local, state, and federal
158 employees. Median earnings for workers on the Makah reservation during this time were \$27,102
159 (Taylor et al., 2015).

160 The economy of the reservation is very dependent on two sectors: tourism and fishing. Neah Bay is
161 said to offer some of the best saltwater fishing in the United States, and the marina serves as a base for
162 one of Washington's most important locations for charter halibut fishing. Other popular tourist activities
163 include hiking, surfing, kayaking, and diving. Tourism-related tribal enterprises include the Warmhouse
164 Restaurant, Cape Resort, Hobuck Beach Resort, and Makah Mini-Mart. Another attraction is the Makah
165 Museum. Tourism slows down during the winter months, resulting in layoffs during the winter. The tribe
166 is interested in attracting wintertime tourists to increase year-round revenue and jobs in this industry
167 (Taylor et al., 2015). Commercial fishing is also a large part of the Makah's economy. About 70
168 commercial fishing vessels operate out of Neah Bay. There is also a Cape Flattery Fisherman's Co-op
169 with a small processing plant, and the Makah Tribe owns the commercial fishing dock in Neah Bay
170 (Taylor et al., 2015). More information on the economics of commercial fishing on the Makah
171 Reservation is described in Section 2.4.

172 Other economic industries on the reservation include the forestry industry and the commercial
173 filming industry which utilizes the area and tribal services. Plans for the Makah Tribe's economic future
174 is to expand the four tourist-oriented enterprises in the short term, and possibly develop a 9-hole golf
175 course and/or a high end resort or retreat center in the long term. Challenges include developing
176 opportunities for younger tribal members with college degrees who wish to stay on the reservation
177 (Taylor et al., 2015).

178 *Quileute Tribe*

179 The Quileute Reservation covers approximately 2,161 acres, including the community center of La
180 Push, a fishing community, and James Island, a sea stack just off the coast connected at extreme low
181 tides. The reservation is located on the Olympic Peninsula and is roughly bounded by the Quillayute
182 River, the Pacific Ocean, and the Olympic National Park (Map 2). Much of the reservation is surrounded

¹² The four coastal treaty tribes adjacent to the study area are: Hoh Tribe, Makah Tribe, Quileute Tribe and Quinault Indian Nation. See Section 1.6 for detailed description of treaty rights.

183 by wilderness areas managed by the National Park Service. La Push is about 15 miles west of Forks
184 (Taylor et al., 2015).

185 In 2010, 460 individuals were living on the reservation, and 2015 estimated tribal enrollment is 777
186 members. Industries with the highest level of employment from 2009-2013 were educational services,
187 and healthcare and social assistance (46.1%); public administration (28.9%); and agriculture, forestry,
188 fishing and hunting, and mining (13.8%) industry clusters. The median earnings for workers on the
189 Quileute Reservation were \$24,205 from 2009-2013. According to the Quileute Tribe's Comprehensive
190 Economic Development Strategies document completed in fall of 2013, the primary sources of
191 employment are government services (tribal and federal), commercial ocean fisheries, subsistence river
192 fisheries, and the Quileute Ocean Park Resort. Annual surveys show that many households derive some
193 proportion of their income from fishing. The fishing and tourism industry are both seasonal (Taylor et
194 al., 2015).

195 Tourism is a source of employment and income to the tribe. The remoteness and natural beauty of
196 the area attracts many visitors. The reservation offers a wide range of recreational activities including
197 wildlife viewing, nature photography, coastal hiking, boating, fishing, kayaking, surfing, camping,
198 swimming, and storm watching. The Quileute also host a number of tribal events, many of which are
199 open to the public. Tourism-related businesses include the Quileute Oceanside Resort complex (open
200 year-round), and River's Edge Restaurant. The Quileute Tribe also owns and operates the marina at La
201 Push. The tribe is also engaged in commercial fishing and hatchery operations (Taylor et al., 2015).

202 Plans for the economic future of the Quileute Tribe include the creation of jobs as a major priority.
203 Plans include improvements to the Oceanside Resort, development of a permanent cultural
204 center/museum facility, development of the tribal owned Ki'tla Business Parks in Forks, expansion of
205 commercial fishing, and acquiring broadband internet service. Similar to the Makah Tribe, a challenge
206 for the Quileute is to develop new employment opportunities for the next generation (Taylor et al.,
207 2015).

208 *Hoh Tribe*

209 The Hoh Reservation is located on the Olympic Peninsula in Jefferson County, about 25 miles south
210 of Forks and 80 miles north of Aberdeen. The reservation is bounded to the north by the Hoh River and
211 includes one mile of ocean shoreline to the west. Until recently, the reservation was about one square
212 mile (640 acres). But the changing course of the Hoh River and resulting flooding of tribal homes and
213 facilities prompted land purchases and land transfers starting in 2008. Today, the reservation
214 encompasses more than 900 acres (Map 2) (Taylor et al., 2015).

215 In 2010, there were 116 individuals living on the reservation. There are about 230 enrolled tribal
216 members. The isolated location of the reservation limits employment opportunities primarily to
217 commercial fishing (21.2%) or to jobs directly with the tribe (75.8%). The U.S. Census Bureau estimates
218 that almost 82% of jobs in 2009-2013 were government positions, including tribal employees as well as
219 other local, state, or federal positions. The median earnings during 2009-2013 for workers on the Hoh
220 Reservation were estimated to be \$38,462 (Taylor et al., 2015).

221 The Hoh depend on the fish and wildlife of the Hoh River and their other usual and accustomed
222 areas for both subsistence and their commercial economy. The Hoh manage tribal forestlands to provide
223 a safe and healthy environment for tribal members and protect basic watershed functions for the
224 cultural and economic needs of the tribe. The Hoh tribe plans for minimal and infrequent harvests of
225 tribal forest lands, and to focus the regeneration of trees on species for cultural use. Plans for the future

226 include using the additional lands to the reservation for housing and government facilities and
227 opportunities for economic development (Taylor et al., 2015).

228 *Quinault Indian Nation*

229 The Quinault Reservation is located in the southwestern corner of the Olympic Peninsula. The
230 reservation covers 208,150 acres, is mostly forested and is crossed by several major rivers including the
231 Queets, Raft, and Quinault Rivers (Map 2). The Pacific Ocean lies to the west, Queets village to the
232 north, Lake Quinault is on the east side, and Moclips is to the south. The rainforest climate brings 80
233 inches of precipitation on the coastal end and up to 150 inches at higher elevations. A total of 173,000
234 acres of the reservation is tribal and Bureau of Indian Affairs-managed forestland (Taylor et al., 2015).

235 In 2010, 1,406 individuals were living on the reservation. As of 2015, total tribal enrollment was
236 2,928. Communities within the Quinault Reservation include Amanda Park, Queets, Qui-nai-elt Village,
237 Santiago, and Taholah. During a period from 2009-2013, industries providing the highest proportion of
238 employment include educational services, and health care and social assistance (33.2%); public
239 administration (28%); and arts, entertainment, and recreation, and accommodation and food services
240 clusters (11%). Additional industries include agriculture, forestry, fishing and hunting, and mining (5.2%);
241 construction (5.2%); and manufacturing (4.5%). According to the U.S. Census Bureau, almost 70% of
242 jobs were government employees. The median earnings for workers on the Quinault Reservation during
243 2009-2013 were \$24,375 (Taylor et al., 2015).

244 Three primary industry clusters are central to the Quinault Indian Nation: Hospitality and Tourism,
245 Fisheries, and Forestry. Tourism-related businesses include the Quinault Beach Resort and Casino
246 (located off-reservation in Ocean Shores), the Quinault Sweet Grass Hotel (also in Ocean Shores),
247 Quinault Marina and RV Park (located in Ocean Shores, yet currently closed), guided fishing trips, and
248 the Quinault Tribal Museum. Fisheries-related businesses include the Quinault Pride Seafood Processing
249 Plant in Taholah, the Quinault National Fish Hatchery, and a fishing support facility at Westport Marina
250 (Taylor et al., 2015).

251 Plans for the future include upgrades to the fish processing plant in Queets, proposed development
252 of land-based sand and gravel resources, development of biomass for renewable energy, and relocating
253 the Taholah village beyond the tsunami hazard zone (Taylor et al., 2015).

254 *Shoalwater Bay Tribe*

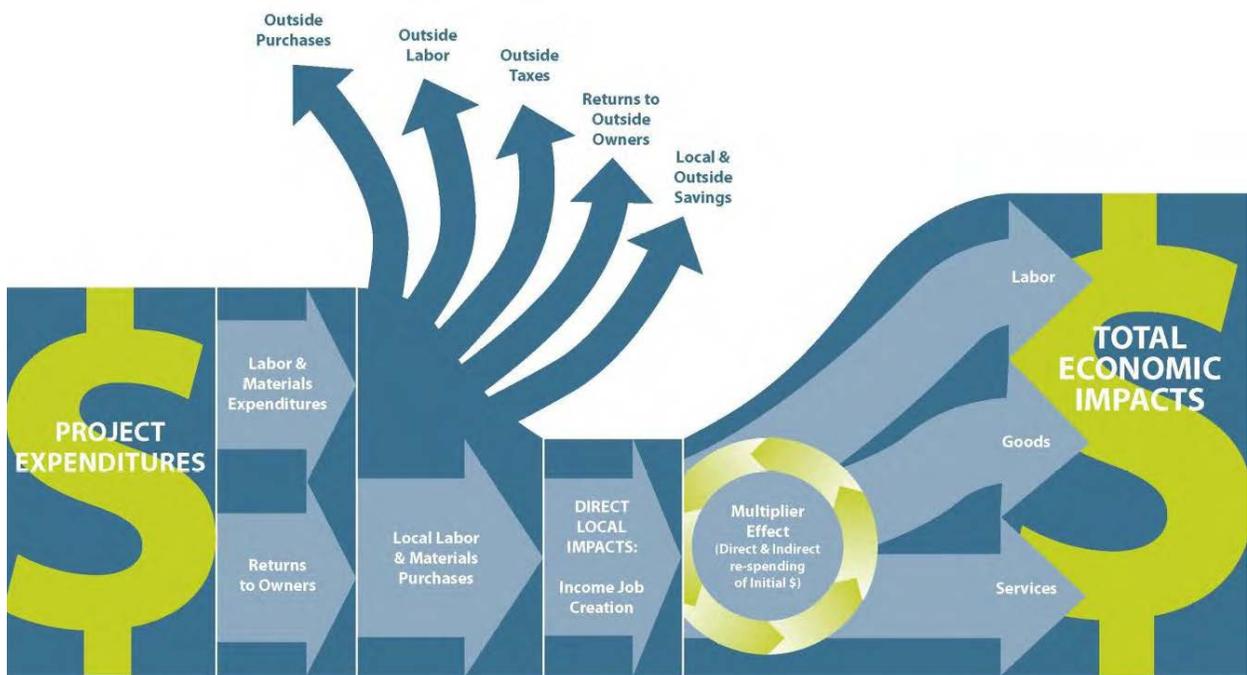
255 The Shoalwater Bay Reservation is located in Pacific County on the north shore of Willapa Bay. The
256 reservation is slightly more than one square mile with 440 acres of uplands and 700 acres of salt marsh
257 and tide flats (Map 2). The upland portion of the reservation is mostly a steep ridge, leaving only a
258 narrow piece of developable land along the shoreline, and much of this strip is within the tsunami
259 hazard zone. Unlike the other four coast tribes, the Shoalwater Bay Tribe did not sign a treaty with the
260 federal government, and therefore does not have secured U&A or hunting areas (Taylor et al., 2015).

261 In 2010, 82 individuals were living on the reservation. The tribe has more than 300 enrolled
262 members. From 2009-2013, the industries with the highest proportion of employment were arts,
263 entertainment, and recreation, and accommodation and food services (33.3%); educational services,
264 and health care and social assistance (26.4%); and public administration (18.1%). The U.S. Census Bureau
265 estimates that over 40% are government employees, and about 43% are jobs with private companies.
266 The median earnings for workers on the Shoalwater Bay Reservation during 2009-2013 were \$23,958
267 (Taylor et al., 2015).

268 Current Shoalwater Bay tribal-owned businesses include the Shoalwater Bay Casino, San Verbena
269 Seafood & Grill, Tradewinds on the Bay (condos for rent), and Georgetown Station convenience store
270 and gas station. The tribe has recently added several hundred acres and plans to add additional housing
271 outside of the tsunami hazard zone (Taylor et al., 2015).

272 Economic impact modeling of ocean and coastal uses

273 The Marine Spatial Planning process funded an economics report that estimated economic
274 contributions of commercial and recreational fisheries, aquaculture, and recreation and tourism to local
275 and state economies. Cascade Economics produced estimates of economic contributions using an input-
276 output model that captures the key, measurable linkages between economic activities. Estimates of jobs
277 and labor income were created and are referred to as total effects and are the sum of “direct”,
278 “indirect”, and “induced” effects. Direct effects are those that arise directly from the spending being
279 studied. For example, spending comes from recreational trip-related expenditures. Indirect effects are
280 those that relate to the businesses that receive a portion of the direct expenditures in exchange for
281 goods and services provided to the focal economic activity. Induced effects are then those related to the
282 spending of personal income earned by the owners and employees of these linked businesses. The
283 “economic multiplier” effect captures the degree to which indirect and induced activities expand the
284 impact of direct expenditures on the economy of interest (see Figure 2.3-1).¹³ Specific economic
285 contribution numbers (total labor income and total jobs) estimated for each industry are discussed
286 within the respective chapters in the MSP. These numbers highlight the economic importance of these
287 ocean and coastal industries to the coastal region and the State. The Cascade Economics report provides
288 additional explanation of the IMPLAN input-output model and its supporting data.



289 Figure 2.3-1: Illustration of regional economic impacts, leakage, and multiplier effects. Source: (cited in Taylor et al., 2015)
290

¹³ 2014 commercial landings data and recreational trip data were used to calculate economic contributions of those sectors, while 2013 data was used for this purpose for the aquaculture sector. In all cases the multipliers used were derived using IMPLAN models based on 2012 regional economic data.

291

292 Coastal hazards and community vulnerability

293 Washington coastal communities are exposed to a number of natural hazards which may influence
294 human safety, businesses, and quality of life. Community vulnerability to hazards can be defined as the
295 attributes of a human-environmental system that increase the potential for hazard-related losses or
296 reduced performance. Characteristics that influence vulnerability include exposure, sensitivity, and
297 resilience of a community. Socioeconomic factors, such as population and economy within hazards
298 zones, vary by community (Wood, 2007). While a detailed analysis of coastal community vulnerability is
299 out of scope for the MSP, a general description of WA community exposure to coastal hazards is
300 provided to give context to the challenges these communities face today and into the future.

301 Coastal natural hazards posing a risk to communities adjacent to the MSP Study Area include severe
302 storms, flooding, coastal erosion, landslides, earthquakes, and tsunamis. With regards to the severe
303 storm hazard, all four coastal counties are vulnerable to high winds (Washington Emergency
304 Management Division, 2013), and exposure to severe storms increased from 2005 to 2010 (Poe,
305 Watkinson, Trosin, & Decker, 2015). Coastal storms can impact other natural hazards, such as erosion
306 and flooding events. Coastal storm surge flooding affects low elevation areas along the Pacific Ocean
307 coast and is most common during winter storm events, generally from November through February.
308 Coastal flooding results from the combination of storm-driven surges and daily tides, with maximum
309 flooding occurring when the peaks of storm-driven surges coincide with high tides. Flooding may destroy
310 structures through wave force, erosion scour, or impact from debris. All of the MSP Study Area coastal
311 counties are susceptible to wind and barometric tidal flooding (Washington Emergency Management
312 Division, 2013).

313 Coastal erosion is another hazard within the MSP Study Area and has been studied from Point
314 Grenville south to the Columbia River. Erosion in this area is generally cyclical, with shoreline erosion
315 occurring during the winter storm months and accretion during the calmer summer months. Areas of
316 localized chronic and episodic erosion have impacted communities such as Westport, North Cove (a.k.a.
317 Washaway Beach), Ocean Shores, and Cape Disappointment and is often influenced by jetties and
318 coastal sediment supply. Coastal storms can increase erosion (Talebi, 2015).

319 Landslides occur when gravity overcomes the strength of the soil and rock in a slope. Saturation,
320 erosion, ground shaking, and human action are contributing factors to landslides. According to the
321 Washington State Emergency Management Division (EMD), areas adjacent to the MSP Study Area that
322 are at risk of landslides include portions of Jefferson County, areas of Grays Harbor County near
323 Aberdeen, and some areas of Willapa Bay in Pacific County (Washington Emergency Management
324 Division, 2013).

325 As discussed in the Geomorphology section, a subduction earthquake is a large looming hazard for
326 the Washington coast. Washington communities are also vulnerable to other earthquakes generated
327 from other faults. Earthquakes can damage infrastructure, disrupt public services and utilities, impact
328 businesses, and risk injury and loss of life. All four MSP coastal counties are considered to be among the
329 most vulnerable in Washington to earthquakes (Washington Emergency Management Division, 2013).

330 Earthquakes may also cause tsunamis. Tsunamis can be generated by distant earthquakes, such as
331 those occurring in Alaska or Japan. Yet Washington's tsunami hazard zone planning is modeled after a
332 potential 9.1 magnitude Cascadia Subduction Zone (CSZ) earthquake located along the West Coast, from
333 northern Vancouver Island down to northern California. This earthquake could produce the largest
334 tsunamis along the coast. Many communities adjacent to the MSP Study Area have significant

335 proportions of their populations within the tsunami hazard zone. Examples of coast wide, county, tribal,
 336 and select city populations within the hazard zone are given in Table 2.3-3. These numbers do not
 337 account for the thousands of visitors to coastal areas every day (Washington Emergency Management
 338 Division, 2013).

339 **Table 2.3-3. The total number and community proportions of residents residing within the tsunami hazard zone for**
 340 **select coastal communities. Source: Washington Emergency Management Division, 2013**

County, Tribe, or City	Proportion of Community Population	Number of Residents ¹⁴
Four coastal counties combined	24%	42,972
Clallam County	3%	2,239
Jefferson County	7%	1,692
Grays Harbor County	42%	28,447
Pacific County	50%	10,595
Makah Tribe	59%	802
Quileute Tribe	15%	54
Hoh Tribe	61%	62
Quinault Indian Nation	42%	572
Shoalwater Bay Tribe	85%	59
Aberdeen (Grays Harbor County) ¹⁵	72%	11,781
Long Beach (Pacific County)	100%	1,281

341
 342 Many coastal communities are planning and preparing for subduction zone generated tsunamis,
 343 including: posting evacuation route and hazard zone signs; establishing 24-hour warning capabilities;
 344 and promoting public readiness through community education (Washington Emergency Management
 345 Division, 2013). Some of the tribes are planning to use recently acquired lands to build housing and

¹⁴ Based on 2000 U.S. Census data

¹⁵ The city of Aberdeen has the greatest number of residents within the tsunami hazard zone, representing the greatest number of people at risk in one local community.

346 other public facilities outside of the tsunami hazard zone^{16,17} (Taylor et al., 2015). Project Safe Haven, a
347 community and tribal effort to identify vertical evacuation options initiated by EMD and the University
348 of Washington, developed several community strategies for tsunami evacuation preparedness
349 (Washington Emergency Management Division, 2013). One example is the Ocosta Elementary School,
350 which is the first vertical evacuation structure built in North America. It is located in Grays Harbor
351 County, just south of Westport. A vertical evacuation platform was built on top of the gym roof and is
352 designed to hold 1,000 people, which provides safe refuge for the children and local community
353 (Buehner, 2016).

354 In addition to tsunami preparation, Washington's coastal communities, in coordination with EMD,
355 the Federal Emergency Management Agency (FEMA), Ecology's Coastal Program, Washington Sea Grant,
356 and other local, state, and federal agencies are working to understand, prepare for, respond to, and
357 mitigate against various natural hazards to reduce risk and increase community resilience. One example
358 is the Coastal Hazards Resilience Network that brings together federal and state government agencies,
359 academic institutions, consultants, and nonprofit organizations to improve regional coordination,
360 integration, and understanding of coastal hazards¹⁸.

361 Coastal stakeholder views

362 People living on Washington's coast hold important, diverse views on social and economic issues
363 and interests that are a part of defining the character of these coastal communities. Summary reports of
364 workshops and interviews completed for the MSP process have helped to capture the various
365 community perspectives of Marine Resource Committee (MRC) participants and other coastal
366 stakeholders in the four coastal counties.

367 Two MSP reports, which capture coastal stakeholder interests and perspectives in further detail are:

- 368 • *Washington's working coast: An analysis of the Washington Pacific coast marine resource-*
369 *based economy* (2013) by Butler et al. provides a qualitative analysis of interviews
370 conducted with the Marine Resources Committees and other coastal stakeholders. Available
371 at: <http://wa-working-coast.wix.com/wa-workingcoast>
372
- 373 • *Coastal voices: A report on citizen priorities, interests, and expectations for Marine Spatial*
374 *Planning along Washington's Pacific coast* (2013) by Kliem summarizes Marine Resources
375 Committee workshops held to identify interests, priorities, and expectations for MSP.
376 Available at: [http://www.msp.wa.gov/wp-content/uploads/2013/06/060413_Coastal-](http://www.msp.wa.gov/wp-content/uploads/2013/06/060413_Coastal-Voices-Version-Final.pdf)
377 [Voices-Version-Final.pdf](http://www.msp.wa.gov/wp-content/uploads/2013/06/060413_Coastal-Voices-Version-Final.pdf)

378 Perspectives of coastal residents and stakeholders provide important context on social and
379 economic interests and concerns for the planning process to consider. The section below briefly

¹⁶ The Quileute Reservation occupies a small piece of land on the coast that is threatened by tsunamis. The Quileute will use 275 acres of newly acquired land from the Olympic National Park as a new site for the Tribal Council's headquarters, tribal school, pre-school, senior center, and other facilities to provide tsunami protection for the tribe (Taylor, Baker, Waters, Wegge, & Wellman, 2015). Other acreage was acquired in the same legislation (PL 112-97), but is not going to be developed (e.g., wetlands).

¹⁷ The Quinault Indian Nation village of Taholah is in the official tsunami hazard zone. Over 1,000 residents, as well as the Taholah Mercantile, jail, courthouse, daycare facility, Head Start facility, and a K-12 school are located within the tsunami zone. The Quinault are currently developing a master plan to relocate Taholah to higher ground beyond the tsunami and flood hazard zone (Taylor et al., 2015).

¹⁸ www.wacoastalnetwork.com

380 highlights some of the frequent themes and perspectives conveyed by coastal stakeholders and
381 residents to provide an insight into commonly expressed views regarding social and economic interests
382 and concerns. Of course, not all residents and coastal users share these perspectives, and even within
383 these interviews and workshops there were a diversity of views.

384 A primary common theme expressed among these comments and workshops include the
385 importance of protecting and valuing the natural-resource based economy of coastal communities. The
386 marine resource-based economy was described as part of their coastal heritage, and the desire to
387 protect existing marine resource industries, such as fishing and aquaculture, was shared across
388 participating stakeholders (Butler et al., 2013; Kliem, 2013).

389 Other themes included the importance of a healthy marine ecosystem and access to natural
390 resources for jobs and to enjoy the rural, natural character of the coast. Protecting these attributes for
391 the benefit of future generations is important to many stakeholders. Many participants shared concerns
392 that new ocean uses would negatively impact local communities and economies, through displacement
393 of local long-term jobs and impacts to the ecosystem. Stakeholders expressed the need to use science as
394 well as local, traditional knowledge in the decision-making process to avoid and minimize impacts.
395 Another theme was meaningful local community involvement in decision-making for siting new uses to
396 reduce conflicts, and balancing the perspectives and needs of local, state, and national interests. Many
397 stakeholders highlighted the unique, multi-jurisdictional management of marine resources in
398 Washington (e.g. fisheries co-management with tribes, and the presence of the Olympic Coast National
399 Marine Sanctuary) and desire for a unique approach and management solution for new uses within the
400 MSP Study Area (Butler et al., 2013; Kliem, 2013).

401 Future trends

402 While each coastal county and community has a distinct socioeconomic profile, many share similar
403 challenges and opportunities into the future. One example of a socioeconomic challenge common to all
404 four coastal counties is the relatively low proportion of working age residents (Poe et al., 2015). Coastal
405 residents have observed that many working age individuals have moved to areas that offer more job
406 opportunities, and there is a concern that without a strong workforce, the coastal region will become
407 less competitive, attract fewer businesses, and lose innovative thinkers (Butler et al., 2013). In contrast,
408 many of the tribes have relatively high proportions of young residents entering the workforce, and are
409 pursuing ways to provide job opportunities for those who wish to stay and work on the reservations
410 (Taylor et al., 2015).

411 Coastal communities have also identified many opportunities for socioeconomic growth for an
412 economically sustainable future. For example, many governments and economic council plans reflect
413 the intention of increasing economic diversification, while continuing to strengthen their existing
414 industries. Resources for small, local business start-ups and expansion are in place and more are under
415 development. Throughout many coastal communities, sustainable natural resource-based industries are
416 seen as vital to a healthy, local economy, and will likely continue to be a focus into the future (Butler et
417 al., 2013; Taylor et al., 2015).

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463

DRAFT

1 2.4 Commercial, Recreational, and Tribal Fisheries

2 Fishing is a longstanding and important use of the MSP Study Area. In acknowledgement of this
3 importance, the law requires this Plan to “[r]ecognize that commercial, tribal, and recreational fisheries,
4 and shellfish aquaculture are an integral part of our state’s culture and contribute substantial economic
5 benefits”(RCW 43.372.005(3)(i)). This chapter promotes that recognition by summarizing how fisheries
6 use the MSP Study Area and by describing their importance to fishing communities and the state
7 economy.

8 The information presented in this chapter primarily follows that of two reports produced for the
9 coastal marine spatial planning process: a fishing sector report (Industrial Economics Inc., 2014) and
10 economic analysis (Taylor, Baker, Waters, Wegge, & Wellman, 2015). Readers are encouraged to consult
11 these reports for further information. Additionally, the basic fisheries statistics on which the two reports
12 rely are collected and maintained by WDFW and the coastal treaty tribes. Most of these core statistics
13 are publically available upon request, subject to certain restrictions in place to protect confidentiality.
14 Information presented in this chapter is a combination of information provided by WDFW, Industrial
15 Economics (2014), Taylor et al. (2015), and other sources as cited in the chapter.

16 As an opening note on terminology, the term “commercial” in this chapter should not be read to
17 cover tribal fisheries. Many tribal fisheries do resemble commercial fisheries in terms of where and how
18 they fish, the markets into which the fish are sold, and in their contributions to the coastal economy.
19 However, tribal fisheries are described separately because they are conducted under special authorities
20 held by the tribal governments. Likewise, tribal members also harvest fish and shellfish non-
21 commercially, for ceremonial and subsistence purposes, yet they would not refer to their fishing
22 activities as “recreational.” The specific fishing activities of the four coastal treaty tribes are described
23 below.

24 Summary of History and Current Use

25 *Fishing Community Engagement and Dependence*

26 The MSP Study Area contains some of the most productive regions of the California Current
27 ecosystem and supports abundant fish and shellfish resources. Washington’s coastal tribes have
28 depended on these resources for thousands of years as did Euro-American settlers since first arriving in
29 the state in the mid-1800s. Today, many coastal communities remain highly engaged, reliant, and
30 dependent on commercial, recreational, and tribal fisheries. Communities highly engaged in fishing may
31 have, for example, relatively high pounds of landings or number of fishing permits, while communities
32 highly reliant on fishing may have relatively high values of landings per capita or fishing permits per
33 capita. Communities with high levels of both engagement and reliance on fishing are considered to be
34 highly dependent on fishing (Jepson & Colburn, 2013).

35 Recent studies have evaluated the engagement, reliance, and dependence of Washington’s
36 communities on fishing. A NOAA study identified a number of communities located adjacent to the MSP
37 Study Area as being some of the most highly fishing dependent communities¹ on the West Coast (Table
38 2.4-1) (Norman, in progress 2017). This classification is based on both fisheries variables and social
39 variables. Although La Push is not included in the table based on the most recent NOAA study, it was
40 identified as a community with high fishing dependence and engagement in a 2007 NOAA study

¹ Fishing dependence was a combination of reliance and engagement indices for commercial and recreational fisheries. For details on methods, please see Norman, in progress, 2017.

41 (Norman et al., 2007). The methodology in the 2017 study relies on social data available via the census
 42 that is only available for a census designated place. As an unincorporated community, this data is not
 43 available for La Push and therefore it was not included in the 2017 study. However, La Push is
 44 recognized as one of several important fishing communities in the MSP Study Area, serving not only
 45 tribal fishers, but also non-tribal commercial and recreational fishers. Detailed information about the
 46 methodology and data used is available in the full NOAA reports. In addition, a national study by the
 47 Brookings Institute found that Pacific County was the fourth most fishing intensive local economy in the
 48 United States in terms of the share that fishing contributed to total county earnings (Kearney et al.,
 49 2014).

50 The fisheries related activities of the coastal communities adjacent to the Study Area are the focus
 51 of this chapter and are described in more detail below. However, the Plan also recognizes that the Study
 52 Area’s fishery resources support a broader set of communities. Although there are relatively few places
 53 for fishing vessels to safely access the ocean in Washington, those few places provide access to a
 54 relatively broad geographic area. The Strait of Juan de Fuca, Columbia River, and Grays Harbor provide
 55 the major access points while La Push and Willapa Bay provide marinas and boat launches for smaller
 56 vessels. Furthermore, the Strait opens the Study Area to the many ports of the Puget Sound region and
 57 the Columbia River gives reliable access to the ports not just in Washington, but in Oregon as well. As a
 58 result, Bellingham and Astoria-Warrenton have been as engaged in the fisheries of the Study Area as
 59 communities like Westport and Ilwaco that are located alongside it.

60 Conversely, the Plan also recognizes that non-tribal fishing communities adjacent to the Study Area
 61 are engaged in and dependent on fishing grounds elsewhere, such as in Puget Sound and off Oregon,
 62 California, and especially Alaska.² Revenue earned by commercial fishing and seafood businesses from
 63 fisheries, like the Bristol Bay Sockeye Salmon fishery, contribute to the viability of these businesses and
 64 to activity in Washington’s state and coastal economies. The Albacore Tuna fishery offers another
 65 example as much of the commercial and recreational catch occurs beyond the 700 fathom Study Area,
 66 yet still supports the communities of the coastal counties.

67 **Table 2.4-1: WA coastal communities adjacent to the MSP Study Area with high commercial fishing dependence Source:**
 68 **Norman in progress 2017**

Bay Center, Pacific County
Chinook, Pacific County
Ilwaco, Pacific County
Neah Bay, Makah Indian Reservation, Clallam County
Taholah, Quinault Indian Reservation, Grays Harbor County
Tokeland, Pacific County
Westport, Grays Harbor County

² The Treaty Tribes are restricted to their Usual and Accustomed ocean fishing grounds.

69 *Fisheries Management*

70 The fisheries occurring within the MSP Study Area are diverse and managed by a complex mix of
71 state, federal, regional, and international processes. Most every species supporting fisheries in the MSP
72 Study Area migrates across or straddles jurisdictional boundaries meaning that cooperation and
73 coordination between governments and fisheries management processes is the norm instead of the
74 exception. In addition, as further discussed in the Treaty Rights chapter, Washington is unique in the
75 nation for having tribal governments that hold treaty rights to fish in ocean waters. Several other tribes
76 hold treaty rights to fish in Puget Sound or the Columbia River for species that are impacted by fisheries
77 in the MSP Study Area. Cooperation and co-management with tribal governments occurs throughout a
78 number of state, regional, and international fisheries management processes. Cooperation with state,
79 tribal, federal, and international governments also occurs at the level of science and monitoring. This
80 section briefly outlines the existing fisheries management forums. More details are given below in the
81 descriptions of individual fisheries.

82 In Washington, the principal authority for managing fisheries is delegated to the Department of Fish
83 and Wildlife (WDFW). The Department includes the Washington Fish and Wildlife Commission, which
84 consists of nine citizen members appointed by the Governor. The Commission holds rule-making
85 authority and is responsible for setting fish and wildlife policy for the Department. It was established to
86 provide an open and deliberative process that promotes public involvement and confidence in
87 management decisions. The Department’s mandate to preserve, protect, and perpetuate fishery
88 resources includes both state and offshore waters, with the latter term defined as the “marine waters of
89 the Pacific Ocean outside the territorial boundaries of the state, including the marine waters of other
90 states and countries.”

91 The Pacific Fishery Management Council (PFMC) is a similarly open and deliberative process
92 established by Congress to manage federal fisheries off the coast of Washington, Oregon, and California.
93 The PFMC’s voting membership consists of six governmental representatives and eight private citizens.
94 The governmental representatives include representatives from WDFW and the state fisheries
95 management agencies of Oregon, California, and Idaho; NOAA Fisheries; and a tribe with federally
96 recognized fishing rights. The citizen members are nominated by the Governors of each state and are
97 appointed by the U.S. Secretary of Commerce. PFMC makes conservation and management
98 recommendations that are reviewed for consistency with national standards and other applicable
99 federal laws and implemented into federal regulation by NOAA Fisheries. PFMC organizes its work
100 primarily around four fishery management plans (FMPs)—Salmon, Groundfish, Coastal Pelagic Species,
101 and Highly Migratory Species—and a Fishery Ecosystem Plan.

102 The Pacific States Marine Fisheries Commission (PSMFC) was created as an interstate compact
103 agency in 1947 with Washington, Oregon, and California as the original members and Idaho joined in
104 1963 and Alaska in 1968. The PSMFC coordinates research activities, monitors fishing activities, and
105 collects data and maintains databases on salmon, steelhead, and other marine fish. The PSMFC does
106 not regulate fisheries, but provides recommendations and a forum for coordination between states for
107 state-managed fisheries.

108 In the international arena, five major processes directly affect fisheries in the MSP Study Area. Three
109 operate under treaties between the U.S. and Canada: the International Pacific Halibut Commission for
110 Pacific Halibut, the Pacific Salmon Commission, and the Pacific Hake/Whiting Treaty. These bilateral
111 management agreements work to monitor the shared stocks and to establish sustainable catch level and
112 allocate them among the two nations. The halibut and salmon stocks covered by the agreements involve
113 the fisheries and interests of Alaska as well. The other two processes affect fishing for Albacore Tuna.

114 Albacore management involves both the Inter-American Tropical Tuna Commission and the Western
 115 and Central Pacific Fisheries Commission and brings in the interests of many nations with fishing
 116 interests in the Pacific Ocean.

117 *Fishery Sectors*

118 The general convention is to classify fisheries, or fishery sectors, based on some combination of the
 119 main species or species group harvested, the area fished, and the fishing gear used. However, other
 120 factors may be used to differentiate one type of fishing from another and the definition of a fishery
 121 sector may differ depending on the management purpose being addressed. Furthermore, broader
 122 species groups, e.g. “Groundfish”, are sometimes used to summarize the activities of multiple fishery
 123 sectors. As the fisheries and fisheries sectors are described and grouped differently within the Cascade
 124 economic report (2015) compared to the chapter, Table 2.4-2 translates the groupings. Each fishery
 125 sector is discussed individually below. Within each sector description, the main fisheries occurring
 126 within the Study Area are also discussed in detail. However, while discussed separately, the Plan
 127 recognizes that there are links between sectors with businesses relying on revenue from more than one
 128 fishery sector. Note that some fisheries may have both a commercial and recreational component, while
 129 others only have one or the other. Furthermore, due to data availability, maps are only available for
 130 those fisheries listed in the far right column. Map 55 shows the combined commercial and recreational
 131 fishing intensity for the MSP Study Area.

132 **Table 2.4-2: Fisheries Sector Groupings and Available Maps**

Sector	Fishery Grouping	Fisheries Described in Chapter	Economic Report Description	Fisheries Use Maps Available
Commercial	Highly Migratory Species	- Albacore Tuna	- Albacore Tuna ³	- Albacore Tuna
	Coastal Pelagic Species	- Pacific Sardine	- Coastal Pelagic Species	- Pacific Sardine
	Groundfish	- Fixed Gear - Bottom Trawl - Midwater Rockfish Trawl - Whiting (Shoreside and At-Sea)	- At-Sea Pacific Whiting - Shorebased Fisheries o Whiting Trawl o Non-Whiting Trawl o Non-Trawl	- Groundfish (Bottom Trawl) - Pacific Whiting - Sablefish (Fixed Gear)
	Shellfish	- Dungeness Crab - Pink Shrimp - Spot Prawn - Razor Clam	- Dungeness Crab - Shrimp - Other Species ⁴	- Dungeness Crab - Pink Shrimp - Razor Clam
	Salmon	- Ocean Troll - Gillnet	- Salmon Troll - Salmon Net	- Salmon Troll
	Pacific Halibut	- Pacific Halibut	- Other Species ³	

³ Some tables report within a general Highly Migratory Species grouping, which is referenced as being comprised of mostly Albacore Tuna.

⁴ Other species includes spot prawn, Pacific halibut, and hagfish.

	Other	- Hagfish	- Other Species ³	
Recreational	Highly Migratory Species	- Albacore Tuna	- Albacore Tuna	- Albacore Tuna
	Groundfish	- Bottomfish	- Bottomfish	- Bottomfish and Lingcod
	Shellfish	- Razor Clam - Dungeness Crab	- Razor Clam	- Razor Clam
	Salmon	- Salmon	- Salmon - Steelhead	- Salmon
	Halibut	- Pacific Halibut	- Pacific Halibut	- Pacific Halibut

133

134

DRAFT

The fisheries use maps referenced in Table 2.4-2 and throughout this Chapter were developed by the WDFW to summarize the available information on areas of high importance to fisheries as required by RCW 43.372.040(6)(c). The primary purpose of the maps is to identify the footprint of each fishery (where fishery has occurred or has the potential to occur); and secondarily, to characterize the areas of high, medium, and low intensity within them. The intensity rankings refer to the relative level of activity within each fishery. They are not rankings of one fishery against another (i.e. a “high” in one fishery may have seen less overall activity than a “low” or “medium” from another, larger fishery).

WDFW used three general approaches to create the maps based on fishery dependent (i.e. logbook or observer) data, professional judgment of fishery managers and participants, or a combination of the two depending on the information available for each fishery:

1. Maps based on fishery-dependent data and percentile rankings: Each hexagon was evaluated for units of fishing effort (i.e. number of set or tows per hexagon) and all hexagons within the fishery’s footprint were ranked as:
 - a. “High”- Top 25% of hexagons
 - b. “Medium”- Middle 50% of hexagons
 - c. “Low”- Bottom 25% of hexagons
2. Maps based on logbook data with criteria-based intensity definitions- Due to limited location and effort data presented in logbooks, each hexagon was evaluated based on available effort data and other criteria that correlates with high activity in the particular fishery (e.g. depth, distance from shore)
3. Maps based on interviews with fishery participants and managers- Some fisheries have no logbook or observer data that can be used to evaluate effort level. Therefore, WDFW consulted with fishery participants and managers to determine intensity levels and footprints of select fisheries.

Major sources of uncertainty should be kept in mind when interpreting these maps. First, the intensity rankings do not represent an estimate of the impact or conflict that would be expected if a new use were to occupy the same space. Conflict in an area ranked as “low” intensity could still cause a significant adverse economic impact to a fishery and fishing communities. Evaluation of the conflict and impact that could arise between a fishery or fisheries and a proposed project would require careful study and examination of all available information. Second, uncertainty as to the footprint of a fishery and the areas of fishing intensity arises from both data limitations and annual variability in the fisheries. Regulations, environmental factors, movement of target species, and other factors affect fishing effort, distribution of the fleet, and community engagement in each fishery year to year. Footprints and intensity levels should be expected to vary.

More specific details for the methods behind producing each map can be found in [*Cite WDFW report on Fisheries use analysis and methods report (when finalized)*].

135

136 *Commercial Fisheries*

137 This section describes the various commercial fisheries operating within the MSP Study Area. The
138 focus is on their general size in terms of pounds landed and ex-vessel revenue earned; basics of how
139 they are regulated; and key aspects of their operations such as gears used, number of participants,
140 major species targeted, and the areas and time of year in which they fish.

141 The core information on commercial fishing activity comes from fish receiving tickets, commonly
 142 referred to as “fish tickets,” that record of the transaction between a vessel owner or operator making a
 143 delivery of commercially caught fish and the purchaser. The fish ticket reports the species or species
 144 group landed, amount of each species (typically in weight but sometimes in numbers of fish), and the
 145 price paid by the buyer for each species or species group landed (i.e. as noted above, “ex-vessel”
 146 revenues). Fish tickets are sent to WDFW and maintained in a state database that is also shared with
 147 state and federal fisheries management agencies through the Pacific States Marine Fisheries
 148 Commission (PSMFC) PacFIN database together with the data from Oregon and California.

149 The commercial fishing activities by the four counties at focus are shown in Table 2.4-3. Grays
 150 Harbor and Pacific Counties have been the most active on all metrics of participation (Table 2.4-3).
 151 Coastal county residents make up the largest proportion of commercial fishing vessel owners (299
 152 vessels) and ex-vessel revenue (\$40.4 million) from landings into coastal ports (Table 2.4-4). Commercial
 153 fishermen residing outside of the Washington coastal county region also fish in the MSP Study Area and
 154 use coastal ports. As Table 2.4-4 shows, there were over 230 vessels registered to Washington residents
 155 residing outside of the outer coast region, accounting for more than \$23.5 million in ex-vessel revenues
 156 in coastal ports in 2014. There were also 72 vessels registered in Oregon and 90 vessels registered
 157 elsewhere that delivered landings to Washington coastal ports in 2014 (Taylor et al., 2015). Table 2.4-5
 158 summarizes the total landings, ex-vessel revenue, and price of each species management group landed
 159 within the Washington coastal counties.

160 **Table 2.4-3: Landings, ex-vessel revenues, and participation by county for Washington coast commercial fisheries in 2014.¹**
 161 **Source: WDFW as reported in Taylor et al. (2015).**

County ⁵	Round weight (1,000 lbs)	Ex-vessel revenue (\$1,000)	Number of dealers	Number of vessels
Clallam	2,020	2,975	20	88
Grays Harbor	97,355	59,742	45	354
Pacific	29,206	29,285	30	364
Wahkiakum	779	966	7	80
WA Coast totals	129,360	92,967	98	700

162
 163 **Table 2.4-2: Count of vessels and total non-tribal ex-vessel revenues in 2014 in Washington coastal ports by vessel owner’s**
 164 **address. Source: WDFW as reported in Taylor et al. (2015).**

Vessel owner’s region	Number of vessels	Ex-vessel revenue (\$1,000)
Washington coast ⁶	299	40,439
Other Washington	232	23,657

⁵ There have been no non-tribal commercial fisheries landings recorded in Jefferson County ports along the outer Washington coast since 2007.

⁶ Vessel owner’s address is in one of the five Washington coast counties

Oregon	72	13,143
Elsewhere	90	13,326
Unknown	7	1,058
No vessel ID	-	1,344
Total	700	92,967

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166

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Table 2.4-3. Landings, ex-vessel revenue, and average revenue per pound in Washington coastal ports by fisheries management group, non-tribal fishery sector, 2014 and 2004-2014 range. Source: WDFW as reported in Taylor et al. (2015).

Management Group	Landings in 2014 (1,000s of round weight lbs)	Landings range during 2004-14 (1,000 lbs)		Ex-vessel revenue in 2014 (\$1,000)	Ex-vessel revenue range 2004-14 (\$1,000 2014 inflation adjusted)		Revenue per lbs in 2014	Revenue per lbs (11 year average) (2014 inflation adjusted)
		Low	High		Low	High		
Groundfish	51,182	26,702	80,517	9,324	5,819	13,703	0.18	0.16
Salmon	2,568	799	2,568	5,152	2,022	5,152	2.01	2.18
Crab	8,615	5,615	19,540	36,567	12,503	43,511	4.24	2.58
Shrimp	30,543	3,382	30,543	16,398	1,868	16,398	0.54	0.49
Coastal Pelagic	17,666	9,759	78,936	3,208	521	8,212	0.18	0.10
Albacore	17,184	10,084	18,600	20,216	11,333	28,216	1.18	1.21
Razor Clam ⁷	282	103	282	560	182	589	1.98	1.86
Other ⁸	1,444	268	2,833	1,769	512	2,832	1.23	1.01

⁷ The numbers from the shellfish category reported in Taylor et al. (2015) included geoduck harvest from the Strait of Juan de Fuca. WDFW updated these figures to include just razor clams commercially harvested in the Study Area.

⁸ Commercial fisheries included in the “other” category of this table are: Pacific Halibut, Spot Prawn, and Pacific hagfish.

Total	129,360	-	-	92,967	-	-	-	-
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168 **Groundfish**

169 The fishery sectors described here are grouped together in large part because they are managed
 170 under the PFMC’s Groundfish FMP. Groundfish is an umbrella term used to describe a diverse group of
 171 species that prefer seafloor habitats. The PFMC Groundfish FMP includes over 90 species— two-thirds of
 172 which are species of rockfish—although the great majority of commercial landings and revenues come
 173 from just a handful of stocks. These key commercial stocks include Pacific Whiting, Sablefish, Dover Sole,
 174 Petrale Sole, Lingcod, and Shortspine Thornyheads.

175 In the aggregate, the groundfish fisheries provide some of the largest annual landings into coastal
 176 ports (Table 2.4-5). From 2004-2014, groundfish was the largest fishery by volume in all years except
 177 2012 and 2013. This high volume of landings is attributable mainly to the Pacific Whiting fishery.
 178 However, the low price per pound paid for Pacific Whiting limits the overall ex-vessel revenue earned by
 179 the groundfish sector.

180 While often described together, there are multiple, distinct fishery sectors managed under the
 181 Groundfish FMP and operating in the Study Area that show diversity in terms of their fishing methods,
 182 fishing grounds, and target species. A first level of distinction can be made between vessels that use
 183 fixed gear (i.e. hook-and-line or pot gear) and those that use trawl gear. Among vessels using trawl gear,
 184 there is a further distinction between vessels that target Pacific Whiting (“whiting”) and those that fish
 185 for species other than Whiting (“non-whiting” or “traditional groundfish”). Another distinction applies
 186 within non-whiting trawl between vessels using bottom trawl gear and vessels using midwater gear to
 187 target rockfish in the water column. Within whiting, there is a distinction between the at-sea sector,
 188 where catch is processed aboard vessels, and a shoreside sector, where vessels land their catch in port.
 189 Each groundfish sector is described below.

190 *Fixed Gear*

191 Sablefish is the main target of the fixed gear sector. The species made up roughly 86% of total
 192 landings by weight and 95% of the total ex-vessel revenue over 2004-2014 in the fixed gear sector. Total
 193 fixed gear landings ranged from 0.9 million lbs to 1.7 million lbs and earning \$2.1 million to \$5.8 million
 194 in revenues. Sablefish is highly valued as seafood with a strong export market. The ex-vessel price per
 195 pound received for fixed gear caught Sablefish is one of the highest on the coast and has been greater
 196 than that paid for Dungeness Crab in some years. In 2014, at least 37 vessels recorded at least \$1,000 of
 197 landings value in this sector, with 29 vessels receiving \$10,000 or more.

198 Fixed gear vessels target sablefish across the U.S. West Coast, yet the MSP Study Area, especially
 199 north of Point Chehalis, has provided some of this sector’s most important fishing grounds. Submarine
 200 canyons and the continental shelf break and upper slope provide key fishing grounds for this sector
 201 (Map 17). Off Washington, fixed gear vessels have been required to fish seaward of 100 fathoms since
 202 2002 because of the need to reduce catch of Yelloweye Rockfish. The fish are targeted using baited
 203 hooks or pots that linked on longlines and placed and left on or near the seafloor and later retrieved. A
 204 string of hooks or pots are commonly referred to as a “set.”

205 *Bottom trawl and midwater rockfish trawl*

206 As noted, non-whiting trawl vessels use bottom trawl or midwater trawl gear to target a variety of
 207 species. Bottom trawl gear has been the more common gear during the 2004-2014 period and is the
 208 basis of the use map. Bottom trawl vessels target flatfish (e.g. Petrale and Dover Sole), Sablefish, and

209 many other species and are active over much of the Study Area's continental shelf and slope habitats
210 (Map 18). The midwater targeting strategy focuses on rockfish, primarily Yellowtail Rockfish, and occurs
211 on the shelf where schooling rockfish can be found. This fishery was depressed during 2004-2014
212 compared to historical levels because of measures taken to rebuild Canary and Widow Rockfish and so
213 no maps were produced for this fishing strategy. Midwater trawling has rebounded some since 2011 and
214 is expected to increase further because the allowable harvests of Canary and Widow are greatly
215 increased now that both species have been declared rebuilt.

216 Overall, non-whiting trawl accounted for between approximately 1.1% and 3.8% of total Washington
217 coast landings during 2004-14. Ex-vessel revenue value ranged from \$0.6 million to \$1.4 million during
218 that same time period. Sablefish earns the highest ex-vessel value per lb among trawl fishery species
219 although Petrale Sole is a highly valued species as well. The management changes made by PFMC over
220 the 2000s to rebuild overfished rockfish and reduce fishing capacity substantially reduced Washington's
221 bottom trawl fleet. However, the MSP Study Area still provides important fishing grounds for the
222 Astoria-based (Oregon) bottom trawl fleet, which is the most active bottom trawl port on the West
223 Coast. Pacific County, Whatcom County (Puget Sound), and Grays Harbor County are where the majority
224 of non-whiting groundfish landings in Washington occur.

225 *Whiting*

226 As noted above, the fishery for Pacific Whiting is conducted by both shorebased and at-sea catcher
227 vessels. The two are reported separately, highlighting the difference in the way the catch contributes to
228 the local economy. All whiting catcher vessels use midwater trawl gear designed to fish in the water
229 column, although trawling can take place close to the seafloor. Vessels in the at-sea sector tend to be
230 larger and have more horsepower with the ability to stay at sea for long periods of time.

231 Whiting are caught predominately off of Washington and Oregon, with the amount of Whiting
232 caught off of Washington varying from year to year, particularly in the at-sea sectors (Table 2.4-6).
233 Shoreside vessels, in contrast, tend to stay as close to port as possible because the flesh quality of Pacific
234 Whiting is improved if processed quickly. The continental shelf and upper continental slope areas of the
235 Study Area are key fishing grounds (Map 19). Avoidance of salmon and rockfish bycatch has been a key
236 influence on where the fishery has occurred during the 2004-2014 time period with the bycatch
237 constraints pushing the fishery into smaller areas than would otherwise be fished if whiting catch were
238 the only consideration.

239 The shorebased Pacific Whiting trawl fishery is conducted off the coasts of Washington and Oregon
240 with active ports at Westport and Ilwaco in Washington. Landings have consistently been the largest
241 component of total commercial landings on the Washington coast in terms of weight from 2004-2014,
242 with the exception of 2012 and 2013 when it was surpassed by Pacific Sardine landings. In 2014, ex-
243 vessel revenue was \$5.5 million. Half of the 10 vessels participating in 2014 received at least \$250,000 in
244 ex-vessel revenue.

245 Within the at-sea sector, there are two distinct sectors: motherships and catcher-processors. In the
246 mothership sector, catcher vessels deliver to a mothership vessel, which only processes whiting. In the
247 catcher-processor sector, vessels both catch and process their own catch. Each of the at-sea sectors
248 operates under a co-op system that operates to divide the PFMC's quotas for whiting and bycatch
249 species like Darkblotched Rockfish. The catcher-processors, mothership processing vessels, and many of
250 the mothership catcher vessels are based in Puget Sound.

251

252

253

254 **Table 2.4-4: Total coastwide annual and estimated catch off the Washington coast by vessels operating in the non-tribal, at-**
 255 **sea Pacific whiting sector. Source: WDFW as reported in (Taylor et al., 2015)**

Sector	Sector total 2014 (metric tons)	Sector total range during 2005-14 (metric tons)		Washington share in 2014	Washington share range 2005-14	
		Low	High		Low	High
Catcher-Processors	103,486	34,620	108,121	0%	0%	52%
Motherships	62,109	24,091	62,109	14%	13%	91%

256 **Salmon**

257 Salmon are perhaps Washington’s most historic and iconic fish. They are highly valued as seafood
 258 and earn the second highest revenue per pound of the species fished in the MSP Study Area (11-year
 259 average of \$2.18 per lb.). The total value of the fishery, however, is limited by the low allowable catches
 260 relative to fisheries like Dungeness Crab and Pacific Whiting (see Table 2.4-5). The commercial salmon
 261 fisheries have been greatly reduced from historic levels primarily because of population declines across
 262 several salmon runs and the major changes in how salmon stock were shared with the treaty tribes that
 263 followed from the Boldt Decision in 1974 (see Tribal Fisheries Section below and Section 1.6 for details
 264 on treaty rights).

265 Two distinct sectors commercially fish for salmon in the MSP Study Area: the ocean troll fishery and
 266 the gillnet fishery. The PFMC is the main process for setting seasons in the troll fishery, while WDFW
 267 sets seasons for the gillnet fisheries. Both fishery sectors, however, are intertwined with the larger,
 268 complex salmon management processes that involve the three West Coast states as well as Alaska and
 269 Idaho, Canada, and the several tribes holding rights to fish for salmon across the Pacific Northwest. The
 270 core challenge across all salmon fisheries has been to focus harvest on hatchery raised fish and healthy
 271 wild populations while reducing pressures on the wild stocks of high conservation need.

272 *Ocean Troll*

273 Troll gear is a type of hook and line gear that vessels pull through the water using bait or artificial
 274 lures to attract fish. Vessels operate over a wide range of ocean waters with the most fishing activity
 275 occurring in depths between 20 and 80 fathoms north of the Queets River and between 20 and 60
 276 fathoms south of that landmark (Map 20). Chinook and coho salmon are the main targets of the troll
 277 fleet. Chinook is the more frequently landed fish in this sector, constituting about 84% of landings by
 278 weight and earning 94% of ex-vessel revenue in 2014. Total ex-vessel revenue was about \$2.4 million in
 279 2014. In general, ocean troll salmon fetches a relatively high price, with \$4.30 per lb. in 2014 and an 11-
 280 year average of \$4.08 per lb. The number of licenses WDFW issued to ocean troll vessels ranged from
 281 152 to 157 between 2004 and 2014. In 2014, at least 111 vessels recorded at least \$1,000 of salmon troll
 282 landings, 79 of which received at least \$10,000 in ex-vessel revenue from those landings. On average,
 283 Pacific County has reported the greatest share of ex-vessel revenues (49.4%), although Grays Harbor
 284 County surpassed Pacific County in 2013.

285 *Gillnet*

286 The gillnet fisheries operate in Willapa Bay, Grays Harbor, and the Columbia River.^{9,10} WDFW
287 regulates the two estuaries separately with seasons timed to intercept the adult fish returning to their
288 natal streams to spawn. Vessels deploy and actively tend free floating nets that entangle the fish in their
289 mesh. Nets can be no longer than 1,500 feet long and there are mesh size regulations depending on
290 harvest area. In addition to Chinook and Coho, gillnetters also target Chum Salmon. In 2014, Coho
291 constituted about 57% of landings by weight and about 50% of landings by value, although these
292 numbers can vary greatly from year to year. Between 2004 and 2014, the number of gillnet licenses has
293 ranged from 192-195 in Willapa Bay and 63 to 64 for Grays Harbor. Landings have ranged from a low of
294 0.5 million lbs in 2007 to a high of 2 million lbs in 2011 with corresponding ex-vessel revenues of \$1
295 million to \$3 million. The 11-year annual average ex-vessel price for salmon gillnet fishery landings for
296 2004-2014 was about \$1.51 per lb. In 2014, 138 vessels recorded at least \$1,000 of salmon net landings
297 on the Washington coast, with 72 vessels receiving at least \$10,000 in ex-vessel revenue from those
298 landings.

299 *Highly Migratory Species*

300 *Albacore Tuna*

301 The Albacore Tuna commercial fishery is managed under the PFMC's Highly Migratory Species FMP.
302 Because of the stock's wide ranging migration, stock assessments, and international agreements,
303 regulation of the fishery is minimal and it is one of the few fisheries on the West Coast where
304 participation is still open to entry from new fishers. Albacore are caught in Washington by both large
305 troll vessels that harvest far offshore, and by locally based smaller troll vessels. Canadian vessels also
306 fish in U.S. waters and make landings in Washington under a treaty between the U.S. and Canada. The
307 fishery happens in the summer and late fall when the fish migrate to the West Coast. While most of the
308 fishing occurs outside the MSP Study Area, within the Study Area fishing is most common between 30
309 and 50 nautical miles offshore but sometimes closer in to 20 nautical miles (Map 21). The Albacore Tuna
310 fishery has the highest participation level among the Washington coast fishery sectors, with between
311 221 and 338 unique vessels making landings into Washington ports each year. Many vessels that
312 participate in the salmon troll fishery also fish for albacore.

313 Washington coast Albacore landings ranged from about 10 million lbs to 18.6 million lbs from 2004-
314 2014. Ex-vessel values ranged from about \$11.3 to \$28.2 million during that same time period. The
315 average ex-vessel price in 2014 was about \$1.18 per lb, with an 11-year average of \$1.21 per lb (Table
316 2.4-5). In 2014, 210 vessels received at least \$10,000 in ex-vessel revenue from tuna landings on the
317 Washington coast. Westport (Grays Harbor) and Pacific County land the vast majority of Albacore on the
318 Washington coast.

319 *Coastal Pelagic Species*

320 The PFMC's coastal pelagic species (CPS) FMP consists of Northern Anchovy, Market Squid, Pacific
321 Sardine, and Pacific Mackerel. These species are caught mostly by vessels using purse seine gear. Off
322 Washington, Pacific Sardine and Northern Anchovy are the main commercial species caught with Pacific
323 Mackerel landed incidentally. WDFW authorized a trial Pacific Mackerel fishery for the first time in 2016.
324 Small scale harvest of anchovies occurs in the nearshore, including state waters, Willapa Bay, and Grays
325 Harbor. Anchovies are generally used for bait, and the majority of anchovies are landed in Grays Harbor.

⁹ The Columbia River fishery is not included in this discussion as it is outside the MSP Study Area.

¹⁰ Spatial data are unavailable to produce a map of the salmon gillnet fisheries in the estuaries for this MSP.

326 The CPS fishery has brought in relatively high volumes of landings (up to 78.9 million lbs in 2012), yet
327 low value per lb (\$0.10 per lb as the 11-year average from 2004-2014). However, this fishery is also
328 highly volatile (the volatility being driven by Pacific Sardine) with landings as low as 9.7 million lbs during
329 2004-14, with large swings from year to year. Ex-vessel revenue from CPS landings in Washington
330 ranged from about \$0.5 million to \$8.2 million from 2004-2014, with \$3.2 million landed in 2014 (Table
331 2.4-5). In 2014, 10 vessels recorded at least \$1,000 of revenue from CPS landings in Washington, seven
332 of which received at least \$10,000 from CPS landings.

333 *Pacific Sardine*

334 Sardine harvest is prohibited in state waters, with the federal water fishery open from April 1 to
335 December 31. Sardines are landed mostly in Grays Harbor County, which has accounted for about 75%
336 of the ex-vessel revenue values on average for sardines. Washington's share of coast-wide sardine
337 harvest has increased recently, due to the changing focus in California to squid, and the proximity of the
338 fish to Westport (Map 22). In 2015 and 2016, the Pacific Sardine fishery was closed by the PFMC
339 because the stock biomass had dropped below a threshold biomass limit. The stock is known to
340 fluctuate in abundance and may rebound above the limit if environmental conditions become favorable.

341 *Shellfish*

342 *Dungeness Crab*

343 Dungeness Crab have been the biggest revenue earner among the commercial species. Ex-vessel
344 revenue ranged from \$12.5 million to \$43.5 million during 2004-2014 (Table 2.4-5), and earned the most
345 coastal fisheries revenue for 9 of those 11 years. They are highly valued as seafood both locally and
346 internationally and earn the highest average price per lb on the coast. The 11-year average ex-vessel
347 price was \$2.58 per lb. The price has been on an increasing trend since 2010, as markets for live crab in
348 Asia have continued to develop. Prices reached extraordinary levels in 2014 with buyers paying \$4.24
349 per lb on average over the year and over \$6.00 per lb in March, April, and May. Dungeness Crab can
350 fluctuate strongly in abundance from year to year because of variability in ocean conditions that affect
351 survival and settlement of the larvae; the annual harvest fluctuates in kind. For example, crab landings
352 were 5.6 million lbs in 2004 and 19.5 million lbs the following year.

353 Fishery participants trap the crabs using baited pots. Pots are deployed on soft bottom in depths
354 ranging from 30 to 600 feet (5 to 100 fathoms) and are fished on lines, a single line to each pot, with
355 length depending on the water depth. Crab are harvested along the entire Washington coast, including
356 inside Grays Harbor, Willapa Bay, and the Columbia River yet the most intensive fishing takes place in
357 the southern half of the MSP Study Area (Map 23). The primary landing ports and processing facilities
358 are in Westport, Chinook, Tokeland, South Bend and Ilwaco. Neah Bay and La Push on the northern
359 coast are minor ports for crab, and product landed there is typically sent elsewhere for processing.
360 Growth in this aspect of the industry drives increasing prices and economic benefits for the industry and
361 coastal communities.

362 WDFW manages the Dungeness Crab fishery in coordination with the coastal treaty tribes and the
363 fisheries management agencies of Oregon and California. Coastwide coordination occurs on a number of
364 issues including a tri-state agreement that establishes procedures for opening the season. WDFW and
365 the coastal treaty tribes negotiate annual management agreements to determine how harvest within
366 the tribal U&As will be shared. Special Management Areas (SMAs), which close portions of the tribal
367 U&As to non-tribal vessels for part or all of the fishing season, and delayed season opening dates have
368 been the main tools for sharing the catch. Tribal participation in the crab fishery began to increase after

369 the 1994 Rafeedie Decision established that the Stevens Treaties applied to shellfish as well.¹¹ The tribal
370 fishery gradually increased after 1994 until reaching current levels in terms of harvest in the mid-2000s.
371 Since 2004, on average, the tribal fishery has accounted for just over 20% of the Dungeness Crab
372 landings on the coast. This same figure was 1% on average over 1990-1994.

373 In terms of participation, 192 vessels recorded at least \$1,000 of Dungeness Crab landings on the
374 Washington coast in 2014, representing the second highest participation level among the Washington
375 coast fishery sectors. Of those, 117 vessels received at least \$100,000 in ex-vessel revenue. Although
376 historically Dungeness Crab fishermen participated almost exclusively in the crab fishery, currently many
377 participate in multiple fisheries in order to sustain their businesses year round. The fishery is highly
378 competitive and causes a race for crab where the bulk of the harvest is within the first two months of
379 the season.

380 The season begins December 1 and closes September 15 of the following year, except where state-
381 tribal agreements have dictated otherwise or when crab quality delays are put in place. In recent years,
382 agreements have kept areas north of Grays Harbor closed to the commercial fishery until January. The
383 delayed season openings have led to concerns about higher competition and use south of Westport.
384 Furthermore, WDFW may close the fishery for other reasons, such as closure for insufficient meat
385 quality or domoic acid to ensure a safe product in the market place.

386 *Pink Shrimp*

387 Pink (a.k.a. "Ocean") Shrimp are caught using trawl gear that is designed to fish slightly off the
388 seafloor. Most shrimp trawl vessels are "double-rigged" meaning that they tow two nets, one on either
389 side of the vessel. The fishery operates in depths of 300 to 750 feet (50 to 125 fathoms) off the
390 Washington and Oregon coasts during season that runs from April 1 to October 31 annually (Map 24).
391 Westport and Ilwaco are the two key landing ports with Westport receiving the bulk of the landings. In
392 seafood markets, Pink Shrimp are often referred to as cocktail shrimp.

393 WDFW manages and coordinates regulations of the Pink Shrimp fishery with the Oregon
394 Department of Fish and Wildlife, as Oregon based fishing vessels fish in the MSP Study Area as well.
395 Volumes of shrimp landings have increased since 2012 with 30.5 million lbs landed on the Washington
396 coast in 2014 (over double of what was landed in 2013). Ex-vessel revenues have similarly been
397 increasing, with \$1.9 million earned in 2007 to \$16.4 million in 2014. This may be partially due to the
398 value of shrimp also rising, with a price of \$0.54 per lb in 2014, which is higher than the 11-year average
399 of \$0.49 per lb (Table 5). In 2014, 32 vessels recorded at least \$1,000 of pink shrimp landings on the
400 Washington coast, including 26 vessels that received at least \$100,000 in ex-vessel revenue from those
401 landings. Shrimp abundance, improved processing capacity, and other factors have contributed to the
402 expansion of this fishery in Washington over recent years. More plans to increase shrimp processing
403 capacity in Westport and the recent purchase of the idle shrimp processing plant in South Bend may
404 further boost this industry.

405 *Spot Prawn*

406 The commercial spot prawn fishery is relatively new, starting in 1999. The fishery occurs along the
407 outer coast of Washington between March 15 and September 15, about 20 to 40 nm offshore at depths
408 between 420 and 600 feet (70 and 100 fathoms). Gear used in this fishery is primarily pot longline. The
409 fishery has been managed as a limited-entry fishery, with eight licenses currently in circulation; between
410 three and five of these licenses are actually active. Participants in this fishery typically also participate in

¹¹ More information on the Rafeedie Decision is available in Section 1.6.

411 other fisheries, such as Dungeness Crab and Albacore Tuna. From 2004 to 2013, the highest value in ex-
412 vessel revenues was \$754,585 (2010) with a low of \$102,257 (2013). Live spot prawns can earn \$10 per
413 lb and greater. It has also become popular to sell “prawn tails” directly to the public during summer.
414 Primary ports for spot prawn landings include Westport, Seattle, Neah Bay, and Port Angeles, with Grays
415 Harbor (Westport) accounting for an average of 87% of fishery revenues from 2004-13 (Industrial
416 Economics Inc., 2014).

417 *Razor Clams*

418 The commercial razor clam fishery occurs from May through June each year and harvest is limited in
419 Washington to the detached spits at the mouth of Willapa Bay in Pacific County, accessible only by boat.
420 Unlike other commercial fisheries, vessels are not used in the actual harvesting. The majority of
421 commercial razor clam catch is sold as bait for the Dungeness Crab fishery. In 2015, 132 commercial
422 razor clam licenses were issued by WDFW, and 122 of those license holders were residents of Pacific and
423 Grays Harbor County.

424 Razor clams are landed exclusively in Pacific County and Grays Harbor, with Pacific County averaging
425 large majority of revenues. Total harvest has ranged from a low of 102,900 lbs to a high of 281,900 lbs
426 between 2004 and 2014. Total revenue has ranged from a low of \$182,390 to a high of \$588,620
427 between 2004 and 2014.

428 *Pacific Halibut*

429 The commercial harvest of Pacific Halibut takes place in an open access directed commercial fishery
430 and through an incidental retention allowance of halibut in the fixed gear sablefish fishery north of Point
431 Chehalis and for the salmon troll fishery coastwide. Due to the derby nature of the fishery and recent
432 increases in effort, the directed commercial fishery only lasts a few days. When open, the directed
433 fishery is only open south of Point Chehalis. Participation varies depending on the timing and availability
434 of other fishing opportunities.

435 *Hagfish*

436 Hagfish (aka slime eels) began as a commercial fishery in 2005 and operates off Washington and
437 Oregon. It remains as one of the state’s few open access fishing opportunities with licenses available to
438 anyone wanting to participate. There have been between 15 and 20 licenses in circulation, with fewer
439 than 3 to all 15 active in any given year. This fishery is open year-round, and operates via pot gear on
440 muddy or sandy bottom between depths of 300 to 480 feet (50 to 80 fathoms), as it is prohibited in
441 waters shallower than 300 feet. The market is extremely volatile with almost all of the product going to
442 Korea. The voluminous slime produced by hagfish makes the fishery a difficult one as well. Westport is a
443 key landing port, and landings are also made in Ilwaco, Port Angeles, Port Townsend, and Blaine.
444 Landings, the price-per-lb, and total revenue in Washington have increased steadily since the fishery
445 started, with ex-vessel values reaching a historical high of about \$2.27 million in 2012.

446 *Recreational Fisheries*

447 This section describes the major recreational fisheries occurring within the MSP Study Area.
448 Fisheries managers typically classify recreational fisheries based on the species or species groups being
449 targeted, but again, they may be classified and categorized differently for different management
450 purposes. Table 2.4-7 lists the categories used here and the average number of angler trips associated
451 with each. Unlike most commercial fisheries, recreational fisheries are open to anyone wishing to
452 participate and a single fishing license authorizes anglers to participate in all MSP Study Area fisheries. A

453 single fishing trip might cover what are described as separate fisheries (e.g., salmon and bottomfish
454 “combo” trip). The full diversity of fishing opportunities, seasons, and rules can be viewed in in the Sport
455 Fishing Regulation Pamphlet published by WDFW each year (Washington Department of Fish and
456 Wildlife, 2016).

457 The major categories described here include salmon, groundfish (called “bottomfish” in state fishing
458 regulations), Pacific halibut, Albacore Tuna, and Razor Clams. With the exception of razor clam harvests,
459 which take place on the beach, the major recreational fisheries discussed here are conducted on boats
460 on the open ocean, as well as inside the estuaries¹² for certain species like salmon. Anglers also fish from
461 shore for species like Redtail Surfperch, and from jetties for species like Lingcod, yet these activities are
462 not discussed in detail here. Likewise, while the focus in this section is on the fisheries happening within
463 the MSP Study Area some fishing trips cross over into the Strait of Juan de Fuca or Columbia River
464 Estuary.

465 The core information on the recreational fisheries of the MSP Study Area is collected by WDFW’s
466 Ocean Sampling Program (OSP). Using a survey sampling design, WDFW staff counts vessels active in the
467 major ports and sample the catch from a portion of them on random days of the week. This information
468 on fishing effort (“angler-trips”) and catch are then used to estimate the total effort and catch for each
469 month of the year. The estimates of catch and effort are publically available together with those from
470 Oregon and California through the PSMFC’s RecFIN database. OSP focuses primarily on the boat mode
471 but also samples anglers fishing from certain jetties.

472 Boat-based recreational fishing has two distinct components: a charter boat, “for-hire” fleet carrying
473 paying passengers and a “private boat” fleet where anglers fish aboard vessels they rent or own. Over
474 the past decade, charter vessels carried approximately 32% of anglers making fishing trips and 66% are
475 taken on private vessels on average (Table 7). Charter boats and private vessel activity varies by species
476 caught and port location. Westport and Ilwaco have had the largest charter boat operations (Table 7).

477 The Washington charter boat industry has been a major part of coastal communities for decades.
478 The industry developed rapidly after World War II, focusing exclusively on salmon through the 1960s
479 and Westport billing itself as the “Salmon Fishing Capital of the World.” The number of charter vessels
480 peaked in 1977 but between 1977 and 1984, there was a rapid decline due to major changes in salmon
481 management and abundance. Those remaining in the business diversified their portfolio of trips and
482 began out new opportunities for bottomfish, Albacore, and eventually Pacific Halibut. Charter boat
483 activity has been relatively stable since the 1990s, but remains below the historical peak (Industrial
484 Economics Inc., 2014).

485 A survey of the charter boat industry indicated that 100% of the charter boat crew, owners, and
486 guides/skippers were Washington coast residents. Charter boat clients out of the Westport area are
487 estimated to be comprised of between 85% and 95% Washington residents, whereas 45% of clients out
488 of the Ilwaco area were estimated to be Oregon residents, 45% residents from inland Washington
489 counties, 5% from the Washington coast, and 5% from other areas (Taylor et al., 2015). On average, over
490 half of the current charter boat trips target salmon, with bottomfish representing the next most
491 frequently targeted species group (Table 8). The average number of charter boat trips annually has
492 decreased by about 8% when comparing trips made during the 2009-2013 period with the number of

¹² Recreational fishing occurs in Willapa Bay and Grays Harbor estuaries. However, while maps were able to be produced for recreational fishing activities in the ocean, spatial data for recreational fishing in the estuaries were unavailable. Therefore, the State is unable to provide maps showing recreational fishing in the estuaries.

493 trips made between 2004 and 2008. Comparing those same time periods, the number of trips targeting
 494 Pacific Halibut, salmon, and bottomfish have declined while Albacore trips have increased.

495

496 **Table 2.4-5. Sport fishing effort by trip mode 2004-2013 average for all coastal Washington port areas. Source: Ocean**
 497 **Sampling Program, WDFW as reported in (Taylor et al., 2015)**

Mode of Fishing Trip	Westport	Ilwaco	Neah Bay	La Push	Chinook	All Areas
Charter boat	32,695	10,171	3,131	1,144	48	47,188
Private boat	20,020	26,181	29,754	7,051	15,416	98,420
Jetty ¹³	-	-	-	-	-	1,783
Total ¹⁴	52,711	36,351	32,881	8,192	15,461	147,389

498

499 **Table 2.4-6. Charter boat fishing effort by targeted species 2004-2013 annual average for all coastal Washington port areas.**
 500 **Source: Ocean Sampling Program, WDFW as reported in (Taylor et al., 2015)**

Targeted Species	Average Annual Number of Trips	Percent of Total
Albacore	1,707	4%
Bottomfish	13,877	29%
Halibut	4,976	11%
Salmon	26,555	56%
Other	74	<1%
Total	47,188	100%

501

502 Private vessel anglers launch, on average, primarily from Neah Bay (30%), Ilwaco (27%), and
 503 Westport (20%) (Table 2.4-7). The smaller ports of La Push and Chinook also offer a limited number of
 504 slips for private boats as well as boat launches. No data are currently available that identify the county
 505 of residence of private boat anglers fishing in ocean waters off the Washington coast. Overall, private
 506 boat trips have increased by about 11% when comparing the number of average annual trips made
 507 between 2009 and 2013 with average annual trips made between 2004 and 2008. Targeted species with
 508 the largest increases in trips were salmon, albacore, and bottomfish. More than 74% of trips taken by
 509 private vessels target salmon (Table 2.4-9). Cascade Economics (Taylor et al., 2015) reports a recent
 510 trend toward larger private vessels capable of traveling farther offshore.

511

512 **Table 2.4-7. Average annual private vessel fishing effort by targeted species 2004-2013 for all coastal Washington port areas.**
 513 **Source: Ocean Sampling Program, WDFW as reported in (Taylor et al., 2015)**

Targeted Species	Average Annual Number of Trips	Percent of Total
Albacore	2,621	3%

¹³ North Bay jetty area of the Columbia River.

¹⁴ Totals may not add to 100% due to rounding

Bottomfish	13,254	14%
Halibut	7,844	8%
Salmon	73,018	74%
Dive	397	<1%
Other	1,285	1%
Total	98,420	100%

515

516 Shore and jetty based anglers primarily fish from the Columbia River Jetty near Ilwaco. In 2013,
517 3,467 trips were recorded by anglers here, substantially higher than the 2004-2013 annual average of
518 1,783 trips. An estimated 87% of the fish caught by jetty anglers in 2013 were salmon, with rockfish
519 making up the remainder (Taylor et al., 2015).

520 Sport catch (a.k.a. the number of fish caught or clams dug) by species group is shown in Table 2.4-
521 10. Catch, trends, and management for each species group are discussed below.

522 **Table 2.4-8. Average annual sport catch in marine waters¹⁵ along the Washington coast 2007/2008 through 2011/2012**
523 **sportfishing seasons. Source: WDFW as reported in (Taylor et al., 2015).**

Species Group	Average Annual Number Caught ¹⁶
Salmon ¹⁷	105,077
Sturgeon ¹⁸	378
Pacific Halibut	7,613
Bottomfish ¹⁹	277,912
Razor Clams	3,129,482

524

525 Salmon

526 The recreational salmon fishery occurs in Willapa Bay, the Chehalis Basin (Grays Harbor, Humptulips
527 River, and Chehalis River), and the Pacific Ocean (Industrial Economics Inc., 2014). Ocean salmon are the
528 most popular finfish target species for effort (Table 2.4-8 and Table 2.4-9), and the second highest in
529 terms of average catch between 2007 and 2012 (Table 2.4-10). Salmon catch has been relatively
530 inconsistent in recent years, with the lowest number of fish caught (37,272 fish) in the 2008/09 season
531 and the highest number (221,205 fish) in the following season (2010/11).

532 During the 2011/12 fishing season, about half of all salmon caught in the Study Area occurred off
533 Westport (WDFW Marine Area 2), about 25% were near the Ilwaco area (WDFW Marine Area 1), and
534 about 12% caught in the area near Cape Flattery (WDFW Marine Area 4a). The species of salmon caught

¹⁵ Marine areas include coastal streams, which are outside of the MSP Study Area.

¹⁶ Numbers represent the number of fish caught or clams dug.

¹⁷ Salmon totals include all species, including coho and Chinook.

¹⁸ Sturgeon total includes only fish caught in coastal streams.

¹⁹ Bottomfish include all rockfish species and other bottomfish.

535 also varies by area, with about half of all Chinook salmon landed in Westport, and about three quarters
536 of all pink salmon caught being landed in Neah Bay (Taylor et al., 2015). Westport and Ilwaco both
537 strongly and equally represent fishery harvest during 2003-2013, a period of inconsistent effort and
538 catch. High and moderate areas for ocean salmon fishing are shown in Map 25. The coastal estuary
539 recreational salmon fishery has also been inconsistent from 2003-2012, with a high of 33,109 fish caught
540 in 2012. Grays Harbor accounts for about 60% of the fish caught (Industrial Economics Inc., 2014).

541 Salmon recreational fisheries off the coast of Washington are managed by WDFW with management
542 coordinated with PFMC and co-managed with the tribes. Because of the migratory behavior of salmon,
543 management is a complex process. FMPs are in place for salmon because some evolutionary significant
544 units are listed under the Endangered Species Act. Most of the Chinook salmon caught, however, are of
545 hatchery origin, largely from hatcheries in nearby coastal streams as well as in the Columbia River and
546 Puget Sound. Marine recreational fishing regulations for salmon include daily limits, release rules,
547 minimum size, and season dates, all of which vary by Marine Catch Area.

548 Bottomfish

549 The recreational bottomfish fishery represents the largest recreational finfish fishery by average
550 number of fish caught annually (Table 2.4-10). The bottomfish fishery is also the second most popular
551 finfish recreational fishery in terms of number of trips taken for targeted species for both charter boat
552 and private boat fishing (Table 2.4-8 and Table 2.4-9, respectively). Primary targets within this fishery
553 are rockfish and lingcod, with Black Rockfish being the main target. Other bottomfish species targeted or
554 kept include lingcod, cabezon, kelp greenling, and Pacific cod. While the season has been open year-
555 round, weather typically limits fishing to March through October. Westport, Neah Bay, and La Push are
556 the primary ports for this fishery. Westport sees the greatest amount of recreational bottomfish fish
557 caught, consisting mostly of Black Rockfish while Neah Bay has a much higher diversity of rockfish
558 species caught, including China, Quillback, and Copper Rockfish. Westport supports most of the charter
559 trips, and Neah Bay hosts the majority of private vessels. The fishery has been relatively stable over time
560 (Industrial Economics Inc., 2014; Taylor et al., 2015). High and moderate recreational fishing activity in
561 the MSP Study Area for bottomfish are shown in Map 26.

562 Pacific Halibut

563 The recreational Pacific Halibut fishery occurs from May through September. It is a quota limited
564 fishery that lasts only four to five days per year in the most popular areas on the coast. The fishery has
565 been relatively stable since 2003 (Industrial Economics Inc., 2014), with a five year average from
566 2007/08 to 2011/12 of 7,613 fish caught per year (Table 2.4-10). The north coast ports of Neah Bay and
567 La Push accounted for about twice the number of angler trips for halibut during the 2011/12 season
568 than along the south coast (Taylor et al., 2015). Neah Bay and La Push have also consistently had
569 recorded the large majority of recreational halibut harvest over the past decade (Industrial Economics
570 Inc., 2014). High and moderate recreational fishing in the MSP Study Area for halibut are shown in Map
571 27.

572 Both private and charter vessels participate in this fishery, but the fishery favors larger vessels since
573 it occurs fairly far offshore. Managers have noticed an increase in private vessels participating in this
574 fishery, growing from about equal participation between private and charter vessels in 2004 and 2005,
575 to double the number of trips made by private vessels than charter vessels in the 2013 season (Industrial
576 Economics Inc., 2014).

577 Washington coastal Pacific Halibut fisheries are managed under the PFMC’s Pacific Halibut Catch
578 Sharing Plan (CSP) for Area 2A (Norman et al., 2007).²⁰ The CSP specifies how the Area 2A total allowable
579 catch, as defined by the International Pacific Halibut Commission, is allocated or “shared” among various
580 state commercial and recreational fishing interests. WDFW manages its recreational fisheries by three
581 subareas: North Coast, South Coast, and Columbia River. The fishery is managed through quotas, and is
582 monitored regularly to close or extend the fishing season as appropriate (Taylor et al., 2015).

583 Albacore Tuna

584 Albacore Tuna is a popular recreational fishery along the Washington coast during the summer and
585 early fall when the fish migrate into the area. As with the commercial fishery, the fish tend to be
586 available between 20 and 100 nautical miles offshore (Map 28). Albacore are caught using jigs, which
587 are trolled behind the vessel, as well as with live bait while drifting. Albacore are targeted by both
588 charter boats and private vessels. The average number of total albacore trips from 2004-2013 was 4,328
589 (Table 2.4-8 and Table 2.4-9). Substantial increases in albacore private boat fishing activity for albacore
590 occurred in 2013, with 7,056 private vessel trips. Westport and Ilwaco are the main ports for this fishery.

591 Razor clam

592 The coastal beach-beach based razor clam fishery is an extremely popular recreational fishery along
593 the Washington coast. Razor clam recreational harvesting, cleaning, cooking, eating, and canning have
594 been an important focus of family relationships and local culture in Washington State coastal
595 communities for many generations. With between 275,000 and 460,000 seasonal digger trips harvesting
596 as many as 6.1 million clams, the fishery generates between \$25 and \$40 M in tourist related income to
597 the economies of the rural coastal communities along the MSP Study Area. About 70% of the fishery
598 harvest occurs along the Long Beach and Twin Harbors areas. Recent years (2013 and 2014) have seen a
599 marked increase in fishery participation and clams dug. The number of clams dug is highly correlated
600 with the number of digger trips. Razor clamming occurs along the southern Washington coast south of
601 the Quinault Indian Reservation to the mouth of the Columbia River and at Kalaloch²¹ (Map 29).

602 Active state management of the razor clam fishery began in 1929 with a daily bag limit of 36 clams
603 per person and no season. Over the years, clamming seasons have been established and daily bag limits
604 have been adapted based on razor clam population assessments. Also, starting in 1993, governments of
605 coastal tribes began to exercise treaty fishing rights for shellfish and since that time razor clam beaches
606 north of Point Chehalis have been co-managed through state and tribal fishery management
607 agreements. Opening of tribal fisheries (commercial, ceremonial, and subsistence) are timed to avoid
608 conflicts with the state recreational fishery openers. At present, with stable populations, the state
609 recreational season starts with the first good tide series in October with sporadic openings each month,
610 depending on the numbers of harvestable clams by area, ending in early to late May. The state (WDFW)
611 recreational daily bag limit is 15 clams per person. Occasionally, long-term area closures of both state
612 and tribal razor clam fisheries have occurred in response to large scale population declines or human
613 health factors. Recently, closures have been due to increases in levels of naturally occurring marine
614 biotoxins (caused by blooms of harmful algae), which can significantly disrupt these fisheries.

²⁰ Area 2A is comprised of the area off the coasts of Washington, Oregon, and Northern California.

²¹ Kalaloch beach is located within the Olympic National Park and the recreational razor clam fishery at this beach is jointly managed by the Olympic National Park and WDFW.

615 **Dungeness Crab**

616 Dungeness Crab is one of the most popular recreational fisheries in the state, mainly in Puget Sound.
 617 However, relatively little activity occurs within the Study Area with most coastal activity limited to
 618 Willapa Bay, Grays Harbor, and the Columbia River. There has been a recent increase in the number of
 619 recreational crabbers who hire charter boats to participate in the fishery prior to the opening of the
 620 commercial fishery. The recreational Dungeness Crab harvest is managed by WDFW. However, WDFW
 621 does not require reporting of recreational harvest along the coast and therefore data on landings or the
 622 number of harvest trips are unavailable.

623

624 **Tribal Fisheries**

625 The coastal tribes have been engaged in fishing throughout their history. Fishing is an integral part
 626 of the history, culture, identity, economy, and future of the coastal tribes. Each tribe participates in and
 627 relies on fishing for jobs and income within their communities as well as for ceremonial purposes and
 628 subsistence. As noted in the introduction to this Chapter, many tribal fisheries use the same or similar
 629 techniques and deliver their catch to many of the same markets as state and federally licensed
 630 commercial fishermen. For sake of terminology however, this Chapter refers to them as tribal or treaty
 631 fisheries to indicate that they are managed under separate authorities held by the tribes. Ceremonial
 632 and subsistence fishing are distinguished where appropriate.

633 The four coastal treaty tribes: Makah, Quileute, and Hoh Tribes, and the Quinault Indian Nation are
 634 co-managers of the fisheries resource with fellow tribes, the state of Washington, and/or federal
 635 agencies. These tribes have reserved treaty rights to 50% of the harvestable fish and shellfish occurring
 636 within the coastal treaty area to harvest within their usual and accustomed areas (U&As). These treaty
 637 tribes also participate in the PFMC process and are represented by a tribal seat so that decisions for
 638 non-treaty fisheries are reflective of tribal fishery management decisions. Tribal fisheries are not
 639 negotiated through PFMC (see Section 1.6 Pacific Coast Indian Tribes and Treaty Rights). The tribal
 640 fisheries profile below summarize available information on fishing activities and economic impacts for
 641 each of the four coastal treaty tribes.²²

642 **Makah Tribe**

643 Fisheries are an important component of the Makah Tribe’s livelihood and economy. Makah tribal
 644 fisheries include 20 different fisheries based on species, gear types, and season, including five species of
 645 salmon, groundfish, and shellfish (Table 2.4-11). The salmon gillnet fishery occurs along the shore near
 646 Cape Flattery and in the Strait of Juan de Fuca, other fisheries occur offshore off the north coast of the
 647 Olympic Peninsula within the MSP Study Area (Taylor et al., 2015).

648 **Table 2.4-9. Makah tribal fisheries**

Mid-water (Pacific whiting, yellowtail rockfish)	Bottom trawl (cod, flatfish)
Longline (halibut, black cod/sablefish)	Ocean troll (Chinook and coho salmon)
Summer strait (Chinook salmon)	Winter strait (Chinook salmon)

²² Information related to the Shoalwater Bay Tribe fishing activity is not included.

Drift gill net (sockeye, chum, and pink salmon)	Set gill net (Chinook salmon)
Dive fisheries (shellfish, sea cucumber, sea urchin)	Dungeness crab (ocean and Strait of Juan de Fuca)
River set net/hook-and-line (salmon)	Tuna
Hagfish (in development)	

649

650 As of 2011, about 188 tribal fishing vessels were estimated to operate out of Neah Bay. The
 651 estimated annual, average ex-vessel value for all Makah tribal fisheries between 2007 and 2011 was
 652 about \$6.5 million. The majority of ex-vessel value comes from the groundfish fishery (Table 2.4-12).
 653 This value does not include the catch by tribal fishers other than that delivered to Neah Bay. The Makah
 654 tribe also participates in the Pacific Whiting fishery, which is either processed at sea or delivered to
 655 Westport, so the ex-vessel values reported in the table understate the total Makah tribal fishery ex-
 656 vessel value (Taylor et al., 2015).

657

658 **Table 2.4-10. Estimated ex-vessel value of tribal fishery landings in Neah Bay: Average of 2007-2011 (2014 dollars). Source:**
 659 **(Taylor et al., 2015).**

Fishery	2007-2011 Average Ex-Vessel Value
Groundfish	\$4,330,000
Salmon	\$1,887,000
Shellfish	\$197,000
Other	\$62,000
Total	\$6,476,000

660

661 **Quileute Tribe**

662 Fishing is a mainstay of the life and economy of the Quileute Tribe; nearly every family on the
 663 Quileute Reservation has members involved in fishing. Crab, salmon (steelhead, coho, and Chinook),
 664 black cod (sablefish), and Pacific halibut are the majority of the catch. Other species include tuna, sea
 665 cucumber, certain rockfish, and other groundfish, such as lingcod (Table 2.4-13). The tribe has shown
 666 growing interest in Pacific whiting. The tribe has an agreement with a non-tribal processor, High Tide
 667 Seafood of Port Angeles, as a buyer for their catch in La Push. Total revenue from Quileute fisheries in
 668 2014 was estimated at about \$1.1 million, and ranged from \$1.1 million to \$3.6 million from 2005-2014
 669 (Taylor et al., 2015).

670 The tribe regulates its own fishery and sets season length, catch, and other restrictions, this
 671 information is then shared with other co-managers. The Dungeness crab fishery is of particular
 672 importance to the tribe. The crab season typically begins in November and runs through October, but
 673 this can vary. Pursuant to a court case decided in 2005, agreements with the state include “Special

674 Management Areas”. These areas are annually negotiated with the co-managers and provide the tribe
 675 with an exclusive area for the opportunity to harvest as non-tribal fleets have a much larger capacity.²³

676 **Table 11. Quileute tribal fisheries 2014 harvest and annual range from 2005-2014* by species (thousands of lbs). Source:**
 677 **(Taylor et al., 2015).**

Species	2014 Harvest	Annual range from 2005-2014 ²⁴	
		Low	High
Crab	65	65	1,184
Black cod	42	7	97
Halibut	12	6	54
Groundfish	33	1	58
Chinook	66	28	66
Coho	279	120	777
Steelhead	28	21	76
Other	0	0	12
Total	525	-	-

678

679 **Hoh Tribe**

680 The Hoh Tribe is dependent economically, culturally, and spiritually upon fisheries within the tribe’s
 681 U&A, and the tribe places considerable emphasis and resources on the management and protection of
 682 its U&A fisheries. Although the tribe does not have a port or marina on the reservation, a high
 683 proportion of tribal members participate in, and are dependent upon, the treaty salmon fishery. No
 684 public information is available about the Hoh Tribe’s treaty harvest or ex-vessel revenues (Taylor et al.,
 685 2015).

686 **Quinault Indian Nation**

687 The Quinault Indian Nation regulates several tribal treaty fisheries within their usual and
 688 accustomed treaty harvest area that includes three major river systems (Queets, Quinault, and
 689 Chehalis/Humtulpis), Grays Harbor, and a large ocean area. Fisheries include gillnet for Chinook, coho,
 690 sockeye, chum salmon, steelhead, and white sturgeon; ocean troll for Chinook and coho salmon; marine
 691 fisheries for halibut, sablefish, lingcod, rockfish, and sardines; Dungeness crab; and razor clams

²³ The specific elements of state-tribal agreements may change from year to year. WDFW issues Letters to Fishers announcing the agreed to management measures on its website before the start of each season at: http://wdfw.wa.gov/fishing/commercial/crab/coastal/letters_notices.html

²⁴ Data from 2010 is not included

692 harvested from the beaches. According to the Quinault Department of Fisheries, the average number of
693 vessels to participate per year from 2004 to 2013 was 35, with 22 of those being crab vessels. The
694 average number of treaty fishers and helpers participating per year during that period was 159. The
695 2004-2013 annual average ex-vessel revenues from Quinault treaty fisheries was about \$9.2 million
696 (Table 2.4-14). Dungeness crab represents the largest proportion of these revenues, highlighting the
697 crab fishery's economic importance to the tribe. Recent years have shown the highest crab fishery
698 revenues, indicating the continued and growing importance of this fishery (Taylor et al., 2015).

699 Quinault continues to develop other treaty fisheries within its ocean U&A including Pacific whiting,
700 tuna, hagfish, spot prawns, pink shrimp, and others.

701 **Table 2.4-12. 2004-2013 Annual ex-vessel revenues from Quinault treaty fisheries (2014 dollars). Source: (Taylor et al., 2015).**

Fishery	Total
Grays Harbor gillnet	\$654,000
Ocean salmon troll	\$71,000
Marine fish	\$1,066,000
Dungeness crab	\$6,794,000
Razor clam	\$637,000
Total fisheries	\$9,223,000

702

703 Economic Impact of Commercial and Recreational Fishing

704 Commercial and recreational fisheries target and create economic benefits from many of the same
705 Study Area fish and shellfish populations. This section describes the different manner in which
706 commercial and recreational fisheries produce those benefits and summarizes their estimated economic
707 contributions to the coastal and state economies. The estimates were produced by the Cascade
708 Economics study (Taylor et al., 2015) and are based on information from 2014. While 2014 provides a
709 baseline that is reflective of the general magnitude of the economic contributions made by commercial
710 and recreational fisheries in the MSP Study Area, actual economic contributions should be expected to
711 vary from year to year based on a number of factors ranging from fluctuations in fish populations to
712 changing conditions in the global economy. For a further explanation of the models used to estimate the
713 economic contribution of MSP Study Area fisheries, please see Section 2.3 Socio-economic Setting and
714 the Cascade Economics report.

715 The economic benefits of commercial fisheries arise as fishers attempt to profit by entering their
716 catches into commerce through sale, barter, or trade and seafood businesses seek to add value by
717 processing and facilitating transactions with restaurants, retailers, and other consumers and users of fish
718 and shellfish products. The revenues earned by fishing operations and seafood businesses are the
719 "direct" economic input to the state and coastal economies.

720 The money fishing operations earn for their catch is referred to as ex-vessel revenues. Ex-vessel
721 revenues are what fisheries management agencies typically use to report the economic size of a fishery.

722 However, ex-vessel revenues are just part of the economic activity generated by a fishery as their effect
723 is multiplied as they move between links in the economy. For example, fishing businesses use ex-vessel
724 revenues to purchase goods and services used in their operations and to pay income to owners and
725 crew. The spending for things like fuel, boat repair and maintenance, gear and supplies, etc. leads to
726 “indirect” effects on the economy as the businesses providing these goods and services turn around and
727 spend on portion of the revenues on expenses and income. A third type of effect, called “induced”
728 effects, happens as owners and employees from fishing and supporting businesses spend their
729 disposable income throughout the economy.

730 Seafood buyers and processors are the next direct link in the economic chain. Although some fishing
731 operations sell their catch directly to the public at the dock, and some processing businesses own and
732 run their own fishing vessels, most fishing operations landing in the state sell their catch to another
733 seafood processing or distribution business. Fish and shellfish from the MSP Study Area are sold into a
734 diverse set of markets, including for: direct human consumption at restaurants and retail stores, pet
735 food, fertilizer and feed in various agriculture and aquaculture operations worldwide, and more. These
736 markets are what give commercial value to the fish and shellfish and the source of the ex-vessel
737 revenues seafood businesses pay to fishing operations.

738 On top of paying ex-vessel revenues, the businesses first receiving fish and shellfish landings create
739 other indirect and induced effects. The degree to which these effects contribute to the state and coastal
740 economies varies. In other words, a dollar of ex-vessel revenue can translate to a much different total
741 economic contribution depending on several factors. For instance, some of the catch goes to large
742 processing facilities located in port that provide substantial employment opportunity to local residents.
743 Other catch requires minimal labor to prepare for market and so may have a lower total economic
744 contribution because of the lack of jobs supported. As another example, some landings are transferred
745 from the fishing vessel straight onto a truck and quickly transported to a processing facility in Oregon.
746 The economic contribution of this landing could be of equal size to the first example, but much of it
747 would “leak” from the state’s economy and so be less beneficial to the coastal counties. However, the
748 reverse also happens with some landings of seafood in Oregon being transported to Washington for
749 processing.

750 Using their model of the economic linkages²⁵ outlined above, Cascade Economics estimated that
751 commercial fishing and primary seafood processing had a total economic contribution of 1,820 jobs and
752 \$77.2 million in labor income in the coastal counties (Table 2.4-15) and 2,830 jobs and \$117.0 million
753 statewide (Table 2.4-16) in 2014. This total economic contribution is based on over 129 million lbs of
754 fish and shellfish and \$93 million in ex-vessel revenues reported to WDFW in 2014.

755 While these estimates capture a core portion of economic activity related to Washington’s
756 commercial seafood industry, they are not intended to be comprehensive. For instance, the estimates
757 do not include the effects of secondary processing activities (e.g., fish oil or fishmeal produced as
758 byproducts of primary processing), the effects from additional distribution and retailing of the seafood
759 landed in the coastal counties, or activities related to imports or fish caught in Alaska. In addition, the
760 estimates do not cover catch from the Study Area that are landed into Oregon or Puget Sound, or the
761 harvesting and processing activities of the Puget Sound based at-sea whiting sector. While no estimate
762 was made for landings into Oregon, Cascade Economics estimated Puget Sound landings contributed an
763 additional \$2.3 million in income and approximately 60 jobs in the coastal counties, with an additional
764 \$8.2 million in income and approximately 190 jobs statewide. They also estimate that the Puget Sound

²⁵ The economic multipliers used were derived using IMPLAN models based on 2012 regional economic data.

765 based at sea whiting processing vessels contribute an additional 220 jobs and \$15.8 million in labor
 766 income to the state.

767 Lastly, Washington’s commercial fishing and seafood industries have strong ties to the fisheries of
 768 Alaska as well as to fish and shellfish imported from elsewhere. Additional information about the
 769 economic linkages between Washington’s fishing communities and commercial fishing in other areas
 770 can be found in the Cascade Economics (Taylor et al., 2015) report.

771

772 **Table 2.4-15. Total contributions to the five-county²⁶ coastal region economy from 2014 Washington coast non-tribal**
 773 **commercial fishing and seafood processing by county of the activity. Source: (Taylor et al., 2015)**

	Coastwide	Clallam County	Grays Harbor County	Pacific County	Wahkiakum County
Income (\$ mil.)	77.2	2.3	50.3	23.7	0.9
Jobs	1,820	70	1,080	610	60

774

775 **Table 13. Total contribution to the State of Washington economy from Washington coast non-tribal commercial fishing and**
 776 **seafood processing by county of the activity. Source: (Taylor et al., 2015)**

	Coastwide	Clallam County	Grays Harbor County	Pacific County	Wahkiakum County
Income (\$ mil.)	117.0	3.4	75.8	36.6	1.2
Jobs	2,830	120	1,700	950	60

777

778 In contrast to commercial fishing, recreational fishing is conducted for sport, enjoyment, or personal
 779 use, and state law prohibits anglers from selling their catch. It is the willingness of anglers to spend
 780 income to make fishing trips in the Study Area that provides the direct economic input to coastal and
 781 state economies. These “trip related expenditures”—on things like fuel for vehicles and boats, fishing
 782 gear and supplies, lodging, food at grocery stores and restaurants, bait, charter boat fees, etc.—that also
 783 produce indirect and induced economic benefits as revenues earned by businesses that provide goods
 784 and services to anglers, and the income earned by owners and employees of these businesses are spent
 785 throughout the economy.

786 Recreational trip related expenditures provide another example of how the location of spending
 787 matters to where economic benefits are received. Anglers traveling into the coastal economies from
 788 elsewhere produce extra benefit by injecting new money into the local economy. On the other hand,
 789 anglers may make a significant portion of the trip-related expenditures at home, benefiting the
 790 economy there instead of in the coastal economy. The charter boat industry is a distinct portion of the
 791 recreational fishing sector and the one that is also considered as a fishery sector. Owners and crew
 792 receive trip related expenditures that in the form fees and tips that anglers pay when taking trips aboard
 793 charter vessels. Because, as reported by Cascade Economics (Taylor et al., 2015), 100 percent of the

²⁶ There were no non-tribal commercial fisheries landings recorded in Jefferson County in 2014.

794 owners and crew reside in the coastal counties, a relatively high proportion of their spending is thought
 795 to remain in and benefit the coastal economy.

796 Using 2014 as a baseline, Cascade Economics estimated that anglers taking trips to fish in the MSP
 797 Study Area made \$30.4 million in trip related expenditures in the coastal area and \$40.9 statewide
 798 (Table 2.4-17). This spending translates to an overall economic contribution of 325 jobs and \$17.3
 799 million in labor income within the coastal economy and 596 jobs and \$32.3 million statewide (Table 2.4-
 800 18). Labor income includes money and benefits paid to employees as well as the earnings of owners and
 801 the self-employed. Of note, these estimates do not include purchases of equipment or durable goods
 802 such as fishing boats, boat trailers, or the vehicles needed to haul them. Such purchases certainly
 803 increase the level of recreational fishing’s economic contribution to the state and coastal economies yet
 804 Cascade Economics reports that they are very difficult to estimate accurately.

805 **Table 2.4-1714. Trip-related expenditures associated with ocean sportfishing trips in 2014 from charter vessels, private**
 806 **vessels, and shore and jetties in the Washington coastal region (2014 dollars). Source: (Taylor et al., 2015).**

	MSP Study Area/Coastal Spending	Spending Elsewhere in WA	Total Spending in WA
Charter vessels	\$15,770,540	\$3,865,590	\$19,636,130
Private Vessels	\$14,416,219	\$6,416,963	\$20,833,182
Shore and Jetty	\$256,964	\$160,641	\$417,606
Total	\$30,443,723	\$10,443,194	\$40,886,917

807

808 **Table 2.4-18. Contribution of trip-related angler expenditures in the MSP Study Area/Coastal Area to coastal area and**
 809 **statewide employment and labor income. Source: (Taylor et al., 2015).**

	MSP Study Area/Coastal Area	Statewide
Contribution to Employment	325	596
Contribution to Labor Income	\$17,327,751	\$32,338,444

810

811 [Related Infrastructure](#)

812 [Ports and marinas](#)

813 The state’s fishing industry operates from several ports located adjacent to the Study Area as well as
 814 in the Strait of Juan de Fuca and inside Puget Sound. These ports provide infrastructure like moorage
 815 and access (e.g. via boat ramps) for commercial and recreational fishing vessels, gear and boat
 816 maintenance opportunities, and are the site of fish buying and processing activities. Below are brief
 817 descriptions of commercial and recreational fishing activity by port to highlight key coastal locations and
 818 communities connected to fishing. Tribal fisheries are not included in the statistics reported in this
 819 section but they do operate out of many of the same ports and depend on the same infrastructure. A

820 map of MSP Study Area ports and adjacent ports is provided in (Map 30). Additional discussion of Ports
821 is in Sec. 2.7 Marine Transportation, Navigation, and Infrastructure.

822 Clallam County ports

823 *Neah Bay*

824 Neah Bay is the largest commercial fisheries port in Clallam County and is also home of the Makah
825 Tribe's fishing fleet, who own the fishing dock. It has had the greatest buyer participation, vessel
826 participation, and landed ex-vessel revenues in the county for most years. Recently (2010-2014), there
827 have been about seven buyers and 40 vessels operating out of Neah Bay. Total ex-vessel revenues from
828 landings in the port in 2014 were about \$1.1 million, the fourth largest in terms of ex-vessel revenues
829 landed in Washington coastal ports.

830 Neah Bay also serves as an important marina for recreational fishing. Over 3,000 average annual
831 charter boat trips were taken from Neah Bay during 2004-2013, and almost 30,000 average annual trips
832 were taken by private vessels during that same time period (Table 2.4-7). Neah Bay serves as the
833 primary private boat marina supporting the most average annual private vessel trips along the
834 Washington outer coast. Salmon, Pacific Halibut, and bottomfish are popular targets from this marina
835 (Taylor et al., 2015).

836 *La Push*

837 The port in La Push is owned and operated by the Quileute Tribe, yet the port also supports non-
838 tribal commercial and recreational fisheries. The port has a seafood processing plant on location. Data
839 confidentiality limits the fishing reporting in La Push for some years. Recent available data indicate that
840 about six buyers and 33 vessels operate in the port. Total ex-vessel revenues from landings in the port
841 for 2014 were about \$0.9 million, the fifth largest in terms of revenue landed on the Washington coast.
842 About 1,600 recreational trips originated from La Push in 2014, with an average of 1,144 charter boat
843 trips on average per year from 2004-2013. The annual average number of private vessel trips from La
844 Push was about 7,051 during that same time period (Table 2.4-7). Recreational fishing trips target
845 bottomfish, salmon, Pacific Halibut, and tuna (Taylor et al., 2015).

846 Jefferson County Ports

847 There have been no non-tribal commercial fisheries landings recorded in Jefferson County ports
848 along the outer Washington coast since 2007. In previous years, fewer than three buyers and fewer than
849 six vessels were operating there (Taylor et al., 2015).

850 Grays Harbor County Ports

851 *Westport*

852 Westport is the largest commercial fishing port on the Washington coast in terms of number of
853 buyers, number of vessels, and total ex-vessel revenues generated from landings. Approximately 30
854 buyers and 300 commercial vessels have been operating in the port in recent years. Total ex-vessel
855 revenues for landings in 2014 were \$59.7 million, more than twice the value of the next largest port on
856 the Washington coast (Taylor et al., 2015). Westport also ranks among the most important commercial
857 fishing ports in country. Considering landings 2014, Westport was ranked 13th by landed weight (100
858 million lbs) and 14th by landed value (\$64 million) for commercial ports in the United States (National
859 Marine Fisheries Service, 2015).

860 Westport is also the most popular port for recreational charter fishing on the Washington coast.
861 About 35 recreational charters operated from the port recently, fishing for salmon, groundfish, Pacific
862 Halibut, and tuna. About 38,500 charter angler trips were taken from Westport in 2014, with an annual
863 average of 32,695 trips during 2004-2013 while approximately 20,020 average private vessel
864 trips were taken during that same time period (Table 2.4-7) (Taylor et al., 2015).

865 Pacific County Ports

866 *Willapa Bay*

867 In recent years, about 10 buyers and more than 100 vessels have been operating out of Willapa Bay
868 ports. The main ports within Willapa Bay ports include South Bend and Tokeland. Total ex-vessel
869 revenues from commercial landings in 2014 were about \$4.8 million, the third largest in terms of value
870 on the Washington coast. Salmon is the primary target for commercial fisheries, although anchovies and
871 crab are also fished in Willapa Bay (Taylor et al., 2015). Willapa Bay ports also support recreational
872 fishing within the estuary.

873 *Ilwaco and Chinook*

874 Ilwaco is the largest port in Pacific County and the second largest commercial fishing port on the
875 Washington coast in terms of number of buyers, number of vessels, and total ex-vessel revenues
876 generated. About 13 buyers and more than 200 vessels have been operating in the port in recent years.
877 In 2014, total ex-vessel revenues paid for landings were \$24.3 million, more than five times greater than
878 the amount recorded in the next largest port, Willapa Bay (Taylor et al., 2015). The Ilwaco/Chinook port
879 areas also rank among the most important commercial fishing ports in country. Based on landings in
880 2014, Ilwaco/Chinook ranked 35th by landed weight (27 million lbs average) and 49th by landed value
881 (\$25 million) for commercial ports in the United States (National Marine Fisheries Service, 2015).
882 Primary commercial fisheries landing in Ilwaco/Chinook target groundfish, salmon, Dungeness Crab,
883 Albacore, and shrimp.

884 Popular recreational fisheries operating from the Ilwaco/Chinook area target salmon, albacore tuna
885 and sturgeon. In Chinook, all charter boat trips ceased in 2009 while the average annual number of trips
886 for private vessels out of Chinook was 15,416 (Table 2.4-7). In Ilwaco, 10,171 average charter boat trips
887 were made per year during 2004-2013, with 26,181 average private vessel trips were made per year
888 during that same time period (Table 2.4-7) (Taylor et al., 2015).

889 Data confidentiality restricts the availability of fisheries data for other Pacific County ports. In recent
890 years, about 11 vessels were making landings in other Pacific County ports along the coast, and as high
891 as 17 vessels landing in ports along the Columbia River (Taylor et al., 2015).

892 *Wahkiakum County ports*

893 A total of 72 vessels made landings in Wahkiakum County ports in 2014, with nearly \$1 million in ex-
894 vessel revenue. Between five and eight buyers were operating in these ports in recent years. Data from
895 individual ports within the county were not available. Wahkiakum County ports deal almost exclusively
896 with salmon landings (Taylor et al., 2015).

897 Future Trends

898 Future trends within the commercial and recreational fishery industries are difficult to predict.
899 Several factors can have a significant influence on the participation and economics of these industries.

900 While no predictions can be made for certain, primary factors are summarized below to give insight to
901 the future trends and challenges of these industries.

902 *Barriers to participation in the commercial fishery industry*

903 Initial entry into the commercial fishing industry can be quite costly. For example, the sector analysis
904 completed by Industrial Economics, Inc. (2014) cited that between purchasing a crabbing vessel,
905 permits, and gear, it could cost around \$250,000 to \$1 million to enter the Dungeness crab fishery. The
906 younger fishing generation typically does not have access to this amount of money. In addition to the
907 high initial costs to enter a fishery, the current trend of participating in multiple fisheries also means
908 additional initial costs to obtain permits and gear types for each fishery. While a diverse portfolio
909 increases the opportunities to earn income throughout the year, it also requires more money to be paid
910 or borrowed before any actual fishing takes place, increasing risk. These financial barriers to entry and
911 participation can create uncertainty around the future of fishing industries, particularly for locally based
912 fishermen (Industrial Economics Inc., 2014; Taylor et al., 2015).

913 *Regulatory uncertainty: commercial fishing and recreational fishing*

914 Fisheries are a highly regulated industry and the primary management aim of long-term
915 sustainability can sometimes be at odds with economic interests in the short-term. Estimates of
916 sustainable catch levels can be highly variable because of uncertainty in the estimates and real
917 fluctuations in the size of fish and shellfish populations even in the best monitored fisheries. Catch rates
918 and fishing effort can be likewise variable. All in all, this variability and uncertainty makes it difficult for
919 commercial and recreational fishing industries to make long-term business plans or to even rely on the
920 forecasts for any given year. For example, if catch in-season reaches the quota for a limiting species like
921 Yelloweye Rockfish, emergency closure of the groundfish fisheries could occur, which would cut the
922 season short and create economic losses. Another example is the quota based recreational Pacific
923 Halibut fishery, which concentrates the fishing season in some areas to a handful of days, yet the season
924 may be extended for additional days if the quota is not caught. Under such circumstances, it is difficult
925 for recreational charters, and the supporting hotel, restaurant, and other businesses that cater to
926 recreational fishermen, to prepare for the influx of Pacific Halibut anglers (Industrial Economics Inc.,
927 2014; Taylor et al., 2015).

928 Other examples of how regulations impact fisheries include the consolidation of the trawl fishery
929 and the management of the Dungeness crab fishery. Increasing costs coupled with the retirement of
930 vessels and permits from the fishery and buyback and nature of the trawl IFQ program has reduced the
931 number of trawl vessels registered to Washington coastal residents. The Dungeness crab industry
932 experienced a significant shift after the 1994 Rafeedie decision, which resulted in the co-management of
933 the Dungeness crab fishery between WDFW and each of the four coastal treaty tribes and ultimately
934 brought about the reduction of Washington crabbing grounds and fleet. The crab fleet has proven
935 resilient and adjusted to the alterations of space, increased competition, and diversification. At the end
936 of 2016, however, the Dungeness crab fishery management structure in where states manage the
937 fishery, even in federal waters, expired, leaving the possibility for a different management regime.²⁷
938 Uncertainty in fisheries management and available quotas affects vessel owners and processors who
939 may be considering making capital investments. Changing fisheries management policies and priorities

²⁷ This is an ongoing management issue with bills in both the Washington State House of Representatives and Senate at the beginning of 2017.

940 will likely continue to affect commercial fisheries in unexpected ways (Industrial Economics Inc., 2014;
941 Taylor et al., 2015).

942 *Environmental factors*

943 As living, natural resources, fisheries are influenced by environmental conditions, which are
944 frequently outside of human control. As noted in the previous section, natural variability in ocean
945 conditions influences stocks from year to year and from fishery to fishery. A warming climate and
946 changing water temperatures may influence fish stocks and fishery seasons, especially for species such
947 as Albacore Tuna, Salmon, Dungeness Crab, Pacific Whiting, and Pacific Sardine. Although many species
948 may be forced out of the area by warming ocean temperatures, other species may expand their range
949 and open new opportunities for fisheries. Ocean acidification may also affect fisheries. Studies are
950 currently investigating the impact of increased ocean acidity on juvenile Dungeness crab and several
951 other fish and shellfish. Concerns also surround ocean acidification's effect on important food sources
952 for salmon (Industrial Economics Inc., 2014; Taylor et al., 2015).

953 Harmful algal blooms (HABs) also influence resource availability. Closures of razor clam beaches to
954 protect human health due to HABs have a significant impact on recreational clamming and the coastal
955 communities supporting the tourism that accompanies razor clamming trips. Recently, HABs have closed
956 both recreational and commercial shellfish fisheries. In May of 2015, an extremely large HAB event
957 occurred that affected the entire U.S. west coast. In Washington, all razor clam fisheries closed in May
958 and most beaches did not reopen until sometime between late December 2015 and mid-February 2016.
959 In early June, the southern half of the Washington coast (including the Columbia River and Willapa Bay)
960 was closed to all Dungeness crab fisheries followed in early August by a closure of a substantial portion
961 of the northern half of the Washington coast (including Grays Harbor). Most of this area remained
962 closed to crabbing through September, the normal end of the commercial season (D. Ayres, WDFW,
963 personal communication, August 4, 2016). Current speculations suggest that HABs may increase in the
964 future as oceans warm and ocean acidity increases (Feely, Klinger, Newton, & Chadsey, 2012; Moore,
965 Mantua, Hickey, & Trainer, 2010), potentially leading to more frequent razor clam and other shellfish
966 closures.

967 *Salmon production and survival*

968 Salmon represent one of the most culturally and economically important fishery species in both the
969 commercial and recreational sectors. However, many factors influence the salmon fishery including:
970 oceanic conditions (which influence ocean survivability and spawning runs), predators (such as California
971 sea lions at the foot of dams and Caspian terns on artificial islands), reductions in hatchery programs,
972 habitat loss, fragmentation, pollution, and overfishing. Due to the complex nature of salmon life
973 histories, as well as human history with salmon, the future of this fishery will likely continue to be
974 dynamic and unpredictable (Industrial Economics Inc., 2014; Taylor et al., 2015).

975 *Seafood markets*

976 World markets can have a profound effect on the supply, demand, and distribution of seafood
977 products. Exchange rates, political events, and overseas demand can influence demand for those
978 Washington seafood products that rely on foreign markets. Some of these market forces can
979 significantly influence profitability almost overnight. Overseas markets for Sablefish and Dungeness Crab
980 are particularly influential. Market volatility will likely continue to be a major source of uncertainty in
981 the commercial fishing economy (Taylor et al., 2015).

982 *Oil spills*

983 Oil spills from marine traffic could potentially affect multiple fisheries for significant periods of time.
984 The anticipated increase in oil tanker traffic along the coast and over the dangerous Columbia River bar
985 has led to stakeholder concerns about the risks of an oil spill to commercial, recreational, and tribal
986 fisheries and how quickly they could recover from such an event (Industrial Economics Inc., 2014; Taylor
987 et al., 2015).

988 *Vessel safety*

989 Fishery representatives have voiced concerns over the safety of fishermen operating in restricted
990 spaces with high competition. This is of particular concern in the Dungeness Crab industry, where the
991 first part of the season is marked with highly competitive, derby-style fishing. The pressure to catch as
992 much crab as quickly as possible can lead to dangerous conditions. Individuals within the fishing
993 industries have expressed great concern that further restrictions in fishing grounds will exacerbate
994 safety issues and may increase fatality rates (Taylor et al., 2015).

995 *Summary*

996 In summary, there are many factors influencing the commercial and recreational fisheries of the
997 Washington coast which lead to a significant level of uncertainty when forecasting future trends. What
998 is certain, however, is the importance of this industry to the economy and social identity to coastal
999 communities adjacent to the MSP Study Area and the state of Washington. Losses within these fishing
1000 sectors could mean a loss of jobs, income, and cultural way of life to coastal residents, including non-
1001 tribal and tribal residents. Fisheries stakeholders are concerned about further space restrictions from
1002 new ocean uses within the MSP Study Area and what this would mean for their industry (Industrial
1003 Economics Inc., 2014).

1004

1005

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2.5 Aquaculture

Aquaculture is a major use within the large coastal estuaries of the MSP Study Area. The shellfish aquaculture industry provides income and jobs to the region and the state, promotes environmental monitoring in the estuaries, and is a key part of the cultural history and identity in Pacific and Grays Harbor Counties.¹ As a state, Washington ranks first in shellfish aquaculture sales in the nation, with Pacific and Grays Harbor counties producing a substantial portion (about 29% in 2012) of the state’s mollusk sales. The industry has a long history within the region and has adapted to several challenges to sustain a thriving industry. Current challenges such as invasive and nuisance species management, regulatory complexities, and climate change will continue to influence the future of aquaculture.

This chapter summarizes the history and current use of shellfish aquaculture in the MSP Study Area. Economic impacts, related infrastructure, and future trends of the industry are also presented here to outline the context of aquaculture and its role in the Washington coastal region.

Summary of History and Current Use

Marine aquaculture is one of the oldest industries in the state of Washington and includes a variety of shellfish species, marine plants, and net-pen-raised salmon. Washington is currently a leader in shellfish aquaculture production in the United States. The U.S. Census of Aquaculture from 2005 ranks Washington first in value of sales of farmed mollusks (over \$63.7 million), with Washington-grown shellfish accounting for 31% of the value of U.S. farmed shellfish production (Industrial Economics Inc., 2014).

Aquaculture in the MSP Study Area is exclusively shellfish and occurs primarily in Willapa Bay (Pacific County), and to a lesser extent in Grays Harbor (Grays Harbor County). Nearly all of the shellfish farms are family-owned businesses, ranging from small “mom and pop” operations to larger, vertically-integrated farms with many thousands of acres. The communities of South Bend and Nahcotta on Willapa Bay are the primary centers for aquaculture activity (Industrial Economics Inc., 2014).

Native Olympia oysters (*Ostrea lurida*) originally dominated Willapa Bay and Grays Harbor. Heavy exploitation by the region’s early Euro-American settlers resulted in the commercial extinction of Olympia oysters by the early 1900s, which led to the development of oyster farms. Pacific oyster (*Crassostrea gigas*) spat was transplanted from Japan starting in 1928. Imports continued until the mid-1970s when Pacific oyster larvae began to be successfully reared in local hatcheries. A thriving oyster industry has existed in the region ever since. Pacific oysters have naturalized in Grays Harbor and Willapa Bay, yet hatchery production has been necessary to ensure stable aquaculture production and supply (Industrial Economics Inc., 2014). Beginning in the mid-2000s, hatcheries in the Pacific Northwest began to experience production failures. An increase in the acidity of coastal waters due to climate change is identified as the likely cause and hatcheries have had to adapt their practices to address the increased acidity in local coastal waters (Washington State Blue Ribbon Panel on Ocean Acidification, 2012).

Invasive and noxious species have also shaped estuary management and the shellfish industry. Most notably was the extensive infestation of the non-native cordgrass species *Spartina alterniflora* and *S. densiflora*. *S. alterniflora* was unintentionally introduced to Willapa Bay during the late 1800s. By 2003, it had spread to over 8,500 solid acres within Willapa Bay. *S. alterniflora* has been present in Grays

¹ Shellfish aquaculture is also important to the coastal tribes to sustain cultural and subsistence uses and provide commercial opportunities. Tribal shellfish aquaculture activities are not discussed in this chapter.

41 Harbor since the early 1990s and *S. densiflora* was discovered in Grays Harbor in 2001. *Spartina* is an
42 aggressive plant that disrupts the ecosystem of the estuaries by outcompeting native vegetation and
43 converting mudflats into *Spartina* meadows. This impacts shellfish beds, as well as migratory bird
44 habitats (Washington State Department of Agriculture, 2015).

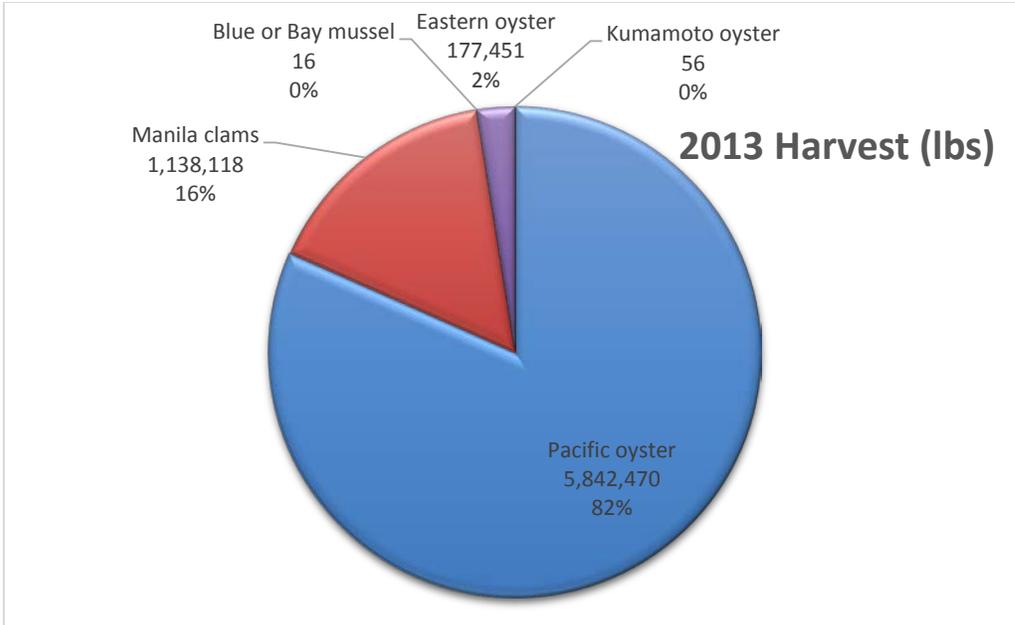
45 An extensive effort lead by the Washington State Department of Agriculture (WSDA) in partnership
46 with Washington Department of Natural Resources (DNR), Washington Department of Fish and Wildlife
47 (WDFW), Washington Department of Ecology (ECY), local governments, tribes, United States Fish and
48 Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and private landowners has
49 resulted in the extremely successful reduction and control of *Spartina*. Control methods include
50 herbicide applications and manual removal. In Pacific County (Willapa Bay) only 0.9 solid acres of *S.*
51 *alterniflora* were reported in 2014, a 99.9% reduction since the peak in 2003. Dedicated resources,
52 surveys, and removal treatments are ongoing to maintain the control program and prevent a resurgence
53 of *Spartina* along the coast (Washington State Department of Agriculture, 2015).

54 Burrowing shrimp (*Neotrypaea californiensis* and *Upogebia pugettensis*) have also been a nuisance
55 species to the aquaculture industry in Willapa Bay and Grays Harbor. These shrimp are native to
56 Washington, but populations have grown drastically starting in the 1940s and 1950s. Burrowing shrimp
57 destabilize the sediment and the beds become too soft to support oysters and aquaculture equipment
58 which has a dramatic economic influence on the aquaculture industry. The pesticide carbaryl was used
59 to control burrowing shrimp since the 1960s, yet was recently phased out of use. An integrated pest
60 management plan has been in place for several years to develop cost effective and environmentally
61 acceptable methods to control burrowing shrimp (Booth, 2007). [Note: Update on imidacloprid
62 interest/permitting activity will be included in next draft of MSP.] Managing these species will continue
63 to be a major challenge for the industry into the future (Taylor, Baker, Waters, Wegge, & Wellman,
64 2015; Washington State Department of Ecology, 2014).

65 The aquaculture industry is currently enjoying strong demand for its products; main products
66 include oysters and manila clams. According to WDFW 2013 data, Pacific oysters account for about 82%
67 of shellfish farmed and harvested in Pacific and Grays Harbor counties. Manila clams make up about
68 16% of harvest. Small amounts of eastern oysters, Kumamoto oysters, and blue and bay mussels are
69 also produced (Figure 2.5-1). By value, Pacific oysters accounted for approximately 83% of the relative
70 value for shellfish in Pacific and Grays Harbor counties, with Manila clams accounting for about 11%
71 (Figure 2.5-2) (Industrial Economics Inc., 2014).

72 Pacific County produces more shellfish than Grays Harbor County. Harvest and value have varied
73 over time (Table 2.5-1), and production data suggest that there has been a general decrease in Pacific
74 oysters² and a general increase in Manila clams over the past 10 years (Industrial Economics Inc., 2014).
75 Due to challenges in accurate and comprehensive reporting within the industry, WDFW recognizes that
76 these numbers may under represent actual harvest. While WDFW data may not reflect true production
77 values, they are currently the best available data to illustrate aquaculture production status and history
78 (Industrial Economics Inc., 2014; Taylor et al., 2015).

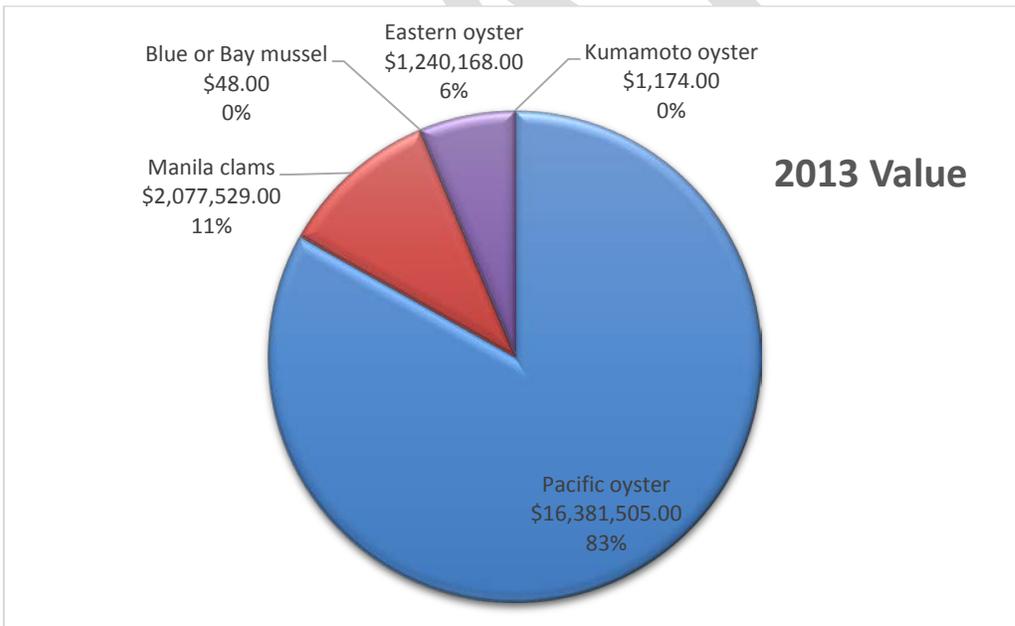
² The reduction in oyster production is likely tied to the reduced number of oysters naturally reproducing in Willapa Bay. Most companies have traditionally relied on a combination of natural and hatchery produced oyster seed, and a reduction in natural oyster sets in Willapa Bay since the mid-2000s is now affecting the overall oyster seed supply (B. Sheldon, personal communication, May 26, 2016).



79

80 **Figure 2.5-1. Relative harvest (round lbs) of farmed shellfish products in Pacific and Grays Harbor Counties, 2013. Source:**
 81 **Industrial Economics (2014).**

82



83

84 **Figure 2.5-2. Relative value (dollars) of farmed shellfish products in Pacific and Grays Harbor Counties, 2013. Source:**
 85 **Industrial Economics (2014).**

86

87 **Table 2.5-1. High and low values for harvest (round lbs) and value (2014 \$) of aquaculture Pacific oyster and Manila**
 88 **clams in Grays Harbor and Pacific Counties, 2004-2013. Source: Industrial Economics (2014).**

Species	Gray Harbor County	Pacific County	Total
---------	--------------------	----------------	-------

	Harvest (lbs)	Value	Harvest (lbs)	Value	Harvest (lbs)	Value
Pacific oyster	1,030,586-1,804,434	\$3,519,614-\$6,134,273	4,276,566-6,803,533	\$11,194,059-\$16,707,209	5,842,470-8,274,431	\$16,381,505-\$21,494,323
Manila clams	0-9,034	\$0-\$24,983	704,446-1,187,787	\$1,419,160-\$2,638,361	704,529-1,196,821	\$1,419,160-\$2,638,361

89 Willapa Bay and Grays Harbor make a considerable contribution to state-wide and national
 90 aquaculture production. According to the USDA, Pacific County ranked 3rd among all Washington
 91 counties and 15th among all U.S. counties in aquaculture sales with over \$22.3 million in total sales in
 92 2012. Grays Harbor ranked 7th statewide, and 43rd nationally, with \$7.8 million in aquaculture sales. For
 93 mollusk production specifically, Pacific County and Grays Harbor County ranked 2nd and 4th, respectively,
 94 statewide in 2012. Pacific County produced about 23% of state farmed mollusk sales, and Grays Harbor
 95 County produced about 6% of statewide sales³ (as cited in Industrial Economics Inc., 2014).

96 Reporting challenges make deriving consistent, representative participation numbers in the
 97 aquaculture sector difficult. The Willapa Grays Harbor Oyster Growers Association (WGHOGA) reports
 98 that in 2014, 28 growers were members in Willapa Bay and 7 growers were members in Grays Harbor.
 99 The number of farms can fluctuate on a regular basis, and are not always consistent with WDFW
 100 estimates (reported 20 farms in Willapa Bay and 6 farms in Grays Harbor in 2012) due to small
 101 operations or frequent changes that may not be reflected in WDFW reported numbers (Taylor et al.,
 102 2015). Another way to measure participation is through tideland leases. All reported shellfish farms
 103 operate on privately owned tidelands or on tidelands that are owned by the state and leased through
 104 DNR to growers. DNR reports that in 2015, approximately 50 leases were held for shellfish farming in
 105 Willapa Bay and Grays Harbor (DNR, personal communication, December 18, 2015). DOH also tracks the
 106 number of harvester and dealer licenses for commercial shellfish, as well as the number of certified
 107 harvest sites for the shellfish industry.

108 Shellfish aquaculture is an extensive spatial use of privately and publically owned tidelands in
 109 Willapa Bay and Grays Harbor. Commercially farmed acreage for aquaculture is estimated between
 110 2,288 to 3,278 acres in Gray Harbor and 14,681 to 17,288 acres in Willapa Bay. This represents
 111 approximately 66% to 80% of the total acreage for shellfish aquaculture in the state⁴. There is significant
 112 uncertainty about the actual numbers of acres in aquaculture production because acreage is
 113 continuously rotated and some portions of tracts may go unused from year to year. Growers report that
 114 they typically farm between two-thirds and one-half of the acreage they own or lease (Taylor et al.,
 115 2015). In addition to privately owned and DNR leased lands, WDFW manages about 10,000 acres of
 116 intertidal and subtidal land as oyster reserves in Willapa Bay, and about 1,000 acres of these reserves
 117 are currently used for oyster production where licensed individuals may harvest naturally occurring
 118 oysters (WDFW, personal communication, May 23, 2016). Spatial use of the estuaries by the shellfish
 119 aquaculture industry is represented in Map 31.

120 Oyster production can be accomplished using natural (aka wild set) or artificial cultivation. In a
 121 natural set, naturally recruited oysters settle onto tidelands covered with oyster shells. Artificial
 122 cultivation requires the purchase or growth of oyster larvae, which are placed in upland tanks of

³ County and growing area aquaculture production and sales amounts vary annually, and therefore so do relative rankings and percentages. Also, data discrepancies between WDFW, USDA, and industry sources may lead to varying results in sales and production numbers between reports.

⁴ Estimates ranges are based on WDFW data compared with grower survey data.

123 warmed water that have been filled with bags of oyster shells onto which the larvae settle. After five to
 124 ten days, the shells with the settled larvae (aka “spat”) are removed and placed into a nursery area.
 125 They are then moved to a “grow-out ground” within the estuary, then transported again to a “fattening
 126 bed” where they mature and grow until they reach harvest size(Industrial Economics Inc., 2014). Oysters
 127 are primarily cultured using bottom culture methods, and some oysters are cultured using off-bottom
 128 techniques such as longlines, flip bags, and racks and bags. The vast majority (approximately 95%) of
 129 oysters cultured in Willapa Bay and Grays Harbor use bottom culture. 100% of Manila clam crops rely in
 130 bottom culture techniques. (B. Sheldon, personal communication, May 26, 2016).

131 Oysters are processed either by shucking or sold in-shell. Oysters for shucking are sent to shucking
 132 houses, where the meat is removed and packaged for sale. Shucked meat can also be used for smoked
 133 oysters. Oysters sold in-shell are generally purchased for cooking (e.g. on the grill) or to be eaten raw on
 134 the half shell (aka “shellstock”). Generally, larger oysters are sent to Asia, medium and small oysters stay
 135 in the U.S., and extra small oysters are sent to local oyster bars on the West coast. Demand for in-shell
 136 oysters is increasing, and some farms are expanding their in-shell production (Industrial Economics Inc.,
 137 2014). Clams are typically cleaned and bagged by the pound and sold to wholesalers or retail outlets.
 138 Some companies are vertically integrated; they farm, process, and distribute their product as well as
 139 provide a retail market. Other farms rely on separate processing facilities and distributors to move their
 140 product (Taylor et al., 2015).

141 The aquaculture sector makes significant contributions to social, cultural, and environmental
 142 systems. Ecologically, oyster beds are important biogenic habitat. They form complex structures that
 143 provide refuge and hard substrate for marine plants and animals, enhancing biodiversity. Shellfish in the
 144 estuaries provide important nursery habitat for commercially and recreationally important species, such
 145 as fish, crab, and others. Research also suggests that shellfish provide environmental services, such as
 146 water quality improvement through nitrogen removal (Skewgar & Pearson, 2011; Taylor et al., 2015).

147 Shellfish aquaculture can also bring water quality impairments to the attention of local
 148 communities. Because of stringent U.S. health standards for water in which shellfish fisheries and
 149 aquaculture operate that are set by the National Shellfish Sanitation Program, these coastal areas often
 150 have amplified monitoring of environmental conditions. Harvest area closures due to water quality
 151 impairments can result in economic hardships for the industry (Taylor et al., 2015). The industry has
 152 assisted state and local government agencies, tribes, and private citizens in the planning and
 153 implementation of improvements to sewage treatment systems or programs to fix local septic systems,
 154 and other water quality pollution reduction programs. The aquaculture industry is often a protective
 155 steward of water quality in and along the coastal estuaries.

156 The aquaculture industry is managed through a complex interaction of multiple agencies, each with
 157 its own mandate, jurisdiction, and standards related to aquaculture. Table 2.5-2 provides a summary of
 158 the primary agencies involved with shellfish aquaculture and their general role.

159 **Table 2.5-2-. Primary regulatory agencies for Washington shellfish aquaculture and their roles.**

Agency	Role
Washington Department of Ecology	Ensures Coastal Zone Management Act consistency Ensures Shoreline Management Act consistency through review and approval of certain Shoreline Permits

	<p>Issues 401 Water Quality Certifications for new and expanded aquaculture operations</p> <p>Issues NPDES permits for herbicide and pesticide applications</p>
Washington Department of Natural Resources	Leases state-owned aquatic lands and authorizes use of those lands for aquaculture operations
Washington Department of Fish and Wildlife	Manages oyster reserves, processes aquatic farm registrations, and authorizes in-state and out-of-state shellfish importation and transfer
Washington Department of Health	<p>State Shellfish Authority, ensure compliance with the National Shellfish Sanitation Program</p> <p>Sets growing area classifications and boundaries; monitors water quality for toxins, pathogens, and viruses; closes areas that are unsafe for harvest; licenses and inspects commercial shellfish harvest and operations; certifies harvest sites; and responds to shellfish related reports and outbreaks</p>
United States Army Corps of Engineers	<p>Requires a Section 404 permit for the discharge of material into waters of the United States</p> <p>Requires a Section 10 permit for work in navigable waters of the United States</p>
Washington Department of Agriculture	<p>Safeguards the public from consuming unsafe, adulterated, or misbranded food through processing plant licenses and product identification requirements</p> <p>Oversees the control of noxious and invasive species</p> <p>Issues registrations for pesticides</p>
Local Governments	Issues aquaculture use permits under local Shoreline Master Programs to protect natural resources, provide for public access, and plan for water-dependent uses

160

161 Economic Impact of Aquaculture

162 The coastal shellfish aquaculture industry provides a significant contribution to the local and
 163 statewide economy. However, comprehensive economic impact estimates are particularly challenging to
 164 generate for this industry due to discrepancies between state collected data and other reports from the

165 industry. Taylor et al. (2015) analyzed data from the state, supplemented with surveys from the shellfish
 166 harvesting and processing industry, to estimate the economic contributions of the industry for the
 167 MSP.⁵ Economic contributions include direct expenditures by the industry, as well as indirect and
 168 induced effects generated by those industry expenditures, including the total number of jobs and total
 169 labor income. Expenditures, total employment, and total labor income generated by the shellfish
 170 aquaculture industry in Pacific and Grays Harbor Counties are presented in Table 2.5-3.

171 Expenditures made by the shellfish industry include payments for goods and services such as payroll
 172 and benefits, seed oysters, ice, packaging, and taxes. A survey of processors and distributors indicate
 173 that about 71% of expenditures made by survey participants are made locally in Washington’s coastal
 174 counties, with 94% of expenditures made within Washington State. About 847 jobs and \$50 million in
 175 labor income are generated by the aquaculture industry (growing and processing) in the Washington
 176 coastal region. An additional 383 jobs and \$23.2 million in total labor income are generated in
 177 Washington State outside of the coastal region by the coastal aquaculture sector’s activities (Table 2.5-
 178 3) (Taylor et al., 2015).

179 **Table 2.5-3. Estimated regional expenditures by the Pacific coast shellfish aquaculture industry and total economic**
 180 **contribution (employment and labor income) to the Washington coast region and statewide. Source: Taylor et al. (2015).**

	Expenditures	Total Employment	Total Labor Income
Washington coast region	\$65.2 million	847	\$50 million
Statewide	\$78 million	1,230	\$73.2 million

181
 182 Included in the total economic contribution to the state economy from shellfish aquaculture are
 183 revenue to the state from aquaculture land leases, license, and permit fees paid by shellfish farmers,
 184 and sales for access to the state-owned Willapa Bay Oyster Reserves for commercial harvest⁶ (Taylor et
 185 al., 2015). DNR leased lands generated about \$327,230 in revenue in 2010, and oyster sales from the
 186 Oyster Reserves have averaged about \$173,000 per year with clam sales averaging about \$15,000 per
 187 year (Industrial Economics Inc., 2014).

188 At the county level, Pacific County in particular has a high economic dependence upon shellfish
 189 aquaculture. A report by Washington Sea Grant (2015) estimated that in 2010, 20% of Pacific County’s
 190 total economy relied on aquaculture. This indicates that Pacific County’s economy is at relatively high
 191 risk if the industry reduces business activities or closes down.

192 Industry representatives, state managers, and economists understand well the limitations of the
 193 above aquaculture economic contribution estimates. The Washington State Shellfish Initiative is looking
 194 to address this issue by designing a system to improve data collection and sharing of information on the
 195 economics of shellfish (Office of the Governor, 2016).

196 [Related Infrastructure](#)

⁵ The estimates produced by the Cascade Economic study (Taylor et al. 2015) are based on information from 2013. The multipliers used were derived using the IMPLAN models based on 2012 regional economic data.

⁶ 60% of the proceeds from the sales of oysters on the reserves goes to research activities in Willapa Bay (WDFW, personal communication, May 31, 2016).

197 *Hatcheries*

198 Shellfish hatcheries are vital to the aquaculture industry. Four companies provide hatchery larvae to
199 farms in Willapa Bay and Grays Harbor: Whiskey Creek Shellfish Hatchery of Netarts, Oregon, Taylor
200 Shellfish of Shelton, Washington, Coast Seafoods Company of Bellevue, Washington (now owned by
201 Pacific Seafood), and the Nisbet Oyster Company of Bay Center, Washington. Some other companies are
202 able to produce some larvae for their own operations, but it is often not enough to fulfill their entire
203 seed need. Most hatchery production occurs in the Pacific Northwest, however the Nisbet Oyster
204 Company has an operation in Hilo, Hawaii, Coast Seafoods has a clam larvae operation in Kona, Hawaii,
205 and Taylor Shellfish has nurseries in California and Hawaii. Some operations in Hawaii were in response
206 to the large scale oyster larvae failures in the mid 2000's and the concern of ocean acidification
207 (Industrial Economics Inc., 2014; Taylor et al., 2015).

208 *Processors*

209 Processing facilities are also vital to the sale of shellfish aquaculture product. Processing can consist
210 of simply cleaning the shell to prepare for selling live⁷, or the product can be processed in-shell (non-
211 living) or be shucked and packed. The DOH has different licensing requirements for different categories
212 of shellfish processors (aka "dealers"). Processors can be licensed to perform various processing and
213 selling activities (e.g. shellstock shippers vs. shucker-packers, etc.⁸). Several processing companies that
214 are licensed to shuck shellfish operate in Pacific County, including Coast Seafoods, Nisbet Oyster
215 Company, Wiegardt Brothers, Ekone Oyster Company, Bay Center Mariculture, Chetlo Harbor Shellfish,
216 Palix Oyster Company, and South Bend Products. Another large company, Taylor Shellfish, ships its
217 product out of the Study Area to a facility in Shelton for processing. Processing in Grays Harbor is more
218 limited, with Brady's Oysters and Lytle Seafood being the only processors of oysters in the area
219 (Industrial Economics Inc., 2014; L. Johnson (DOH), personal communication, December 22, 2015).

220 Processors also ship their product in- and out-of-state, as well as overseas. Many processing
221 companies transport the product themselves or rely on another company or consolidated shipper
222 (Taylor et al., 2015; L. Johnson (DOH), personal communication, December 22, 2015).

223 *Water access*

224 As an estuary use, water access is required for the farming of shellfish. Willapa Bay has marinas that
225 are primarily used by oyster growers, such as Bay Center Marina and Nahcotta, to transport and store
226 boats, along with other aquaculture water access related activities. Some farms and processors have
227 their own private docks and water access for operations in Willapa Bay and Grays Harbor.

228 *Future Trends*

229 Shellfish growers and processors face many current challenges and future uncertainties within the
230 industry. Primary among future uncertainties are invasive and native nuisance species control,
231 regulatory and policy changes, climate change, workforce availability, and changes to estuary uses.
232 Experimentation with geoduck culture and the development of the Manila clam market are
233 opportunities for aquaculture expansion.

234 *Invasive and native nuisance species control*

⁷ DOH uses the term "shellstock" to describe oysters that are washed and kept live.

⁸ For descriptions of the various dealer license categories, please see Industrial Economics (2014).

235 Invasive and native noxious and nuisance species are perceived by aquaculture stakeholder
236 representatives as the greatest threat to the industry (Industrial Economics Inc., 2014). While the 99.9%
237 reduction of *Spartina* in Willapa Bay is a substantial success story (Washington State Department of
238 Agriculture, 2015), other invasive and nuisance species pose current and future risks to aquaculture
239 growing conditions in Willapa Bay and Grays Harbor. Current species include (but are not limited to) the
240 noxious weed⁹ Japanese eelgrass (*Zostera japonica*), burrowing shrimp (*Neotrypaea californiensis* and
241 *Upogebia pugettensis*), and two species of non-native oyster drills (*Ceratostoma inornatum* and
242 *Urosalpinx cinerea*) (Industrial Economics Inc., 2014; Taylor et al., 2015).

243 The impacts on aquaculture production by nuisance species can be quite significant, with one expert
244 suggesting declines of as much as 10%-20% in shellfish production per year in areas of high burrowing
245 shrimp populations. Controlling burrowing shrimp can be quite challenging and costly to the industry,
246 and currently requires the use of pesticides to be effective. Similarly, Japanese eelgrass also requires the
247 use of herbicides for control. The industry must comply with several regulations to treat oyster beds
248 with pesticides, including obtaining permits from ECY, and following the label requirements on pesticide
249 registrations from the WSDA and the U.S. Environmental Protection Agency (EPA). Even so, the
250 application of chemicals for these species in some cases is environmentally controversial and has been
251 met with resistance from certain consumer and public groups, adding to the challenge the aquaculture
252 industry faces in managing nuisance species.

253 In addition, new species may be introduced in the future or environmental changes to the estuaries
254 could result in a species interaction shift that can have unforeseen impacts to aquaculture. Present day
255 and potential future invasive and nuisance species will continue to be a threat and create significant
256 operational, regulatory, and economic challenges for the aquaculture industry (Industrial Economics
257 Inc., 2014; Taylor et al., 2015).

258 *Regulatory burden and uncertainty*

259 Regulatory requirements are seen by many industry representatives as complicated, burdensome,
260 costly, time consuming, and not conducive to a growing aquaculture industry. Main concerns voiced
261 include: (1) resources required to comply and keep up with permit application, renewal, and reporting
262 requirements, etc.; (2) as a result of new permit requirements, the industry is vulnerable to additional
263 challenges or appeals which can result in expensive legal proceedings; and (3) environmental
264 requirements with which shellfish farms must comply are burdensome. The complicated nature of
265 aquaculture industry regulations is a current challenge, and will continue to pose challenges to the
266 future of the industry, particularly if new, more restrictive regulations are put into place (Industrial
267 Economics Inc., 2014; Taylor et al., 2015). The Shellfish Interagency Permitting Team, part of the
268 Washington Shellfish Initiative, has recently released recommendations to address permitting
269 challenges in the aquaculture industry and will continue to work to improve the permitting process
270 (Lund & Hoberecht, 2016).

271 *Climate Change*

272 A changing climate could lead to alterations of environmental conditions within the estuaries, and
273 ultimately the growing conditions for the aquaculture industry. Among the key concerns related to
274 climate change are the consequences of ocean acidification, sea level rise, and water temperature.

⁹ A “noxious” weed in Washington is the traditional, legal term for any invasive, non-native plant that threatens agricultural crops, local ecosystems or fish and wildlife habitat. For more information on noxious weeds in Washington, including Japanese eelgrass, go to <http://www.nwcb.wa.gov/default.asp>

275 Ocean acidification is one of the primary environmental concerns for the shellfish aquaculture
276 industry in the MSP Study Area as well as elsewhere in Washington. As ocean acidity increases, calcium
277 carbonate upon which young oysters rely to grow their shells becomes less available. This leads to
278 thinner shells, slower growth rates, and higher mortality rates. Because oysters and other shellfish are
279 most vulnerable when they are young, scientists believe that ocean acidification is likely the cause of
280 failure of the natural set in recent years, as well as large scale hatchery failures using local seawater. The
281 state of Washington has recognized the severity of this issue and potential risks to the economy and
282 culture of the aquaculture industry, and the Governor's office has taken a number of steps to promote
283 research and actions to address this issue, including a Washington State Blue Ribbon Panel on Ocean
284 Acidification (Washington State Blue Ribbon Panel on Ocean Acidification, 2012). Based on the Blue
285 Ribbon Panel recommendations the Governor and legislature created the Marine Resource Advisory
286 Council and the Washington Ocean Acidification Center to advance coordinated efforts to address ocean
287 acidification.¹⁰

288 Hatcheries and oyster production companies have incurred considerable costs to address the
289 consequences of ocean acidification, and are investing for the future in anticipation of further increases
290 in ocean acidity. The Blue Ribbon Panel estimated that ocean acidification has already cost the oyster
291 industry over \$110 million. One company has opened a hatchery in Hawaii to avoid the increased
292 acidification of waters entering the Pacific Northwest, which has increased the cost of producing and
293 providing oyster spat. Many companies may not have the means to relocate hatcheries if they own one
294 or may not be able to absorb the costs of purchased spat (Industrial Economics Inc., 2014; Taylor et al.,
295 2015).

296 The failure of natural oyster sets (either from ocean acidification or other conditions) creates
297 challenges and increased costs for the oyster industry. One company has seen a five to six time increase
298 in seeding process costs. The failure of a natural set in the Willapa Harbor State Oyster Reserve, which
299 depends completely on the occurrence of natural larvae sets, will diminish oyster supply. This in turn will
300 decrease income provided by the reserve as well as reduce the quality of oyster habitat and the
301 associated ecosystem services within Willapa Bay (Industrial Economics Inc., 2014; Taylor et al., 2015).

302 Sea level rise may also impact the shellfish industry. Most shellfish culture occurs on the intertidal
303 substrate, and the intertidal zone will shift landward or be reduced as a result of sea level rise. This may
304 decrease access to aquaculture beds, decrease available harvest time at low tides, and likely shift
305 optimal growing areas. Changes in property boundaries and harvest areas will create logistical and
306 management challenges for the oyster industry (Taylor et al., 2015).

307 As water temperatures rise with climate change, the shellfish industry could be impacted in a
308 number of ways. First, increased temperatures may reduce shellfish growth, reproduction, distribution,
309 and health. Second, rising water temperatures may increase the occurrence of Harmful Algal Blooms
310 (HABs), which can produce natural toxins that cause human illness or death when they are concentrated
311 within filter feeding shellfish, and bacteria, which also can cause human illness. *Vibrio parahaemolyticus*
312 is a naturally-occurring bacterium common in Washington in the warm summer months. *V.*
313 *parahaemolyticus* causes illnesses each year, mostly impacting consumers of raw oysters. DOH is
314 responsible for monitoring HABs and *V. parahaemolyticus* in shellfish growing areas. DOH is concerned
315 that HABs and *V. parahaemolyticus* will increase in frequency, duration, and severity with rising water
316 temperatures. Rising water temperatures may also result in new, more dangerous varieties of toxins and
317 other pathogens. DOH tracks reports of shellfish-related illnesses and monitors for emerging toxins and

¹⁰ More information on the Marine Resource Advisory Council can be found at
<http://www.ecy.wa.gov/water/marine/oceanacidification.html>

318 pathogens in close collaboration with research partners at the National Oceanographic and Atmospheric
319 Administration (NOAA), the Food and Drug Administration (FDA), and academia. The emergence of new
320 toxins and pathogens would result in a significant negative economic impact to the industry (Industrial
321 Economics Inc., 2014; Taylor et al., 2015; L. Johnson, personal communication, December 22, 2015).

322 *Potential changes to estuary uses*

323 Changes in the intensity and frequency of current co-uses of the estuaries may influence the
324 shellfish aquaculture industry on the coast. Projected increases in crude oil transportation by ship and
325 by rail is of particular concern (See Section 2.7 Marine Transportation, Navigation, and Infrastructure).
326 Concerns center on the risk of an oil spill, and the potential severe impact it could have to the industry
327 through contamination of shellfish beds. Another concern for Grays Harbor growers is the federal
328 navigation channel deepening (See Section 2.10.3 Dredge Disposal). Past navigational dredging is
329 believed to contribute to loss of oyster beds now buried by sand, decreased production from wave
330 action, and changes in substrate size (Industrial Economics Inc., 2014). These changes to marine traffic
331 and increases in oil transportation place additional uncertainty for the future of the aquaculture
332 industry.

333 Potential new uses addressed within the Marine Spatial Plan also cause some concern among
334 industry representatives. Aquaculture is highly dependent upon environmental conditions such as water
335 flow and water quality. Some representatives are concerned about what effect a Marine Renewable
336 Energy project within or near the estuaries may have on water flow (Industrial Economics Inc., 2014).
337 Another potential concern is the possibility of net pen aquaculture within the estuaries. Finfish
338 aquaculture can be associated with reduced water quality in shallow and poorly flushed sites (See
339 Section 2.10.2 Offshore Aquaculture). There is currently no net pen aquaculture (finfish) within the
340 estuaries. If net pens were to be developed within Grays Harbor or Willapa Bay, growers may be
341 concerned about potential water quality changes and the consequences for the shellfish industry.
342 Currently, there is no known active interest in net pen aquaculture in Willapa Bay or Grays Harbor and it
343 is unlikely this activity would be sited here in the future.

344 In summary, even while facing several existing challenges and future uncertainties, the aquaculture
345 industry is currently enjoying strong demand for its products. Experts believe the industry can continue
346 to grow and thrive if: the industry is able to innovate and adjust to changing climatic conditions and
347 other challenges, such as invasive and nuisance species; policy makers can address concerns of uses
348 such as crude oil transportation; and the regulatory structure allows for a reasonable and flexible
349 opportunity to address these challenges. Furthermore, experts have identified areas of potential
350 expansion into the culture of geoduck clams and further develop production and markets for Manila
351 clams (Industrial Economics Inc., 2014). Aquaculture is important economically and socially to the coast
352 and the state of Washington, and will continue to play a role in future policies and decisions for coastal
353 and marine uses.

354

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397

DRAFT

1 2.6 Recreation and Tourism

2 The Pacific Coast of Washington relies on an economy based in recreation, tourism, and natural
3 resources. The tourism and recreation benefits offered by the mostly rural coast are important to both
4 the residents of local communities and also to visitors from throughout the state and beyond. A survey
5 by Point 97 and the Surfrider Foundation (2015) found that recreational visits to the coast by
6 Washington residents are a substantial driver for local economies with spending of \$481.2 million in the
7 2014.

8 This chapter summarizes the role of recreation and tourism in the MSP Study Area and highlights
9 popular recreational activities. The economic impacts, related infrastructure, and future trends of
10 recreation and tourism are also described here.¹

11 Summary of History and Current Use

12 The natural setting of Washington’s Pacific coast has always been a major draw for visitors and
13 residents. Large portions of the Washington coast have been designated to protect and facilitate public
14 recreation. For example, Olympic National Park was established in 1938 by President Roosevelt and has
15 three park districts directly on the coast adjacent to the Study Area (Industrial Economics Inc., 2014).
16 Another example is the Washington State Seashore Conservation Act of 1967 which recognized the
17 importance of the pristine Washington shoreline in “...provid(ing) the public with almost unlimited
18 opportunities for recreational activities, like swimming, surfing, and hiking; for outdoor sports, like
19 hunting, fishing, clamming, and boating; for the observation of nature as it existed of hundreds of years
20 before the arrival of Europeans; and for relaxation away from the pressures and tensions of modern life”
21 (RCW 79A.05.600) and established much of the southern area of the coast as a Seashore Conservation
22 Area for public recreation use and enjoyment.

23 The northern portion of the MSP Study Area (Clallam and Jefferson Counties) is a rugged, dramatic
24 cliff coastline with limited public access points. The Makah, Quileute, and Hoh Indian Tribes have
25 reservation lands in the northern portion, and much of the rest of the northern coast is within the
26 Olympic National Park. Recreational features of the northern coast include Cape Flattery; Olympic
27 National Park’s campgrounds and trails; several surfing beaches; coastal trails and beaches for walking,
28 hiking, and camping; and various tribal facilities, including lodging, marinas, and trails. The northern
29 coast primarily attracts visitors looking to spend time connecting with nature (Industrial Economics Inc.,
30 2014).

31 The southern coast (Grays Harbor and Pacific counties) provides visitors with opportunities to enjoy
32 nature while taking advantage of amenities associated with more developed areas. The southern coast
33 is dominated by long, sandy beaches as well as the two large estuaries with calmer waters protected
34 from the open ocean. The southern coastal area contains more than ten state park facilities, the
35 Seashore Conservation Area (SCA), the Quinault and Shoalwater Bay Indian Reservations, and several
36 major coastal communities (Maps 1 and 2). Second-home communities that incorporate amenities and
37 rental programs have become popular along the southern coast (Industrial Economics Inc., 2014).

38 Recreation Activities

¹ Recreational fishing is not included in this section as it is covered in Section 2.4 Commercial, Recreational, and Tribal Fisheries.

39 A panel survey conducted in 2014-2015 by Point 97 and the Surfrider Foundation (2015) collected
40 data on Washington resident recreation activities in the MSP Study Area. The survey evaluated where
41 respondents recreated, what types of activities they participated in, and how much they spent on
42 various activities and trips.² In total, the study estimated that Washington State residents (18 years of
43 age and older) take about 4.1 million trips to the MSP Study Area per year. Pacific (37%) and Grays
44 Harbor (35.6%) counties received the largest proportion of recreational trips to the Study Area by WA
45 residents, followed by Clallam (20.2%) and Jefferson (7.2%) counties. Areas with high densities of
46 recreation trips include Ocean Shores, Westport, Long Beach/Seaview, Pacific Beach, La Push, and
47 Kalaloch, although it is clear that the entire MSP Study Area coast has some usage for recreation (Map
48 32) (Point 97 & Surfrider Foundation, 2015).

49 Respondents were asked to identify all of the recreational activities they participated in during
50 coastal trips to the MSP Study Area in the previous twelve months. The top five most popular activities
51 identified were beach going (67.7%), sightseeing/scenic enjoyment (62.3%), watching marine life from
52 shore (39.9%), photography (36.3%), and hiking or biking (33.1%). Respondents were also asked to
53 identify their primary activity on their most recent trip and the top three primary recreation activities in
54 the MSP Study Area were beach going (32%), sightseeing/scenic enjoyment (22.6%), and camping
55 (11.3%). Other types of recreational activities along the coast include swimming, beach driving, tide
56 pooling, surfing, kayaking and paddle boarding, SCUBA diving, windsurfing, boating, horseback riding,
57 whale watching, and others (Point 97 & Surfrider Foundation, 2015). Maps displaying the spatial
58 intensity of grouped and individual recreational activities in the MSP Study Area can be found in the
59 Point 97 & Surfrider Foundation (2015) report. Some of the recreational activities are highlighted
60 below.

61 [Wildlife viewing](#)

62 Wildlife viewing from shore ranked highly as a frequent activity among coastal visitors to the MSP Study
63 Area. Visitors also participate in wildlife viewing on the water from private boats and charter boats or
64 guide services. Popular marine wildlife to view along the coast, in the estuaries, and on the ocean
65 include a variety of birds like bald eagles, osprey, blue herons, brown pelicans, and snowy plovers; and
66 marine mammals like whales, seals, otters, and sea lions. The peak season for whale watching is
67 between March and May as gray whales migrate along the coast, and even can be found swimming
68 inside Grays Harbor. Humpback whales can also be spotted as they migrate seasonally along the coast
69 (City of Hoquiam & Washington State Department of Ecology, 2016). Along the Northern coast, Neah
70 Bay offers opportunities to view seabirds, sea lions, and Gray whales. La Push offers whale watching
71 from the beach and boat charters out of the marina to view the Gray whale migration near shore and
72 occasionally transient orcas. South of La Push through Kalaloch and Queets are many more
73 opportunities to view wildlife including whales, brown pelicans, sea lions, harbor porpoise harbor seals,
74 and sea otters. On the Southern Washington Coast the whale watching and wildlife viewing
75 opportunities continue near Moclips, Pacific Beach, Copalis, and Ocean City. In Westport, whale
76 watching tours are available leaving from Westport Marina. In the Ocean Shores area, Damon Point and
77 the Oyehut Wildlife Recreation Area are notable for their bird watching opportunities (Taylor, Baker,
78 Waters, Wegge, & Wellman, 2015).

79 The Grays Harbor and Willapa Bay estuaries and wildlife refuges are particularly popular sites for
80 shore-based bird watching. The Grays Harbor National Wildlife Refuge (NWR) is a migration stopover
81 for thousands of shorebirds in the spring and fall (Taylor et al., 2015). The peak bird migration is
82 typically in late April and early May. Thousands of people attend the Grays Harbor Shorebird Festival to

² Details on the methodology used are available in the full report: Point 97 & Surfrider Foundation, 2015.

83 view the migration of hundreds of thousands of Arctic-bound shorebirds. The festival features shorebird
 84 viewing, field trips, lectures, and a birding market place and nature fair (City of Hoquiam & Washington
 85 State Department of Ecology, 2016). The Willapa National Wildlife Refuge (NWR) estimates that in 2010
 86 there were 109,500 visitor use days to participate in wildlife observation/photography. The diverse
 87 habitats found at Willapa NWR support over 200 species of resident and migratory birds. At Leadbetter
 88 Point on the northern tip of the Long Beach Peninsula over 100,000 birds can be seen during the peak
 89 spring migration (U.S. Fish and Wildlife Service, 2011).

90 **Waterfowl hunting**

91 Waterfowl hunting is another recreational use of the areas adjacent to the MSP Study Area. The
 92 Washington Department of Fish and Wildlife (WDFW) has management authority for all non-tribal
 93 waterfowl hunting within the state, and all hunting requires a small game license and potentially
 94 additional regulations depending on the species. Treaty tribes set hunting regulations for their
 95 members and tribal members do not require a state license (Skewgar & Pearson, 2011).

96 Duck and goose hunting occurs in all of the coastal counties. Statistics from WDFW for 2015 show
 97 the numbers of duck and goose hunters are highest in Grays Harbor County while the rate of harvest is
 98 highest in Pacific County for both ducks and geese. See Table 2.6-1 and Table 2.6-2. The Willapa NWR
 99 estimates that in 2010 there were 350 visitor use days to the refuge to hunt waterfowl (U.S. Fish and
 100 Wildlife Service, 2011), while the Grays Harbor NWR does not allow hunting.

101 **Table 2.6-1: 2015 Recreational duck hunting in WA coastal counties. Source: WDFW**

County	Number of Hunters	Hunt Days	Harvest	Harvest Rate (harvest/days)
Clallam	379	2231	5815	2.61
Jefferson	210	1228	2278	1.86
Grays Harbor	865	4765	11144	2.34
Pacific	398	2080	5866	2.82

102

103 **Table 2.6-2: Recreational goose hunting in WA coastal counties. Source: WDFW**

County	Number of Hunters	Hunt Days	Harvest	Harvest Rate (harvest/days)
Clallam	118	836	331	0.40
Jefferson	31	207	24	0.12
Grays Harbor	224	839	542	0.65
Pacific	123	626	827	1.32

104

105 Clamming

106 A particularly popular recreational activity on the south Washington Pacific coast is razor clamming.
107 Razor clam (*Silqua patula*) recreational harvesting, cleaning, cooking, eating, and canning have been an
108 important focus of family relationships and local culture in Washington State coastal communities for
109 many generations. With between 275,000 and 460,000 seasonal digger trips harvesting as many as 6.1
110 million clams, the fishery generates between \$25 and \$40 million in tourist related income per season to
111 the economies of small coastal communities (Ayres, D., WDFW, personal communication, June 1, 2016).
112 Clamming is allowed at designated beaches along much of the southern half of the Washington coast
113 Map 29. Occasional long-term area closures of the razor clam fishery due to increases in levels of
114 naturally occurring marine biotoxins (caused by harmful algae blooms) can significantly disrupt the
115 fishery, as well as negatively impact the coastal tourism industry which significantly benefits from
116 recreational razor clammers visiting the coast (Ayres, D., WDFW, personal communication, June 1,
117 2016). For more information on the recreational razor clam fishery, please see the Fisheries chapter.

118 While razor clamming is a more popular recreational activity, there is also a recreational hardshell
119 clam fishery. Hardshell clams includes littleneck clam (*Leukoma staminea*) and butter clam (*Saxidomus*
120 *gigantea*). The National Park Service has done some population assessment of hardshell clams on
121 beaches in Olympic National Park (Map 29). Hardshell clamming differs from razor clamming in that
122 there is a relatively lower density of hardshell clams; they live on remote, exposed, wilderness beaches;
123 and digging them is more challenging because they live in a mixed-coarse substrate of sand, gravel, and
124 cobble. The hardshell clam recreational fishery in Olympic National Park is relatively small due to the
125 challenges of harvest and lower density (Fradkin, S., NPS, personal communication, October 28, 2016).
126 WDFW does allow harvest of hardshell clams within the Willapa Bay estuary and those stocks receive
127 greater harvest pressure (Ayres, D., WDFW, personal communication, November 18, 2016).

128 Boating

129 As seen in Map 33, recreational vessels transit the majority of the MSP Study Area. Recreational
130 vessels, as defined for the study, include private vessels like sailboats, motorboats, and small
131 independent fishing boats only when they are transiting the area but not when fishing. The data for the
132 map was obtained through the Automatic Identification System (AIS) which is a tracking system used on
133 ships and by vessel traffic services for identifying and locating vessels by electronically exchanging data.³
134 Recreational boaters on the Pacific Coast of Washington participate in a variety of activities including
135 sailing, cruising, viewing wildlife, and fishing. One unique activity on the coast is the Coho Ho Ho, a
136 sailing rally from Puget Sound to San Francisco. About a dozen boats participate annually, and while the
137 organization does not recommend specific routes to each boat, they suggest a halfway stop in Newport,
138 OR and educate participants to be responsible boaters. Many of the participants will continue from San
139 Francisco down to San Diego to join up with the larger Baja Ha Ha sailing rally with a final destination of
140 Cabo San Lucas, Mexico. (Lombard, D., Coho Ho Ho, personal communication, October 26, 2016).

141 Surfing

142 Surfing is practiced by a relatively small percentage of the overall recreational user community, yet
143 surfers are a dedicated user group. Surfers are known to make frequent trips to the coast and,
144 therefore, are considered avid users of coastal resources and important contributors to local economies.
145 Surfers travel great distances to reach quality waves. While surfers are predominately from Washington,

³ While AIS is required for larger vessels, it is not required for recreational private vessels. Therefore, some recreational vessels are not represented in this map. The map only includes data from vessels that choose to use AIS.

146 visitors from Oregon and British Columbia are common at Washington surf spots. Surfers also come
147 from as far away as Montana, California, the East Coast, and even Australia. Several surfing spots are
148 scattered along the Washington coast. The Clean Water Classic, the longest running Pro/Am Surf
149 Competition in the Pacific Northwest, is held in Westport in early October. The event is organized by
150 volunteers and draws nearly 700 visitors, benefiting the Surfrider Foundation chapters in Washington,
151 Oregon, and British Columbia (Dennehy, C., Surfrider, personal communication, August 10, 2016).

152 Beach prospecting

153 Ocean beach prospecting is another recreational use with a relatively small, yet committed group of
154 people that participate. Beach prospecting first began on Washington's coastal beaches in 2008, when
155 interest from the prospecting community prompted a two year pilot program for beach prospecting on
156 three beaches within the SCA jointly evaluated by WDFW and Parks (Washington Department of Fish
157 and Wildlife & Washington State Parks and Recreation Commission, 2010). The pilot program was
158 successful, and currently, small scale mining and prospecting are allowed year round on ocean beaches
159 within the SCA between the line of ordinary high tide and the line of extreme low tide. This activity is
160 managed by WDFW and Parks, and miners are required to follow the rules within the WDFW Gold and
161 Fish pamphlet (a type of umbrella Hydraulic Project Approval) (Washington Department of Fish and
162 Wildlife, 2015). Because WDFW no longer issues individual Hydraulic Project Approvals (HPA) for this
163 activity and Parks does not quantitatively track ocean prospecting, the State cannot provide current
164 participation numbers. The most recent estimates are during May 2014 – July 2015, when WDFW
165 required individual HPAs for beach prospecting, and issued about 260 HPAs for this activity (Aaron, K.,
166 WDFW, personal communication, June 1, 2016).

167 Economic Impact of Recreation and Tourism

168 Recreation has always been a part of the economy in the coastal counties. Historically, recreation
169 and tourism have played a small part relative to other industries such as fishing, forestry, and
170 manufacturing, yet the recreation and tourism sector is growing and increasing in prominence (Taylor et
171 al., 2015). Currently, recreation and tourism are often the most popular human uses of coastal and
172 marine settings. A 2011 study on the ocean economy for the five Pacific coast counties (Clallam, Grays
173 Harbor, Jefferson, Pacific, and Wahkiakum) adjacent to the MSP Study Area shows that tourism and
174 recreation was the largest sector and accounted for approximately 78 percent of employment and 50
175 percent of GDP for the portion of the economy that depends directly on ocean resources. This study
176 was not limited to the Study Area, but also includes Wahkiakum County, and the portions of Clallam and
177 Jefferson counties adjacent to the Strait of Juan de Fuca and Puget Sound (NOAA Coastal Services
178 Center, 2014).

179 Specific to the MSP Study Area, survey respondents spent an average of \$117.14 per person per
180 coastal trip in 2014-2015, and Point 97 & the Surfrider Foundation (2015) estimated that the total
181 annual coastal trip spending by Washington residents was about \$481.2 million statewide (Table 2.6-3).
182 This and other surveys indicate that Washington residents and out-of-state visitors spend the most
183 money on accommodations, food and beverages, and transportation when visiting the coast (Point 97 &
184 Surfrider Foundation, 2015; Taylor et al., 2015). Estimated trip spending associated with MSP Study Area
185 coast trips by out-of-state visitors is about \$160 million within the coastal region, with an additional
186 \$29.8 million spent elsewhere in the state (Table 2.6-3) (Taylor et al., 2015).

187 Recreation and tourism trip spending in the MSP Study Area generates economic activity that
188 supports jobs and personal income for residents of the coastal area and elsewhere in the state. In the
189 coastal study area, recreation trip-related spending by Washington residents is estimated by Taylor et al.

190 (2015) to support 4,725 jobs and \$196.8 million in labor income within the coastal economy. As dollars
 191 and economic activity multiply through the state’s economy, an estimated 9,309 jobs statewide are
 192 supported directly and indirectly by recreation and tourism in the coastal area, as well as \$413 million in
 193 labor income (Table 2.6-3).⁴ Many communities along the MSP Study Area are heavily reliant on
 194 employment generated by the recreation and tourism industry. For example, resident employment in
 195 tourism-sensitive industries exceeds 50% of overall employment for communities such as Pacific Beach
 196 (57.5%), Copalis Beach (82%), Ocean City (85.7%), and Seaview (57.5%) (Taylor et al., 2015).

197 **Table 2.6-3. Estimated recreation and tourism trip spending associated with Study Area coastal trips by Washington State**
 198 **residents and out-of-state visitors and total economic contribution (employment and labor income) to the Washington coast**
 199 **region and statewide. Source: Taylor et al. (2015).**

	Trip spending by WA residents	Trip spending by out-of-state visitors	Total employment (from trip spending by WA residents)	Total labor income (from trip spending by WA residents)
Washington coast region	\$330.9 million	\$160 million	4,725	\$196.8 million
Statewide (total)	\$481.2 million	\$189.8 million	9,309	\$413 million

200

201 **Related Infrastructure**

202 Coastal recreation and tourism activities are linked closely with available access for outdoor
 203 activities and supporting amenities such as lodging or camping, food, and entertainment. As noted
 204 earlier, the northern and southern coastal regions differ in the types of recreational and tourism
 205 experiences they offer, as well as supporting public access and amenities. The northern coastal region
 206 offers recreation and tourism users with an opportunity to connect with nature in a more private and
 207 rugged wilderness setting supported by Olympic National Park lands, coastal hiking, surfing, and a few
 208 camping and lodging amenities. The southern coast provides users with long sandy beaches optimal for
 209 kite flying, beach driving, razor clamming, horseback riding, and other activities. Several coastal
 210 communities are nearby to support dining and lodging options.

211 **National Park and Wildlife Refuges**

212 Olympic National Park is located on the Olympic Peninsula and covers much of Clallam and Jefferson
 213 Counties. In addition to the large park area inland on the Peninsula, the park also has three coastal
 214 districts which account for much of the northern MSP Study Area coastline (Map 1). Olympic National
 215 Park is the region’s predominant recreation and tourism destination, and receives an estimated 3 million
 216 visitors annually, with about 759,000 to 783,000 estimated visitors each year to the three coastal park
 217 districts during 2011-2014. Park facilities include coastal public access points, trails, campgrounds, and
 218 wilderness campsites (Industrial Economics Inc., 2014).

⁴ Total employment and labor income estimates were generated by Taylor et al. (2015) using economic multipliers derived from IMPLAN models based on 2012 regional economic data. For more information see the Socioeconomics chapter and the Cascade Economics report.

219 Five National Wildlife Refuges are located within the Study Area (Map 1); Flattery Rocks, Quillayute
220 Needles, and Copalis National Wildlife Refuges are offshore and public access to these islands is
221 prohibited, although wildlife viewing from boats is allowed (Industrial Economics Inc., 2014). Grays
222 Harbor and Willapa National Wildlife Refuges are on the mainland and open to visitors. Grays Harbor
223 National Wildlife Refuge is a main attraction in the Grays Harbor/Aberdeen area, where a 1,800 foot
224 boardwalk provides access for viewing the hundreds of thousands of migrating shorebirds visiting the
225 Refuge's muddy tidal flats. Willapa National Wildlife Refuge has several units located adjacent to Willapa
226 Bay encompassing habitat such as salt marsh, muddy tidelands, forest, freshwater wetlands, streams,
227 grasslands, coastal dunes, and beaches. This diversity supports a variety of recreational activities,
228 including wildlife viewing, hiking, hunting, boating, photography, fishing, and shellfish harvesting (Taylor
229 et al., 2015). A study in 2011 estimated 114,680 visits to the Willapa National Wildlife Refuge in 2011,
230 with associated spending totaling and estimated \$1.8 million (Industrial Economics Inc., 2014).

231 *State Parks and Public Areas*

232 Washington State Parks and Recreation Commission manages several state parks, the Seashore
233 Conservation Area (SCA) (Map 1), and ocean beach approaches along the coast within Grays Harbor and
234 Pacific counties. Many of the parks have overnight facilities with campground sites, while others are day
235 use only. Approximately 9,220,903 people visited Pacific coast state parks, SCA, and ocean beach
236 approaches in 2013, with an estimated \$3,299,696 in revenue. The most popular state managed areas
237 for visitation along the coast are North Beach SCA (1.5 to 2.6 million visitors per year), Long Beach SCA
238 (1.7 to 3 million visitors per year), Cape Disappointment (0.6 to 1.5 million visitors per year), and South
239 Beach SCA (0.7 to 1.3 million visitors per year) (Industrial Economics Inc., 2014).

240 Public access is critical for supporting and facilitating coastal recreation. In general, there are more
241 public access opportunities in the southern half of the Study Area compared to the northern half (Map
242 34). Coastal towns, state parks, SCA, and broad sandy beaches are among the main reasons why the
243 public has more opportunities to access the beach in Grays Harbor and Pacific Counties. The remote
244 location, rugged coastline, limited population centers, and tribal reservations limit the opportunity for
245 convenient public access in Jefferson and Clallam Counties, although in some locations, the tribes
246 support and facilitate public tourism and recreation on their reservation lands. The Olympic National
247 Park also has access points, campgrounds, and wilderness campsites for the enjoyment of the coast.
248 While visited less frequently and in more restricted areas, the northern half of the MSP Study Area
249 provides visitors with a unique opportunity to enjoy the remote beauty of the Olympic Peninsula's
250 ocean coast.

251 *Marinas*

252 Marinas and boat launches support public access to the water. (See Map 30) Marinas provide
253 opportunities for private boat owners to launch their boats, as well as support charter operations for
254 bird and wildlife viewing, sightseeing, and fishing. The two marinas in Clallam County that support
255 recreation within the MSP Study Area are owned by tribes - the Makah Tribe (Makah Marina in Neah
256 Bay) and Quileute Tribe (La Push Harbor Marina). There are no marinas for use by the public in Jefferson
257 County in the MSP Study Area. Several marinas and ports provide public access for recreational users in
258 the southern half of the MSP Study Area, including the popular Westport Marina. The Quinault Nation
259 purchased the Ocean Shores Marina but has closed due to needed repairs and dredging. There is a boat
260 launch in the river mouth in Taholah that is only open to tribal members. In Willapa Bay, there are
261 several marinas and public boat launches including, but not limited to: Nacohtta, Bay Center Marina,

262 Tokeland Marina, Raymond Port Dock, and South Bend. Ilwaco and Chinook (on the Columbia River) also
263 have recreational boat access and support users of the MSP Study Area.

264 *Lodging*

265 Lodging is an important part of the coastal infrastructure that both attracts visitors and supports the
266 tourism industry. Lodging options on the Pacific coast of the MSP Study Area include campgrounds, RV
267 parks, motels, hotels, bed and breakfast inns, and rental homes. The Point 97 & Surfrider Foundation
268 (2015) study found lodging expenses as the highest expenditure for coastal trips (averaged \$25.96,
269 including those without lodging expenses). The average estimated total annual expenditures for all
270 visitors is approximately \$481 million with 22% of that going to lodging - approximately \$107 million
271 annually (Point 97 & Surfrider Foundation, 2015).

272 Highlights in Clallam County include the Hobuck Beach Resort owned by the Makah Tribe, Quileute
273 Oceanside Resort owned by the Quileute Tribe, and campgrounds and wilderness campsites in Olympic
274 National Park. In Jefferson County, Olympic National Park includes the Kalaloch Lodge as well as a
275 variety of campgrounds and wilderness campsites. In Grays Harbor County, the Quinault Nation owns
276 the Quinault Beach Resort and Casino; state parks offer camping, RV camping, and yurts; and the coastal
277 towns and cities offer a variety of lodging. In Pacific County, lodging options include the Shoalwater Bay
278 Casino owned by the Shoalwater Bay Tribe, RV and tent campsites, cabins, and yurts at state parks, and
279 hotels and motels in the coastal cities (Industrial Economics Inc., 2014).

280 *Future Trends*

281 Future trends within the recreation and tourism industry on Washington's Pacific coast are difficult
282 to predict. The industry may be influenced by population growth, development of second home
283 communities, limited access, and water quality issues. These issues that may influence the industry are
284 discussed below.

285 *Population growth and access*

286 The specific recreational activities preferred by visitors to the coast have not changed substantially
287 in recent history. Comparing the results of the Surfrider Foundation recreation survey in 2014-2015 and
288 a Washington State Recreation and Conservation Office report for 2002-2012 shows that out of the top
289 five recreational activities of beach going, sightseeing, camping, hiking, and photography, only the rate
290 of beach going changed significantly with increasing rates (as cited in Taylor et. al, 2015). New trends in
291 recreation are growing on the coast of the MSP Study Area, including stand up paddleboarding and kite
292 surfing, showing continued demand for access.

293 Between 2015 and 2025, total population growth in the coastal counties is projected to average
294 nine percent, and statewide growth is predicted at eleven percent (as cited in Taylor et al, 2015). While
295 it can be inferred that an increase in population would lead to an increase in demand for recreation and
296 tourism activities and facilities, this growth may be restricted by limited access to some areas of the
297 Pacific coast. As discussed above, the northern half of the study area has fewer public access
298 opportunities than the southern half of the study area. Although there are many opportunities for
299 access to the beach along the southern coast, anecdotal evidence shows that during peak periods
300 certain facilities lack sufficient parking to handle large crowds. Population growth and the increasing
301 popularity of certain activities may increase overcrowding (Taylor et al., 2015).

302 *Environmental factors*

303 The potential exists for a variety of environmental issues to impact the recreation and tourism
304 industry in the future. Potential erosion, particularly along the southern coast, could impact recreation
305 facilities and access to recreation and port facilities. Water quality is also a concern, past issues have
306 impacted recreational users of ocean resources and the potential exists for future effects as well. The
307 razor clam fishery, a highly popular recreational activity, has had frequent closures due to harmful algal
308 blooms. Marine algae blooms have also killed birds and caused health symptoms among surfers on
309 coastal beaches (Industrial Economics Inc., 2014).

310 Similar to the concerns highlighted in the Fisheries chapter, local stakeholders are also concerned
311 about the potential for oil spills to threaten coastal recreational resources. The impacts of an oil spill on
312 the natural resources of the Pacific coast could affect the recreation and tourism industry for an
313 extended period of time.

DRAFT

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352

2.7 Marine Transportation, Navigation, and Infrastructure

Marine shipping, transportation, and the associated infrastructure are significant uses of the MSP Study Area. Although this report is focused on the MSP Study Area, it is impossible to discuss marine transportation, navigation, and infrastructure without recognizing the relationship to activity in the Strait of Juan de Fuca, Puget Sound, and coastal points north and south of the Study Area. It is also challenging to separate out the economic impacts of these uses for just the Study Area as most studies and economic forecasts encompass broader areas. Therefore, this discussion of marine transportation, navigation, and infrastructure will often highlight impacts to the larger region.

This chapter summarizes the history and current use, economic impacts, and future trends of marine transportation, navigation, and associated infrastructure in the MSP Study Area.

Summary of History and Current Use

Shipping

Early trade began with Native peoples along the coast traveling widely by water, expanded with the introduction of European explorers focused on the region's natural resources, and continued to grow into the 18th and 19th centuries as competition for the northwest and its trade resources intensified. Washington eventually developed as an exporter of raw materials with well-developed trading networks (Washington Department of Archaeology and Historic Preservation, 2010). Settlers were drawn to the region due to the availability of natural resources and potential for trade with important early exports in lumber, shingles, and high-grade coal. Railroad companies developed a monopoly on moving cargo and received grants of federal land, with state and local governments often providing further land concessions leading the railroads to own large parcels of prime waterfront property (Caldbeck, 2010).

As a response to the railroad monopoly, Washington passed the Port District Act of 1911 that allowed voters to create and form public port districts that were required to devote their efforts and resources to developing and operating harbors and related facilities for public benefit. They also had the power to levy taxes, incur debt, and take land through eminent domain. Within 15 years of the Port District Act, all 11 of the state's currently operating deep-draft ports had been established including the ports of Grays Harbor, Seattle, and Tacoma. The ports and trade generally prospered during World War I and World War II, and suffered challenges during each transition to a postwar economy. Over time, the ports became more technically sophisticated and were able to handle a greater variety of cargoes with reduced effort and expense. The Port of Grays Harbor is the only deep-draft port in the MSP Study Area. Although the Port of Grays Harbor took 11 years to open its first public deep-draft pier and terminal in 1922, by 1924 more than one billion board feet of lumber exports passed through the port (Caldbeck, 2010). Today the Port of Grays Harbor has four terminals and five deep-draft berths with direct access to railroad lines. The primary imports and exports are liquid- and dry-bulk cargo and automobiles.

A report by BST Associates (2014), describes cargo shipping transits and provides projections for the Pacific Northwest (PNW) Gateway which includes 11 seaports, airports, and international land crossings for the states of Washington and Oregon.¹ The PNW Gateway accounted for \$204 billion dollars of goods in international trade in 2013. The PNW is the key gateway for goods moving between the United States and Asia and totals 13% of waterborne U.S.-Asia trade. The PNW was also the sixth largest gateway for waterborne trade of exports of American products based on 2013 export value. The largest

¹ Throughout this section, Pacific Northwest (PNW) refers to Washington and Oregon.

42 trading partners through PNW ports for waterborne trade are China (31%), Alaska and Hawaii (23%),
43 Japan (18%), and South Korea (6%) (BST Associates, 2014).

44 Marine traffic through the MSP Study Area is highly influenced by trends and shifts in trade patterns
45 throughout the United States and the world that dictate the traffic flow through the ports in Puget
46 Sound, the Columbia River, and the Pacific Coast. Container traffic in the PNW region, through Tacoma,
47 Seattle, and Portland, saw strong growth through 2005, but then experienced a decline due in part to
48 the economic recession and competition from other ports. Container volumes began to recover in 2011,
49 remained flat in 2012-2013, and are projected to grow slowly at a rate of 2.2 percent annually from
50 2013-2035. However, even as container volumes have recently increased, container vessel traffic has
51 continued a slight decline, due largely to the increasing size of container vessels (BST Associates, 2014).

52 **Cargo shipments**

53 Grain exports in the PNW are primarily handled through Columbia River ports. However, world
54 competition in the market is intense and the volume of corn available for export has reduced due to
55 increased domestic demand for use in ethanol production. Soybean exports through the PNW have
56 increased and there continues to be strong demand for vegetable oils. Upgrades at port facilities on the
57 Columbia River and at Grays Harbor have improved the grain elevator capacity. Annual exports of grain
58 and oilseeds through PNW ports doubled between 2002 and 2010 from less than 16 million metric tons
59 to nearly 33 million metric tons. Growth is projected at 2.2 percent annually from 2013 to 2035 (BST
60 Associates, 2014)

61 Key dry bulk commodities at Puget Sound and coastal ports include scrap metal, wood chips, sand
62 and gravel, cement, and gypsum. Columbia River exports include minerals, ores, chemicals and
63 fertilizers, petroleum by-products, and wood chips. Since 2000, dry bulk shipments has had generally
64 slow growth in volume and is projected to continue to grow at 1.3 percent per year from 2013 to 2035
65 (BST Associates, 2014). This forecast could change substantially with increases in dry bulk shipments of
66 coal or potash if potential projects on the Columbia River or Puget Sound move forward (BST Associates,
67 2014).

68 Liquid bulk commodities in the PNW are primarily petroleum, including crude oil and refined
69 products, with handling of much smaller volumes of other liquids like chemicals and fertilizers. The Port
70 of Grays Harbor handles mainly biodiesel which includes the byproducts of methanol and glycerin while
71 ports in the Columbia River handle petroleum products and chemical products. In addition to the
72 existing volume of shipments, there are multiple projects that are in the planning or permitting stages
73 that could substantially increase the volume of shipments. These include crude oil rail-to-vessel transfer
74 facilities in Grays Harbor (discussed further in future trends section below), and Columbia River ports.
75 Additional facilities are proposed for methanol production and export on the Columbia River and LNG
76 export at Ferndale. The volume of liquid bulks transported by vessel has decreased over the past
77 decade. The decrease was driven by a reduction in receipts of crude oil from Alaska as production has
78 decreased there and been replaced by other sources including crude oil coming to the PNW by rail from
79 North Dakota. Waterborne movements of petroleum products are projected to decline from 2013-2035
80 with an average annual growth rate of -0.4 percent. This does not include the potential future projects
81 which could increase the shipments (BST Associates, 2014).

82 Other major PNW commodities include automobiles, lumber, heavy machinery, bundled metal, and
83 scrap steel (referred to as neobulk²) and logs, forest products, and other project cargoes like wind
84 turbines, and heavy equipment parts (referred to as breakbulk³). The majority of PNW automobile
85 imports are handled at Columbia River ports, some through Tacoma, and more recently the Port of
86 Grays Harbor, which now handles exports of Chrysler vehicles. Log exports have been relatively strong
87 in the past few years as a result of growing demand in China, Japan, and Korea. Breakbulk exports of
88 forest products like lumber, pulp, and paper have declined significantly, however there was an increase
89 in 2013. Steel breakbulk shipments declined significantly with the downturn in U.S. commercial and
90 residential construction markets but have begun to rebuild slowly. The economic recession caused
91 breakbulk and neobulk trade to bottom out in 2008, with vehicle imports especially impacted. Since
92 2008, volumes have recovered and exceed the pre-recession level. Volumes are expected to continue to
93 grow slowly at an annual rate of 0.7 percent through 2035 (BST Associates, 2014).

94 Vessel traffic

95 Vessel types transiting the MSP Study Area include tank vessels that carry bulk liquids like oil,
96 methanol, biodiesel, and vegetable oil. Tank vessels are tank barges that are propelled using a tug and
97 self-propelled tankers. Cargo vessels carry dry goods like grain and wood and include self-propelled
98 cargo ships, cargo barges that are propelled using a tug, and RoRo vessels (roll-on/roll-off) that carry
99 automobiles or other wheeled vehicles (City of Hoquiam & Washington State Department of Ecology,
100 2016). Passenger vessels such as cruise ships also transit the study area occasionally. Patterns of use by
101 other vessels such as fishing and recreational uses are described other chapters (Section 2.4 Fisheries
102 and Section 2.6 Recreation and Tourism).

103 Vessels are defined by their carrying capacity or deadweight tonnage (dwt), or the number of metric
104 tons that a vessel can transport of cargo, stores, and bunker fuel. Tankers calling in the PNW range from
105 12,000-190,000 dwt. In Puget Sound, tankers carrying crude oil and products are limited to 125,000
106 dwt. There is no regulatory tonnage limit for tankers operating in Grays Harbor or the Columbia River.
107 The depth of the navigation channel for the Columbia River and Grays Harbor does limit the size of
108 vessel used in these areas. Crude oil and products are also handled by integrated tug-barges (ITB)⁴ and
109 articulated tug-barges (ATB).

110 The average size of vessels calling in PNW ports increased 2-3 percent annually for most vessel types
111 between 2002 and 2011 based on the average deadweight tons per call. Container vessels calling at
112 PNW ports range from 1,000 to 5,000 TEU⁵ ships that serve Alaska, Hawaii, and smaller international
113 trade routes. Container vessels in Pacific trade have increased in size, with shipping lines increasing
114 from 5,000 TEU to over 10,000 TEU vessels. The growing size of the container ships for efficiency has
115 meant a decrease in the number of container ship calls and this is expected to continue or level out in
116 the future (BST Associates, 2014).

² Neobulk includes general cargo that is prepackaged, counted, and loaded individually, not in containers, and transferred as units at the terminal.

³ Breakbulk includes general cargo that is loaded in bulk units and either packaged in boxes or barrels or attached to pallets or skids, not in containers, and transferred at the terminal.

⁴ There have not been any ITBs in the Puget Sound region for years (Veentjer, J., personal communication, February 6, 2017).

⁵ The 20-foot equivalent unit (TEU) is the standard industry measurement for containers. However, containers come in several sizes and most in use today are 40-foot containers (Washington State Department of Commerce, 2014).

117 The number of vessel calls in the PNW is forecast to decline to 3,336 vessel entrances in 2035. The
118 number of vessel calls peaked in 1996 at 5,431 and fell to 3,947 in 2013. This decline was due in part to
119 increased vessel size, and average to a -1.9 percent trend per year. Between 2013 and 2035 the forecast
120 of a decline of 611 vessel calls averages to -0.8 percent per year. This prediction is based on historical
121 trends from Ecology Vessel Entries and Transits reports and Marine Exchange of Puget Sound data for
122 Puget Sound and Grays Harbor. This does not include any of the projects in the planning or permitting
123 stages that could increase the volume of dry bulk or liquid bulks shipped through the PNW (BST
124 Associates, 2014). If the proposed projects move forward there is the potential for significant increases
125 in vessel traffic.

126 There are a number of maps that show the density of the different vessel types in the MSP Study
127 Area: cargo vessel density (Map 35), passenger vessel density (Map 36), tanker vessel density (Map 37),
128 and tug and tow vessel density (Map 38).

129 *Navigation*

130 The variety of vessel types and density of vessels transiting the MSP Study Area necessitates a
131 number of schemes that are designed to guide vessel paths through the area to avoid conflicts. These
132 are discussed below and the shipping lanes, federal navigation channels, and navigation agreement
133 lanes are highlighted in Map 39.

134 The U.S. Coast Guard (USCG) maintains aids to navigation (ATON) within the MSP Study Area, which
135 include a mixture of lateral and non-lateral buoys, beacons, and automated identification system (AIS)
136 (USCG, personal communication, February 7, 2017). The USCG also maintains lighthouses at Cape
137 Flattery, North Head, Grays Harbor, and Cape Disappointment (United States Coast Guard, 2016c).

138 Vessel Traffic Service Puget Sound, maintained by the U.S. Coast Guard functions to facilitate good
139 order and predictability on the Salish Sea waterways by coordinating vessel movements through the
140 collection, verification, organization, and dissemination of information (USCG, personal communication,
141 February 7, 2017). Vessels can be tracked for informational purposes using AIS that are required on all
142 large commercial vessels (City of Hoquiam & Washington State Department of Ecology, 2016). The U.S.
143 Coast Guard works cooperatively with the Canadian Coast Guard's Marine Communications and Traffic
144 Services (MCTS) to manage vessel traffic in adjacent waters to cover offshore approaches and all of the
145 Salish Sea (U.S. Coast Guard Navigation Center, 2016). The Marine Exchange of Puget Sound (MXPS)
146 monitors arriving and departing commercial vessels in the Puget Sound region and Grays Harbor. The
147 MXPS does not proactively track or monitor vessels offshore, but has the capability to do so out to about
148 50 miles (Veentjer, J., personal communication, February 6, 2017). The Merchants Exchange of Portland
149 also monitors arriving and departing commercial vessels in the Columbia River and has the capability to
150 do so out to about 50 miles off the Washington and Oregon coasts (Veentjer, J., personal
151 communication, February 6, 2017).

152 Traffic separation schemes (TSS) are designed to establish traffic lanes that separate opposing
153 streams of traffic. There are TSS designated for the approaches to the Strait of Juan de Fuca including a
154 western approach, the southwestern approach, and a precautionary area. Additional TSS are designated
155 for within the Strait of Juan de Fuca, approaches to Puget Sound, and within Puget Sound. Washington
156 Sea Grant worked with towboaters and crab fishermen to establish towboat lanes along the Pacific
157 Coast between San Francisco, CA and Cape Flattery, WA. The towboat lanes are designed to limit
158 interactions between fishing gear and towing vessels that can destroy the gear and foul the propellers
159 and shafts of the towing vessels (National Oceanic and Atmospheric Administration, 2016).

160 The Olympic Coast National Marine Sanctuary (OCNMS) encompasses much of the northern half of
161 the MSP Study Area. Prevention of spills of oil or other hazardous material from a major marine
162 accident is one of OCNMS' highest priorities as such a spill would be a threat to the resources and
163 qualities of the sanctuary. The International Maritime Organization (IMO) designated an Area to Be
164 Avoided (ATBA) within the OCNMS (Map 39). The IMO establishes ATBAs in defined areas where
165 navigation is very hazardous or where it is important to avoid casualties. The ATBA recommends certain
166 classes of vessels in-transit to stay outside of the defined area. It is a voluntary program that applies to
167 ships and barges carrying oil or hazardous materials as cargo and all ships 400 gross tons and above that
168 are solely in transit. Voluntary compliance is very high. The ATBA does not apply to vessels engaged in
169 activities like fishing and research that are otherwise allowed in the sanctuary. It also does not apply to
170 government vessels, but they are encouraged to avoid the area when solely in transit (Olympic Coast
171 National Marine Sanctuary, 2015).

172 Most deep draft vessels and barges carrying liquid bulks (petroleum, petroleum products, biofuels
173 and chemicals) travel well offshore unless they are entering or departing a port. However, barges and
174 vessels that are accessing the Port of Grays Harbor, and barges that are carrying dry cargoes (regardless
175 of destination) do transit the coastal area just below the Area to Be Avoided (ATBA). This is a
176 consideration for development of offshore energy systems (BST Associates, 2014). The Grays Harbor
177 Navigation Channel is nearly 23 nm long, begins approximately 4 miles offshore and runs in an easterly
178 direction allowing access for deep-draft vessels to the Port of Grays Harbor facilities (City of Hoquiam &
179 Washington State Department of Ecology, 2016). All deep-draft vessels are limited by the depth of the
180 navigation channel in Grays Harbor.

181 The West Coast Offshore Vessel Traffic Risk Management Project Workgroup⁶ recommends that,
182 where no other management measure such as ATBAs, Traffic Separation Schemes (TSS), or
183 recommended tracks already exist, vessels 300 gross tons or larger transiting coastwise anywhere
184 between Cook Inlet, AK and San Diego, CA should voluntarily stay a minimum distance of 25 nautical
185 miles (nm) offshore. They also recommend that with those same management exceptions, tank ships
186 laden with crude oil or persistent petroleum products should voluntarily stay a minimum distance of 50
187 nm offshore (West Coast Offshore Vessel Traffic Risk Management Project Workgroup, 2002). AIS data,
188 as seen in Maps 35, 36, 37, and 38, indicate that most of the vessels transiting the MSP Study Area do
189 stay offshore as recommended. Exceptions to this include vessels entering and exiting Grays Harbor and
190 Willapa Bay as well as smaller vessels including tug/tow vessels.

191 *Ship and boat building, maintenance, and repair*

192 The ship and boat building, maintenance, and repair sector of the maritime industry includes new
193 construction, maintenance, refurbishment, and modernization of commercial, recreational, and military
194 vessels. This sector has a long history in Washington with a great demand for shipbuilding as the timber
195 industry drove early shipping and Seattle developed as a trade and shipping center. Another center for
196 trade developed on Puget Sound when Tacoma was chosen as the western terminus of the Northern
197 Pacific Railroad's transcontinental line. As a result, shipyards began to establish themselves on Puget
198 Sound (Community Attributes Inc., 2013).

199 The majority of this industry is centered outside the area adjacent to the MSP Study Area. The
200 commercial companies in this sector are larger, but there are fewer of them, while the recreational

⁶ The West Coast Offshore Vessel Traffic Risk Management Project was co-sponsored by the Pacific States/British Columbia Oil Spill Task Force and the U.S. Coast Guard, Pacific Area. The full report and workgroup membership are available at: <http://oilspilltaskforce.org/>.

201 companies are smaller but more numerous. The Puget Sound Naval Shipyard in Bremerton is the largest
202 and most diverse shipyard on the west coast, and has more than 11,000 civilian employees (Community
203 Attributes Inc., 2013).

204 One example of this sector in the MSP Study Area is the Westport Shipyard. The Westport Shipyard
205 in Grays Harbor was founded in 1964 and began by building oceangoing vessels for the Pacific
206 commercial fishing fleet but now specializes in yacht and commercial construction. In addition, the
207 company has a shipyard in Port Angeles, WA and a yacht sales center in Fort Lauderdale, FL. Since the
208 founding of the shipyard, the total vessels built by Westport include over 100 recreational yachts, 170
209 commercial fishing vessels, 35 commercial passenger vessels, and 7 other commercial vessels. The
210 Westport Shipyard is a 170,000 square foot enclosed facility, the Port Angeles shipyard is a 100,000
211 square foot enclosed facility, and there are an additional cabinet shop and upholstery shop supporting
212 the operation (Westport, 2016).

213 In addition to the larger boat building operations, there are a number of locally important, smaller
214 facilities in the ports and marinas within or directly adjacent to the MSP Study Area that support boat
215 haul out and repairs. These facilities are important to the operation of other sectors including fishing
216 and aquaculture.

217 Economic Impact

218 Marine transportation and shipping has an economic impact on the coastal counties adjacent to the
219 MSP Study Area. It is challenging to try to isolate the impacts to just the coastal counties, because
220 vessels transiting through the MSP Study Area are coming from and bound for a variety of locations,
221 including the Puget Sound or Columbia River ports, which are part of the total ocean economy for the
222 state.

223 Washington State

224 Community Attributes Inc. performed an economic impact study of the maritime cluster in
225 Washington in 2013. They define the maritime cluster to include six core sectors, including maritime
226 logistics and shipping; ship and boat building, maintenance, and repair; maritime support services;
227 passenger water transportation; fishing and seafood processing; and military and other federal
228 operations. The focus of this chapter is on the first three sectors listed, but the economic information
229 covers all six sectors. For Washington in 2012, the entire maritime cluster directly employed more than
230 57,700 people in the state, and was responsible for \$15.2 billion in gross business income (Community
231 Attributes Inc., 2013).

232 The subsectors relevant to this chapter include maritime logistics and shipping which includes port
233 and harbor operations, deep and shallow water goods movement, inland water freight transport, and
234 refrigerated warehousing and storage. Boat and ship building, repair, and maintenance includes new
235 construction of vessels, maintenance, refurbishment and overhaul, and modernization. Maritime
236 support services include support for commercial, recreational, and defense-related maritime activities
237 like boat dealers, marinas, fueling and lubricant businesses, engineers, naval architects, parts suppliers,
238 and construction. Table 2.7-1 summarizes the maritime impacts of these subsectors throughout
239 Washington.

240 **Table 2.7-1: Summary of economic impacts from maritime subsectors in Washington State. Source: Community Attributes**
241 **Inc., 2013.**

Maritime subsector	Employer establishments	Wages (\$ millions)	Jobs	Gross business income (\$ millions)
Maritime logistics and shipping	800	1,156.0	16,700	3,722.4
Maritime support services	300	387.7	4,600	864.2
Boat and ship building, repair, and maintenance	150	1,163.8	16,500 ⁷	1,489.7
Fishing and seafood processing	720	1,113.4	15,400	8,592.6
Passenger water transportation	130	262.8	4,500	544.5
Total	2,100	4,083.7	57,700	15,213.3

242 **Coastal counties**

243 A separate economic analysis, Economics: National Ocean Watch (ENOW), was conducted by the
 244 NOAA Coastal Services Center using data from 2005-2011. ENOW describes six economic sectors that
 245 depend on the ocean: living resources, marine construction, marine transportation, offshore mineral
 246 resources, ship and boat building, and tourism and recreation. The ENOW analysis describes the ocean
 247 economy at the county level and shows the contribution of the five Pacific coastal counties (Clallam,
 248 Jefferson, Grays Harbor, Pacific, and Wahkiakum) to Washington’s ocean economy. These five counties
 249 accounted for 6 percent of employment and 3.9 percent of GDP in the statewide ocean economy. The
 250 impact of the marine transportation sector in the Pacific coastal counties as compared to the impact
 251 statewide is displayed in Table 2.7-2.

252 **Table 2.7-2: Marine transportation contribution to the ocean economy of the five Pacific Coast counties and statewide.**
 253 **Source: NOAA Coastal Services Center, 2014.**

Marine Transportation	Pacific Coast Counties ⁸	Statewide
Establishments	6	409
Employment	63	19,105
Wages (thousands of dollars)	4,523	1,279,000

⁷ Included in this subsector are more than 11,000 civilian jobs at the Puget Sound Naval Shipyards in Bremerton.

⁸ These numbers are reported for the five Pacific Coast Counties, and not by individual county, due to data confidentiality requirements. Where the number of establishments is low in one county, the data is suppressed, allowing results for only the larger coastal area to be shown. In Jefferson and Clallam counties, it is likely the analysis overestimates the numbers for establishments directly adjacent to the MSP Study Area. This includes the entire county, so information from establishments on the Strait of Juan de Fuca and Puget Sound is included.

Average wages	71,794	66,961
GDP (thousands of dollars)	7,976	2,594,000
Self-employed workers	40	523

254

255 **Port of Grays Harbor**

256 The Port of Grays Harbor is a major economic driver for coastal Washington and also has economic
 257 impacts in other parts of the state. Port of Grays Harbor facilities support the movement of waterborne
 258 cargo into and out of the state. In total, 2.38 million metric tons of cargo moved through Port of Grays
 259 Harbor facilities in 2013. This included soy meal and other bulk commodities, automobiles, forest
 260 product exports in chips and logs, and liquid bulk (Martin Associates, 2014). Table 2.7-3 estimates the
 261 economic impact based on five commodities; wood chips, grain, automobiles, logs, and liquid bulk at
 262 2013 levels. Table 2.7-3 shows 574 direct jobs and \$143.5 million of direct business revenue generated
 263 by these five commodities through the port. Of the 574 direct jobs, 94 percent were held by Grays
 264 Harbor residents (Taylor, Baker, Waters, Wegge, & Wellman, 2015).

265 **Table 2.7-3: Economic impacts of cargo activity at Port of Grays Harbor marine terminals. Source: Martin Associates, 2014.**

Category	
Jobs (number)	
Direct	574
Indirect	645
Induced	305
Total Jobs	1,524
Personal Income (\$1,000)	
Direct	\$36,239
Induced	\$79,654
Indirect	\$14,860
Total Income	\$130,754
Business Revenue (\$1,000)	\$143,488
Local Purchases (\$1,000)	\$31,513
State and Local Taxes (\$1,000)	\$12,291

266 The Port of Grays Harbor marine cargo terminals have a total revenue impact of \$143 million, \$118
 267 million of which can be allocated to specific commodity types (Table 2.7-4). Much of this revenue can
 268 be tied to the state of Washington through payment of salaries and wages, purchase of local goods and
 269 services, and the payment of state and local taxes. However, the revenue also has a national and
 270 international impact beyond those uses. The impact of the specific commodities being shipped through
 271 the Port of Grays Harbor can also be seen through the distribution of direct revenue impact. The
 272 greatest revenue on a per ton/revenue basis is generated by handling of autos followed by grain. The
 273 majority of the revenue generated by autos and grain is in the surface transportation sector followed by
 274 terminal operations (Martin Associates, 2014).

275 **Table 2.7-4: Revenue impact by commodity generated by the Port of Grays Harbor marine cargo terminals. Source: Martin**
 276 **Associates, 2014.**

Commodity	Direct Revenue (\$1,000)	Tonnage Metric Tons	Revenue 1,000 Tons
Chips	\$1,130	94,732	\$11.93
Grain	\$69,186	1,360,611	\$50.85
Autos (units)	\$32,513	92,790	\$350.39
Logs	\$5,165	317,390	\$16.27
Liquid bulk	\$10,241	433,981	\$23.60
Not allocated	\$25,253		
Total	\$143,488		

277
 278 The Port of Grays Harbor and other ports outside of the MSP Study Area face competition from each
 279 other, ports on the west coast, and even the east and gulf coasts. Shifts in the trade patterns have the
 280 potential to cause economic impacts within the areas adjacent to the MSP Study Area.

281 Related Infrastructure

282 Ports and marinas

283 There are a number of ports and marinas adjacent to the MSP Study Area that provide a variety of
 284 functions including moorage and access for recreational and commercial fishing vessels, fish processing,
 285 shipping and storage, and vessel and gear maintenance. An overview of the ports and marinas is
 286 provided here, with further detail on fishing related functions available in the Fisheries chapter and
 287 dredging requirements in the Dredging and Dredge Disposal chapter.

288 Some of the ports discussed below are outside of the MSP Study Area, including the Port of Neah
 289 Bay, Port of Ilwaco, and the Port of Chinook. These ports and marina all provide critical services
 290 important to uses within the Study Area and contribute significantly to the coastal economy.

291 Clallam County ports

292 *Neah Bay*

293 The Makah Tribe owns and operates the Makah Marina in Neah Bay, which primarily serves as a
294 fishing marina and dock. The facility has undergone recent upgrades that are expected to help retain
295 fishing related jobs and also improve oil spill response capabilities by providing a safe dock for response
296 vessels. Upgrades to the dock included building a new concrete dock and a new facility with offices, a
297 hoist, an ice plant, and two icing stations (Taylor et al., 2015). The Makah Marina at Neah Bay is
298 protected from waves by an Army Corps of Engineers maintained riprap wave barrier. The marina has
299 200 slips and caters mostly to private boats. It is open for recreational use from April through
300 September. The USCG operates a small boat station just east of the marina.

301 *Quileute Harbor Marina*

302 The Quileute Harbor Marina, owned and operated by the Quileute Tribe and located in La Push, is
303 the only designated safe harbor between Neah Bay and Westport. The marina has 95 slips, some of
304 which are leased to commercial and recreational fishermen. The U.S. Coast Guard uses the marina as
305 homeport for the Quillayute River Station, the only search and rescue station between Grays Harbor and
306 Neah Bay. In 2014, the marina underwent improvements including plank replacement on existing docks
307 and construction of a new boat ramp that will allow for removal of larger vessels. The Army Corps of
308 Engineers also performed some dredging of the Quillayute River at the harbor. The west end of the
309 marina has facilities that the tribe leases to High Tide Seafoods including a high dock with a lift, ice
310 machine, and space for a fish processing plant in La Push and it serves tribal and non-tribal fishers
311 (Taylor et al., 2015).

312 *Jefferson County ports*

313 Jefferson County does not have any ports or marinas on the coast in the MSP Study Area. The Port
314 of Port Townsend and other marinas are located on Puget Sound.

315 *Grays Harbor County ports*

316 *Port of Grays Harbor*

317 The Port of Grays Harbor is the only deepwater port on the Pacific Coast of Washington. It is also
318 two days of travel time closer to Asia than Puget Sound ports, which gives it a locational advantage
319 promoting expansion beyond traditional commodity shipments (Taylor et al., 2015). The Port of Grays
320 Harbor was the second Port District to be created in the state in 1911, after the Port District Act passed
321 earlier in the year. The Port's first facility, Pier 1, opened in 1922. For several years in the 1920s, Grays
322 Harbor was the largest lumber exporting port in the world with exports exceeding a billion board feet
323 annually. Lumber exports continued to provide the bulk of the Port's business into the 1980s. After a
324 dramatic reduction in logging in the 1980s-1990s, the Port worked to diversify its business (Ott, 2010).
325 The Port did this by undergoing a dredging project to accommodate oceangoing vessels that continue to
326 grow in size and by maintaining a connection with two Class 1 Railroads via an agreement with a
327 shortline railroad which allowed for the development of a bulk handling facility and automobile export
328 operation (Ott, 2010). The Westport Marina, a facility of the Port of Grays Harbor, is the number one
329 seafood landing point in Washington. The Port of Grays Harbor is the number one exporter of American

330 grown soybean meal (Taylor et al., 2015). The Port has diversified and now includes automobiles,
331 biodiesel, other liquid, dry bulk, and overhigh/overwide (OHOW)⁹ products among goods shipped.

332 The Port of Grays Harbor operates four marine terminals at the eastern end of Grays Harbor that are
333 supported by secure cargo yards, an on-dock rail system, and covered storage. Terminal 4 is the main
334 general cargo terminal and the largest, with a 1,400 ft. long berth that can handle two vessels and
335 serves as the primary Ro/Ro and breakbulk cargo terminal. Terminal 3 is a deep water terminal with on-
336 site rail. Terminal 2 is a dry and liquid bulk facility that is served by a rail loop. Terminal 1 is a barge and
337 liquid loading facility with an on-site rail loop (Port of Grays Harbor, n.d.).

338 *Westport Marina*

339 The Westport Marina is a 550 slip marina owned and operated by the Port of Grays Harbor. It is
340 home to a large commercial fishing fleet and recreational fishing vessels, including the state's largest
341 charter fishing fleet. Current annual moorage rates show 94 recreational vessels and 188 commercial
342 fishing vessels. There is also a boat launch for private boats and boat trailer parking. (Taylor et al.,
343 2015). The USCG operates a small boat station which is located at the south corner of the marina.

344 *Quinault Marina*

345 The Quinault Nation owns the Ocean Shores Marina but it is currently closed due to needed repairs
346 and dredging (Taylor et al., 2015).

347 *Pacific County ports*

348 *Port of Peninsula*

349 The Port of Peninsula owns a commercial facility in Nahcotta, WA located on the Willapa Bay side of
350 the Long Beach Peninsula. The Port District serves the oyster, clam, and crab industries, a gillnet fleet,
351 and recreational users with 90 slips and a public boat launch. In 2009, the port rebuilt the service pier
352 providing the shellfish industry on Willapa Bay with a modern, environmentally responsible, and secure
353 facility to support business expansion and improve productivity. The service pier provides the only fuel
354 service on the bay and utilizes an above-the-ground storage tank (M. Delong, personal communication,
355 October 8, 2014). The Port also sponsors the Willapa Bay Oyster House Interpretive Center, an
356 interpretive center focused on the local oyster industry. Twenty-five percent of the nation's oysters go
357 through the Port of Peninsula (Coast & Harbor Engineering, 2011; Cook, 2012). Increased Manila clam
358 and oyster production in Willapa Bay have elevated the Port to a major landing facility for the region (M.
359 Delong, personal communication, October 8, 2014).

360 *Willapa Bay*

361 The Port of Willapa Harbor was formed in 1928, and developed port facilities for shipping lumber
362 and other forest products as well as fishing and oyster vessels. The Port of Willapa Harbor owns and
363 operates three water access facilities within Willapa Bay: the Raymond Port Dock, Tokeland Marina, and
364 Bay Center Marina.

365 The Raymond Port Dock has a 50,000 square foot "high dock" that services commercial vessels.
366 There is an additional 700 feet of floating docks available for moorage (Port of Willapa Harbor, n.d.-b).
367 The Bay Center Marina provides moorage for oyster barges and fishing vessels, with capacity for

⁹ Overhigh/overwide cargo products are handled specially, not normally a full cargo, and can be added to both neobulk and breakbulk vessels.

368 approximately 40 vessels. The Bay Center Marina is located within the navigation channel of the Palix
369 River and requires regular dredging to maintain viability as a marina (Port of Willapa Harbor, n.d.-a).

370 The Tokeland Marina is located at the north end of Willapa Bay and offers recreational and
371 commercial moorage with over 1,000 feet of floating dock. There is also a public fishing pier and boat
372 ramp. The marina and entrance channel experience significant sedimentation and the Port of Willapa
373 Harbor has launched a maintenance dredging program in Tokeland to maintain the dredging previously
374 done by the U.S. Army Corps of Engineers (Port of Willapa Harbor, n.d.-c).

375 South Bend has a recreational dock for canoeing, kayaking, and fishing as well as a boat launch
376 (Taylor et al., 2015). South Bend also has commercial fish landings directly at seafood processors in the
377 area.

378 *Ilwaco and Chinook*

379 The Port of Ilwaco is located in the southwest corner of Washington just inside the Columbia River.
380 The Port serves commercial fishermen, recreational boaters, two major seafood processing businesses,
381 and a U.S. Coast Guard Station. The Port serves vessels from Washington, Oregon, Alaska, and Canada
382 with an 800-slip marina (Pacific County Economic Development Council, 2013; G. Glenn, personal
383 communication, October 22, 2014). In 2013, 23,720 private trips were launched from Ilwaco, a popular
384 sport fishing port. Facilities at the port include a boat launch, two small boat hoists, and two fuel docks
385 (Taylor et al., 2015).

386 The Port of Chinook is located on the southwest corner of Washington, a few miles up the Columbia
387 River from the Port of Ilwaco. The Port of Chinook is home to recreational and commercial fishing boats
388 as well as a major crab cannery facility (Pacific County Economic Development Council, 2013). The Port
389 has 300 slips and can accommodate commercial and sport fishing vessels up to 60 feet in length.
390 Additional facilities include a boat launch, boat hoist, and a fueling facility (Taylor et al., 2015).

391 *Emergency Response*

392 *United States Coast Guard*

393 The USCG Station Grays Harbor has the Coast Guard's first on water response responsibility over the
394 area ranging from Queets River south to the Long Beach Peninsula, including Willapa Bay. The station
395 has four vessels that perform search-and-rescue activities. The U.S. Coast Guard Captain of the Port of
396 Sector Columbia River, whose office is located in Astoria, Oregon, has the authority to close the bar at
397 Grays Harbor due to severe weather that makes it unsafe for vessels to transit (City of Hoquiam &
398 Washington State Department of Ecology, 2016).

399 USCG Station Cape Disappointment is in Ilwaco at the mouth of the Columbia River. It is the largest
400 search and rescue station on the Northwest Coast with 50 crewmembers. The station has five search
401 and rescue boats and provides search and rescue to commercial and recreational mariners within 50 nm
402 of the Columbia River entrance. This area is one of the most dangerous river bars in the world and the
403 crewmembers respond to 300-400 calls for assistance each year (United States Coast Guard, 2016b).
404 Station Cape Disappointment and Station Grays Harbor are units of the USCG Sector Columbia River with
405 headquarters in Warrenton, Oregon. The headquarters has more response assets available than
406 individual stations. Sector Columbia River's area of responsibility includes 420 nm of coastline in
407 Washington and Oregon and the Columbia River (United States Coast Guard, 2016a).

408 USCG Station Quillayute River is located in La Push on the Quileute Tribe’s reservation. The station
409 has two lifeboats to respond to emergency calls in the area between Cape Alava and Queets River. The
410 station is supported by USCG Air Station/Sector Field Office Port Angeles.

411 USCG Station Neah Bay has life boats to respond to emergencies from Cape Alava to the northern
412 extent of the MSP Study Area.

413 Emergency towing vessel

414 There is an emergency response towing vessel (ERTV) permanently stationed at Neah Bay and
415 available to assist vessels off the coast of Washington or in the Strait of Juan de Fuca. Any “covered”
416 vessels,¹⁰ essentially tank vessels, cargo vessels, and passenger vessels, that are transiting to or from a
417 Washington port through the Strait of Juan de Fuca are required to include the towing vessel in Neah
418 Bay in their oil spill emergency response plans (City of Hoquiam & Washington State Department of
419 Ecology, 2016). The ERTV is industry-funded to be on station in Neah Bay and available for hire 24 hours
420 a day to assist vessels having maneuvering issues (e.g. propulsion and steering problems) or vessels that
421 are directed by the U.S. or Canadian Coast Guards to obtain towing or escort assistance (National
422 Oceanic and Atmospheric Administration, 2016). More than 90% of the assistance provided has been
423 escorting, often as required by the U.S. Coast Guard (J. Veentjer, personal communication, February 6,
424 2017).

425 The tug is intended to be able to make up to, stop, hold, and tow a drifting or disabled vessel of
426 180,000 metric dead weight tons in severe weather conditions (National Oceanic and Atmospheric
427 Administration, 2016). The ERTV could assist with vessels in a difficult situation in or near Grays Harbor,
428 however, under normal weather conditions, it could take an average of 12 hours to reach the harbor
429 and under adverse weather conditions, transit time to Grays Harbor could be as much as 18 hours. Tugs
430 currently operating on the Columbia River could provide the same assistance; travel time would be
431 approximately 12 hours to Grays Harbor.

432 Since 1999, the ERTV has been deployed to either stand by or directly assist 54 vessels that were
433 either completely disabled or had reduced ability to maneuver. The types of vessels assisted have
434 included deep draft cargo vessels, large fish and fish processing vessels, fully laden oil and chemical tank
435 ships, and tugs with tank barges in tow. During 14 of these responses, the ERTV had to tow the disabled
436 vessels to prevent them from drifting onto the rocks and spilling oil. The potential combined oil spill for
437 those 14 cases is over 3 million gallons (Washington State Department of Ecology, 2016).

438 Future trends

439 Shipping

440 For Washington and Oregon, waterborne cargo volumes are projected to continue growing at
441 modest rates. Overall growth is projected to average 1.3 percent per year between 2013 and 2035
442 across all cargo types. However, the number of vessels is predicted to continue to decrease as
443 companies shift to using larger vessels and therefore require fewer vessels (BST Associates, 2014).¹¹

¹⁰ RCW 88.46.010(5) defines covered vessel as “...a tank vessel, cargo vessel, or passenger vessel.” The RCW further defines a cargo vessel as “...a self-propelled ship in commerce, other than a tank vessel or a passenger vessel, of three hundred or more gross tons, including but not limited to, commercial fish processing vessels and freighters.” It also further defines passenger vessels as “...a ship of three hundred or more gross tons with a fuel capacity of at least six thousand gallons carrying passengers for compensation.”

¹¹ The average size of deep-draft vessels calling at the Port of Grays Harbor has increased on average by 3.2 percent per year between 2005 and 2012, from 28,300 tons to 35,300 tons (BST Associates, 2014).

444 These predictions are not specific to the coast of Washington, but also include Puget Sound, Columbia
445 River, and Oregon ports. It is hard to predict impacts for individual Pacific coast ports and activities
446 based on projections for the larger area.

447 Changes in world trade patterns may affect trade flows through the PNW. Trade with China is being
448 affected by economic shifts including rising wages and an increasing exchange rate. If multinational
449 firms decide to relocate production away from China, this could shift waterborne container trade and
450 decrease the trade moving through the PNW. So far, there has only been a modest shift in trade routes
451 and it is unknown how this will change in the future. This potential loss of cargo trade may be offset by
452 exports of containerized and non-containerized products from the PNW to China as a result of rising
453 incomes in China stimulating increased consumption of U.S. products (BST Associates, 2014).

454 Cargo forecasts for specific commodities for the PNW include a 2.2 percent increase in grain and
455 oilseed exports between 2013 and 2035. There have been significant increases in grain and oilseed
456 exports due to increased demand in Asia, increased production, and favorable ocean freight rates (BST
457 Associates, 2014). Neobulk, including automobiles and logs, is an important component of Grays Harbor
458 trade and is predicted to grow annually at 0.7 percent through 2035. For liquid bulk, the largest
459 volumes in the PNW are in crude oil and refined products. There has been a trend of declining
460 waterborne shipments of petroleum products as a result of production shifting from Alaska to Canada
461 and the Bakken region of the United States and a shift to rail transportation. The trend is expected to
462 continue and then stabilize with a forecast of a negative 0.4 percent growth rate from 2013-2035 (BST
463 Associates, 2014). This trend could be impacted by proposed oil transfer projects in Grays Harbor,
464 Vancouver, Portland, and British Columbia. The potential impact of these proposed facilities to vessel
465 transit is discussed below.

466 The Port of Grays Harbor is constantly in competition with other ports, not only nearby in the Puget
467 Sound and Columbia River but also among the west, east, and gulf coasts. The port has previously been
468 able to diversify as products being shipped have shifted away from forest products and towards other
469 cargo like auto exports to maintain a competitive edge. However, the competition between ports is also
470 based on rail rates, port rates, and ocean accessibility, so it is unknown how this will affect the port in
471 the future (Taylor et al., 2015).

472 *Oil shipping and facilities*

473 Another dynamic factor in attempting to forecast cargo movements to and from PNW ports is the
474 energy sector. Proposals to develop new or modify existing bulk crude oil terminals exist for two
475 facilities on the coast of Washington as well as several others in Oregon, Washington, and British
476 Columbia that could impact the coast. If they are permitted, such new facilities could increase the
477 number and type of vessel transiting through the MSP study area and increase the volume of crude oil
478 carried through the area.

479 One of the proposals is to expand existing bulk liquid storage facilities owned by Contanda (formerly
480 Westway Terminal Company) at the Port of Grays Harbor. The maximum annual throughput of crude oil
481 would be 17.9 million barrels per year (City of Hoquiam & Washington State Department of Ecology,
482 2016). A proposal by Imperium Renewables Inc. to expand existing bulk liquid storage facilities at the
483 Port of Grays Harbor has been paused as new ownership under the name Renewable Energy Group
484 (REG) reevaluates the expansion proposal. (Washington State Department of Ecology, n.d.).

485 Contanda operates at Terminal 1 at the Port of Grays Harbor and proposes to expand facilities to
486 store crude oil brought in by rail from the Bakken area in the U.S. or from Canada. For the Contanda
487 proposal, either tankers or tank barges could be used. If tank barges are used, it would result in an
488 additional 119 annual vessel calls at Terminal 1 or an additional 238 vessel trips through the navigation
489 channel when operating at maximum throughput (City of Hoquiam & Washington State Department of

490 Ecology, 2016). The final Environmental Impact Statement (EIS) was released for the Westway
491 Expansion Project in September 2016 and Contanda (Westway) is waiting for a decision on the Shoreline
492 Substantial Development Permit by the City of Hoquiam (Washington State Department of Ecology,
493 n.d.).

494 Oil Spill Response

495 Vessels transiting the MSP Study Area bring the potential for oil spills, an ongoing challenge of
496 managing marine transportation. There are a number of state and federal laws and regulations that
497 address the potential for oil spills on or near the water and the associated preparedness and response
498 planning and actions. The Washington State Department of Ecology (Ecology) has responsibility for
499 preventing and planning for oil spills in state waters. Ecology is also responsible for organizing a rapid
500 and coordinated response to oil and hazardous substance spills wherever they occur in the state.

501 Vessels transporting oil have a variety of required measures that contribute to the prevention of oil
502 spills. The features include construction design (double bottoms and sides), mechanical measures (oil
503 discharge monitoring systems and emergency shutdown devices), and navigational equipment (depth
504 sounders and electronic position fixing devices to verify position and prevent collisions or groundings).
505 Onsite storage and handling facilities at the terminal trains that transport oil also have federal and
506 state design standards, equipment, and training requirements to prevent oil and pollutants from
507 reaching the environment. The Environmental Impact Statement (EIS) for the proposed Westway crude
508 oil expansion recommends over 70 mitigation measures for the facility and project related vessels and
509 trains. The proposed mitigation for vessel transport includes use of tug escorts for laden tankers and
510 tank barges in Grays Harbor and implementing a formalized vessel management system. The EIS
511 identified that no mitigation measures would completely eliminate the adverse consequences of a fire,
512 spill or explosion and the potential adverse environmental impacts could be significant. (City of
513 Hoquiam & Washington State Department of Ecology, 2016).

514 There is a coordinated oil spill response framework including the National Contingency Plan,
515 Northwest Area Contingency Plan, local response plans, facility response plans, vessel response plans,
516 and transportation regulations that establish roles and responsibilities, identify resources, and identify
517 response procedures for oil spills or threat thereof. The Northwest Area Contingency Plan covers
518 Washington, Oregon, and Idaho and includes site-specific geographic response plans (GRPs). A GRP has
519 two main objectives: to identify sensitive resources at risk of injury from oil spills and to describe and
520 prioritize strategies to protect these sensitive resources at risk. (City of Hoquiam & Washington State
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522 Outer Coast, Grays Harbor, Willapa Bay, and Lower Columbia River.

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1 2.8 Military Uses

2 The military has a prevalent historical and current presence within Washington State and the MSP
3 Study Area. Primary ocean activities include the United States Department of the Navy training and
4 testing ranges and the United States Coast Guard operations for navigation, search and rescue, vessel
5 safety, and coastal defense.

6 Summary of History and Current Use

7 *United States Department of the Navy*

8 The United States Department of the Navy has had an active presence within the State of
9 Washington since the mid-nineteenth century. Currently active range complexes within the Navy's
10 Northwest Training and Testing Area include areas in Pacific Ocean offshore waters, Puget Sound, and
11 Alaska. These sites have existed for decades. The Navy's mission is to maintain, train, and equip combat-
12 ready naval forces capable of winning wars, deterring aggression, and maintaining freedom of the seas.
13 This mission is achieved in part by conducting training and testing within the MSP Study Area (United
14 States Department of the Navy, 2015).

15 Navy training and testing in the Pacific Northwest is conducted in established maritime operating
16 areas and warning areas, including air and water space areas in the eastern North Pacific Ocean, which
17 overlap with the MSP Study Area. These training and testing areas are located within and outside of
18 Washington state waters. Existing range complexes and facilities that overlap with the MSP Study Area
19 include the Northwest Training Range Complex and the Naval Undersea Warfare Center Division Keyport
20 Range Complex (Map 40). The Northwest Training Range Complex (NWTRC) encompasses land, air, and
21 sea areas that extend westward into the Pacific Ocean from the Strait of Juan de Fuca to 130 degrees
22 west longitude (about 250 nautical miles), and southerly parallel to the coasts of Washington, Oregon,
23 and Northern California. The Naval Undersea Warfare Center Division Keyport Range Complex includes
24 the Quinault Range Site, which is located off the coast of Jefferson and Grays Harbor Counties and
25 includes a 1 mile surf zone area at Pacific Beach, WA (United States Department of the Navy, 2015).

26 The Navy protects America's global interests around the world by operating on, above, and below
27 the sea. In addition to keeping the sea lanes open to travel and trade, the Navy needs to be ready to
28 respond to a wide range of situations such as large scale conflict, homeland defense, anti-piracy
29 operations, and humanitarian assistance and disaster relief. This level of readiness and capability is
30 achieved through comprehensive, realistic training and testing. The key to ensuring national security,
31 maintain freedom of the seas, and avoiding tragic loss of life is to ensure that Sailors receive realistic
32 training that fully prepares them to defend the United States, and that the equipment they rely on is
33 thoroughly tested prior to use.

34 The Navy tests ships, aircraft, weapons, combat systems, and sensors and related equipment, and it
35 conducts scientific research activities to achieve and maintain military readiness. The Navy performs
36 training activities in the offshore area (MSP Study Area) such as anti-air warfare, anti-surface warfare,
37 anti-submarine warfare, electronic warfare, mine warfare, and naval special warfare. Sonar, ordnance,
38 munitions, and targets are used during Navy testing and training activities. Flight formation practice,
39 submarine mine exercises, target practice, tracking exercises, and torpedo testing are some specific
40 examples of the types activities the Navy performs (United States Department of the Navy, 2015).

41

42 United States Coast Guard

43 The United States Coast Guard and its preceding agencies have been operating in Washington State
44 since 1854. The arrival of the cutter Jefferson Davis in 1854 and the construction of 16 lighthouses in
45 Washington during the 1850's, including the Cape Disappointment Lighthouse, established the Coast
46 Guard's presence in Washington (Washington State Department of Archaeology and Historic
47 Preservation, 2011). Today, the U.S. Coast Guard 13th District serves Washington, along with Oregon,
48 Montana, and Idaho, and is headquartered in Seattle.

49 The purpose of the Coast Guard is to safeguard the Nation's maritime interests in the heartland, in
50 ports, at sea, and around the globe. The Coast Guard plays a vital role in navigational safety and
51 regulation in the region. Coast Guard activities within the MSP Study Area include conducting search and
52 rescue, patrolling the coast to enforce safety and fisheries regulations, conducting safety and
53 compliance inspections and exams on commercial vessels and waterfront facilities, and protecting our
54 nation's strategic defense and critical infrastructure. The Coast Guard also includes an Auxiliary, a civilian
55 volunteer element of the Coast Guard which focuses on recreational boating safety (United States Coast
56 Guard, 2015).

57 The U.S. Coast Guard serves the dangerous waters of the Washington Pacific coast. The stormy and
58 foggy weather that frequents the MSP Study Area necessitated the development of several lighthouses
59 and lifesaving stations to protect lives and respond during emergencies. Today, the 13th District operates
60 within the Study area based out of units in Ilwaco (Station Cape Disappointment), Westport (Station
61 Grays Harbor), La Push (Station Quillayute River), and Neah Bay (Station Neah Bay) (Map 40)
62 (Washington State Department of Archaeology and Historic Preservation, 2011). The Coast Guard also
63 operates and maintains several federal aids to navigation throughout the Study Area (United States
64 Coast Guard, 2015). While some areas may be subject to higher activity based on proximity to units or
65 other infrastructure, the Coast Guard operates throughout the entire MSP Study Area.

66 Related Infrastructure

67 Within the Study Area, the Navy's activities consists mostly of training and testing activities, and no
68 pier-side infrastructure is located within the MSP Study Area (United States Department of the Navy,
69 2015). Infrastructure for the Coast Guard includes lifesaving stations, lighthouses, stations to house fleet
70 operations, and federal aids to navigation. Coast Guard Units are operated out of Neah Bay, La Push,
71 Westport, and Ilwaco. Federal aids to navigation, which include lighthouses, buoys, warning signs, sound
72 signals, warning lights, and others are located throughout and adjacent to the Study Area (United States
73 Coast Guard, 2015).

74 Future Trends

75 The Navy and the Coast Guard will continue to operate within the Study Area, with possible
76 adjustments to their activities based on requirements to fulfill their respective missions. The Navy will
77 continue to train and test within the Northwest Training and Testing Area, and has recently reassessed
78 some activities starting in 2016. No changes in Navy range areas or new range sites are currently
79 proposed (United States Department of the Navy, 2015).

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1 2.9 Research and Monitoring Activities

2 Marine waters off Washington’s outer coast host a wide variety of research and monitoring
3 activities conducted by numerous institutions and government agencies, many focused on baseline data
4 to understand oceanographic conditions. Other research includes fisheries and other marine animal
5 population surveys, habitat surveys, and tectonic research. Emergent issues such as hypoxia, ocean
6 acidification, water temperature, and harmful algal blooms are already a focus of research and will likely
7 continue to expand in the future.

8 Summary of History and Current Use

9 Washington’s marine environment is the scene of a variety of oceanographic, geologic, and marine
10 biology research. Several academic and research institutions, governments, and other organizations
11 participate in research activities within the MSP Study Area. Examples of organizations conducting
12 research and monitoring include the University of Washington School of Oceanography, Oregon State
13 University, NOAA’s Pacific Marine Environmental Laboratory, Northwest Fisheries Science Center,
14 National Centers for Coastal Ocean Science, National Data Buoy Center, tribal governments, WA state
15 agencies, and the Olympic Coast National Marine Sanctuary. Other federal agencies that perform
16 research also include the United States Fish and Wildlife Service, United States Geological Survey, and
17 the Olympic National Park. Many of these institutions work collaboratively with each other and others
18 organizations through research centers and initiatives, such as the Northwest Association of Networked
19 Ocean Observing Systems (NANOOS), the Ocean Observatories Initiative, and the Oregon Health
20 Sciences University's Center for Coastal Margin Observation and Prediction (see NANOOS, 2015; Oregon
21 State University, 2015; University of Washington, 2015).

22 A primary focus of research within the Study Area is collection of baseline data to understand
23 oceanographic conditions, marine habitats and populations, and marine hazards. Data collected include
24 temperature, salinity, carbon dioxide levels, tides, water currents, oxygen levels, and plankton blooms
25 along with other oceanographic parameters (NANOOS, 2015). Population assessments for fishery
26 resources, seabirds, and marine mammals are conducted routinely for management and conservation
27 purposes (e.g., Menza et al., 2015; NOAA Fisheries, 2015). Other research is directed at, but not limited
28 to, intertidal, pelagic, and deep-sea habitat (Office of National Marine Sanctuaries, 2008), the Cascadia
29 Subduction Zone (e.g., Johnson, Solomon, Harris, Salmi, & Berg, 2014), benthic substrate sampling and
30 seafloor habitat mapping (e.g., Goldfinger, Henkel, Romsos, Havron, & Black, 2014; Office of National
31 Marine Sanctuaries, 2008), and coastal geomorphology.

32 Equipment for research includes research vessels outfitted with sampling and trawling gear,
33 moorings, anchored hydrophones, shore-based instrumentation, and in-water gliders equipped with
34 oceanographic sensors. Research vessels owned by state universities are based in Seattle or Newport,
35 Oregon. NOAA’s research ships serve the entire West Coast from California to Alaska, are based in
36 Newport, Oregon. State agencies operate small (<30 feet) research vessels. Private vessels can also be
37 contracted for specific projects. Research vessels, gliders, and other mobile equipment may perform
38 established transect cruises, or focus on more temporary locations for specific projects. Fixed-location
39 platforms may be deployed seasonally or year-round.

40 Related Infrastructure

41 Limited infrastructure is in place within the MSP Study Area to conduct long-term monitoring.
42 Permanent and semi-permanent infrastructure includes buoys, moorings, and shore side stations (Map
43 41). These are generally equipped with sensors to measure oceanographic conditions, such as water

44 temperature, carbon dioxide, light, wave height, wind, etc. Oceanographic buoys, both seasonal and
45 year-round, include NANOOS' Chá bã buoy and accompanying NEMO sub-surface profiler off of La Push,
46 NOAA NDBC's Cape Elizabeth and Neah Bay buoys, and the Olympic Coast National Marine Sanctuary's
47 nearshore seasonal mooring array (NANOOS, 2015). Another example is the Washington Line, which is a
48 part of the Ocean Observatories Initiative's Endurance Array and consists of three buoys transecting
49 east-west recently deployed offshore of Grays Harbor (Woods Hole Oceanographic Institution, 2011).

50 Future Trends

51 Although not the most spatially extensive use within the MSP Study Area, research and monitoring
52 activities will continue to have a presence within Washington's offshore and nearshore waters. The
53 Study Area will likely remain an important area for scientific research and resource management
54 surveys, particularly for understanding key processes and issues such as sustainable fisheries, ocean
55 circulation, climate change, water temperatures, ocean acidification, hypoxia, fisheries populations, and
56 harmful algal blooms.

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2.10.1 Marine Renewable Energy

Marine renewable energy is the conversion of potential energy from offshore wind¹, waves, and tidal currents to electric power through the installation of energy generating devices in the marine environment. The State of Washington, the United States, and several other countries around the world have identified marine renewable energy as a potential option to help diversify their energy portfolio and reduce carbon emissions from traditional energy sources, such as coal, oil, and gas (Copping et al., 2013; Musial & Ram, 2010). The State of Washington's Energy Independence Act of 2006, also known as Initiative 937, enacted a Renewable Energy Portfolio Standard that requires electricity utilities with 25,000 or more customers to acquire a minimum percentage of their power from eligible renewable energy resources.² Minimum percentage targets were set at 3% of total load from renewable energy by January, 2012, 9% by January 2016, and 15% by January 2020 (RCW 19.285).

The types of renewable energy that qualify under the Renewable Energy Portfolio Standard include marine renewable energy (i.e. offshore wind, wave, and tidal currents) and other renewable energy types such as terrestrial wind³, solar, biomass, and biodiesel.⁴ Solar, biomass, biodiesel, ocean thermal energy conversion, and other renewable energy resources are currently not relevant options within the MSP Study Area and therefore are not addressed here.

Marine renewable energy is a potential new use of ocean space within the MSP Study Area and state law requires marine renewable energy to be addressed within the MSP. Specific requirements include a series of maps that summarize locations with high potential for marine renewable energy production with minimal potential for conflicts with other existing uses or sensitive environments (RCW 43.372.040(6)(c)). Also required is a framework for coordinating state agency and local review of proposed energy projects (RCW 43.372.040(6)(f)).

The MSP is non-regulatory, meaning that it does not have the authority to explicitly approve or prohibit marine renewable energy projects. The MSP can identify key information about offshore wind, wave, and tidal current technologies, suitability, related infrastructure, environmental concerns, potential compatible uses, potential conflicts, and potential locations where energy generating facilities could be sited to reduce environmental and user conflicts. This information is used as context to inform MSP recommendations made by the State and shaped by stakeholders. The following sections within this chapter provide key information about marine renewable energy.

Summary of History and Current Use

History in United States and the World

Several countries around the world are currently promoting the use of marine renewable energy. Europe is currently the leader in offshore wind development and installed capacity, and has several testing sites for wave and tidal energy devices (Copping et al., 2013; Navigant Consulting, Inc., 2014;

¹ Offshore wind energy is wind energy extracted over water and is therefore included as marine renewable energy in the MSP.

² Utilities may use renewable energy credits or bundled renewable energy resources to meet the targets. Renewable energy resources must be located within the PNW, with limited exceptions.

³ Terrestrial wind has been the predominant renewable resource acquired so far (Washington State Department of Commerce, 2014a).

⁴ Most hydropower (i.e., energy derived from hydroelectric dams) is not included as an eligible renewable energy source to meet the Portfolio Standard (RCW 19.285).

35 Sotta, 2012). As of 2015, the currently installed global offshore wind energy capacity was about 12,107
36 megawatts (MW) (Global Wind Energy Council, 2015). Navigant Consulting (2014) estimated that about
37 6,600 MW are currently under construction globally, yet the future long-term capacity growth of the
38 industry is uncertain. Several pilot projects have tested wave and tidal current energy technology and
39 environmental effects around the world (Copping et al., 2013; Pacific Northwest National Laboratory,
40 2015). Wave and tidal current technologies are mostly in the pre-commercial (research, development,
41 and testing) phase (Augustine et al., 2012), however the first commercial tidal current array became
42 operational in Scotland in 2016 (Nova Innovation Ltd., 2016).

43 The United States has an active interest in marine renewable energy. The U.S. is working toward
44 diversifying its energy portfolio, with a strong interest in advancing clean energy technologies. A diverse
45 clean energy portfolio can increase the nation's energy security while reducing emissions that contribute
46 to climate change (Musial & Ram, 2010). Offshore wind, wave, and tidal current energy resources,
47 technologies, market factors, infrastructure requirements, cost feasibility, and other factors are being
48 actively assessed by institutions such as the Department of Energy's National Renewable Energy
49 Laboratory (NREL), Pacific Northwest National Laboratory (PNNL), and Sandia National Laboratory, the
50 Northwest National Marine Renewable Energy Center (NNMREC), Electric Power Research Institute
51 (EPRI), and others (Augustine et al., 2012; EPRI, 2011; Lopez, Roberts, Heimiller, Blair, & Porro, 2012;
52 Musial & Ram, 2010; Navigant Consulting, Inc., 2013b, 2014; Schwartz, Heimiller, Haymes, & Musial,
53 2010).

54 The first wind farm in the United States, Block Island Wind Farm, began operations in December
55 2016 off the coast of Rhode Island. A number of other offshore wind projects are in advanced stages of
56 development across the country (Navigant Consulting, Inc., 2014). The Bureau of Ocean Energy
57 Management (BOEM), the federal agency responsible for issuing leases for offshore energy in federal
58 waters, has created several wind energy areas along Atlantic coast to facilitate development of projects.
59 BOEM has awarded lease sales along the Atlantic coast through competitive auctions and is in the
60 process of scoping and announcing additional lease sales. BOEM has also processed several unsolicited
61 lease requests. BOEM task forces and panels have been established in at least 14 states to help
62 coordinate between federal, state, and local governments and engage stakeholders (Navigant
63 Consulting, Inc., 2014).

64 In Oregon, a proposed offshore wind project about 18 miles offshore from Coos Bay is currently in
65 the permitting phase. The WindFloat Pacific Project is planned to consist of up to five deep-water
66 turbines in approximately 350 meters (1,150 feet) water depth. Estimated project capacity is up to 30
67 MW. The project is scheduled to be commissioned in 2017 (Principle Power, Inc., 2013).

68 The U.S. also has a small number of wave and tidal current energy device testing facilities, sites, and
69 pilot projects. that enable people to test the feasibility of technology as well as to study potential
70 environmental effects (Augustine et al., 2012). The Pacific Marine Energy Center (PMEC) is an umbrella
71 for marine energy testing facilities at NNMREC, a partnership between Oregon State University, the
72 University of Washington, and University of Alaska Fairbanks. PMEC supports open-water testing of full-
73 scale wave converters at the North Energy Test Site off Newport, OR (PMEC-NETS), sub-scale wave
74 converters in Puget Sound, and river current turbines at the Tanana River Test Site near Fairbanks, AK
75 (PMEC-TRTS). A grid-connected wave energy test site off Newport (PMEC-SETS) is also in the advanced
76 stages of planning, and additional capacity to test sub-scale current turbines is being developed (Oregon
77 State University, 2015). In addition to these facilities, the US Department of Energy and US Department
78 of Defense have established the Wave Energy Test Site (WETS) on Oahu, HI for field testing of full-scale
79 wave energy converters. Some pilot projects are anticipated to become larger scale commercial projects
80 once testing is completed (PNNL, 2013).

81 *Summary of History in Washington*

82 The State of Washington saw several marine renewable energy proposals in the past, some located
83 within the MSP Study Area. The MSP Study Area has significant offshore wind and wave resources (EPRI,
84 2011; Lopez et al., 2012; Schwartz et al., 2010), and limited tidal current resources (Van Cleve, Judd,
85 Radil, Ahmann, & Geerlofs, 2013). However, there are currently no active operating or proposed marine
86 renewable energy projects within the MSP Study Area.

87 A notable past energy proposal within the MSP Study Area was the Makah Bay Offshore Wave
88 Energy Pilot Project. This project proposed four wave energy conversion buoys with an estimated 1 MW
89 maximum capacity, enough to power about 150 homes on the Makah Indian Reservation. The project
90 was estimated to have a mooring footprint of 625 x 450 feet and was to be located within the Olympic
91 Coast National Marine Sanctuary (OCNMS). The project received a Federal Energy Regulatory
92 Commission (FERC) conditioned license, which included approval of a 3.7 mile long transmission cable to
93 connect to the onshore electricity grid. The Clallam County Public Utility District (PUD) planned to
94 purchase the power once the applicant acquired all state and federal licenses (Federal Energy
95 Regulatory Commission, 2006, 2007). The project proponent surrendered the rights to the project in
96 April 2009, citing economic reasons (Federal Energy Regulatory Commission, 2009).

97 Another past proposal was for a tidal current energy demonstration project outside of the MSP
98 Study Area in Puget Sound. Located in Admiralty Inlet near Whidbey Island, the Snohomish County
99 Public Utility District #1 (SnoPUD) proposed installing two OpenHydro tidal energy turbines at a depth of
100 about 190 feet to operate for three to five years. Starting in 2007, SnoPUD, along with other agencies
101 and stakeholders, identified potential environmental impacts and performed several baseline studies
102 collecting information such as physical environment, benthic habitat, and water quality data. SnoPUD
103 received a FERC pilot project license in March, 2014 (PNNL, 2014). In September 2014, SnoPUD issued a
104 press release stating that they suspended the tidal pilot project due to rising costs (Snohomish County
105 Public Utility District No. 1, 2014) and they surrendered the FERC license in December 2015.

106 The University of Washington is a partner in NNMREC for researching and testing tidal current
107 devices, and has supported testing for two intermediate-scale temporary wave converters, one in Puget
108 Sound and one in Lake Washington; both outside of the MSP Study Area (Oregon State University,
109 2015). Further wave energy converter testing in Lake Washington is planned and NNMREC is also
110 modifying a vessel to conduct in-water testing of research-scale current turbines, scheduled to begin
111 testing in 2016 (B. Polagye, personal communication, June 7th, 2015). PNNL's Marine Laboratory in
112 Sequim has also received funding for testing environmental monitoring technologies potentially in the
113 presence of scaled tidal current or wave power devices (S. Geerlofs, personal communication, May 20th,
114 2015).

115 *Current and Emerging Technologies*

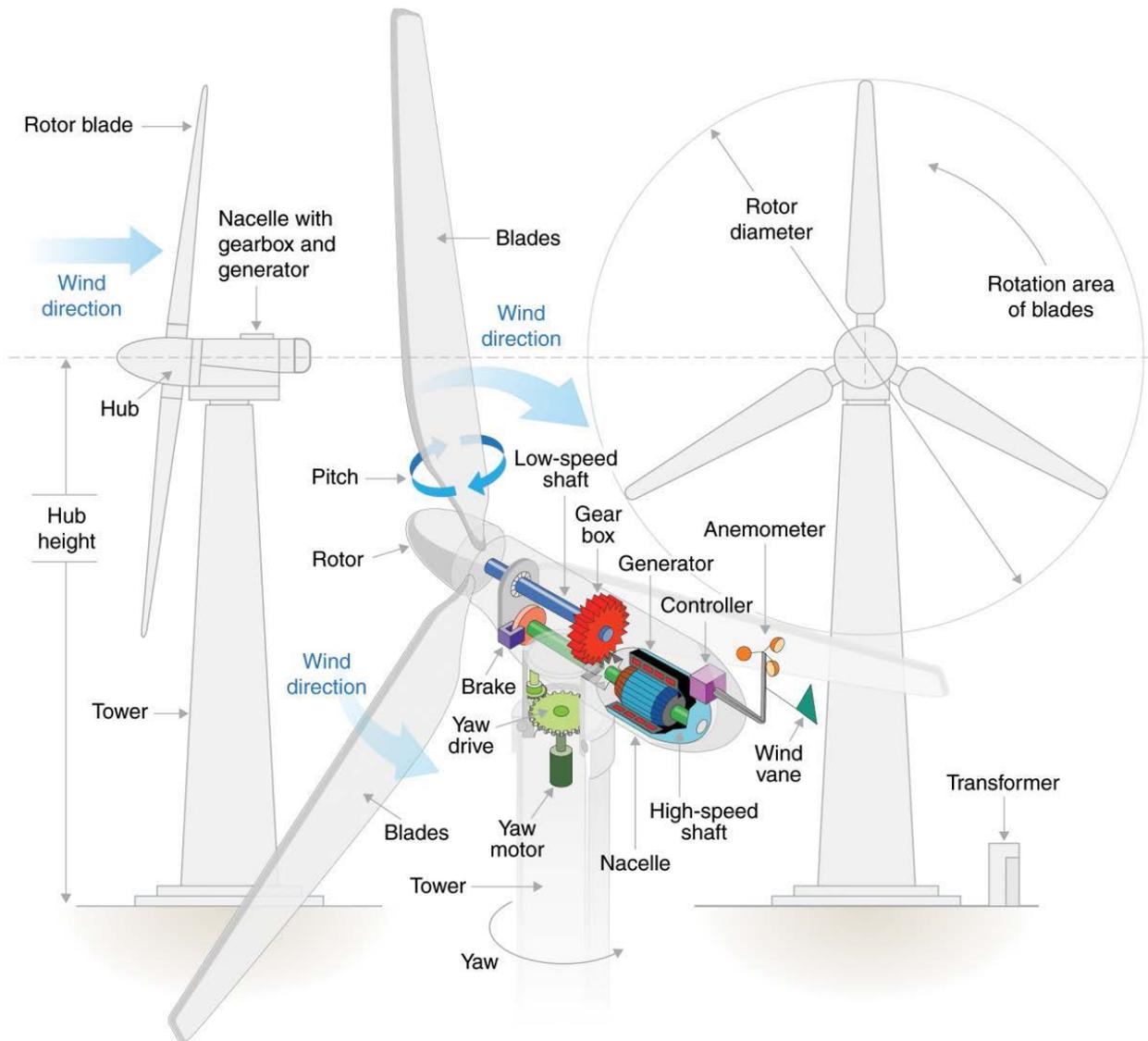
116 As mentioned above, marine renewable energy involves converting naturally-occurring energy in
117 the ocean into electricity from three types of energy resources available within the MSP Study Area:
118 offshore wind, wave, and tidal current. The following sections briefly describe the associated
119 technologies for harnessing each of these three resource types.

120 *Offshore wind energy*

121 Offshore wind energy technology evolved directly from the land-based wind energy industry. Wind
122 turbines operate by converting kinetic wind energy into electrical energy. Turbines typically have three
123 blades and rotate around a hub which is connected to a nacelle with a gearbox and generator (Figure

124 2.10.1-1) (Augustine et al., 2012). Offshore wind turbines are trending toward larger sizes compared to
125 onshore wind turbines because larger turbines can capture energy more efficiently and are not
126 constrained by land-based transportation logistics which restrict onshore wind turbine size (Navigant
127 Consulting, Inc., 2013b, 2014). U.S. planned offshore wind projects currently have an average turbine
128 capacity of about 5 MW, ranging from 3 to 8 MW (Navigant Consulting, Inc., 2014). For example, the
129 turbines for the planned WindFloat Pacific project have 6 MW capacity with rotor diameters up to about
130 500 feet (Principle Power, Inc., 2013). Some manufactures are pursuing turbine designs in the 10 to 15
131 MW range (Navigant Consulting, Inc., 2014).

132 The amount of power produced from an offshore wind farm will depend upon the installed capacity
133 of the project, wind speeds, location, and capacity factor. The capacity factor is the percentage of time
134 that the generator is producing power. The average capacity factor for recently installed offshore wind
135 projects ranges from about 28%-50% (Navigant Consulting, Inc., 2014), which is greater than terrestrial
136 wind with an average net capacity factor of about 32% in the Columbia Basin (Northwest Power and
137 Conservation Council, 2016).



138

139 **Figure 2.10.1-1. Components of a wind turbine. Source: Augustine (2012).**

140 Offshore wind turbines are attached to foundations within the marine environment. These
141 foundations vary in design, with different designs suitable for different water depth zones. The most
142 commonly used foundation in currently constructed projects globally is the monopile design, followed
143 by a gravity base design (Navigant Consulting, Inc., 2014). These two foundation designs are suitable for
144 shallow water in about 30 meters (100 feet) or less (Musial & Ram, 2010; Sotta, 2012). Technologies
145 under development and demonstration for transitional water depths (30 to 60 meters; or 100 to 200
146 feet) include tripod, jacket, multipile (Musial & Ram, 2010), and twisted jacket foundations (Department
147 of Energy, 2014).

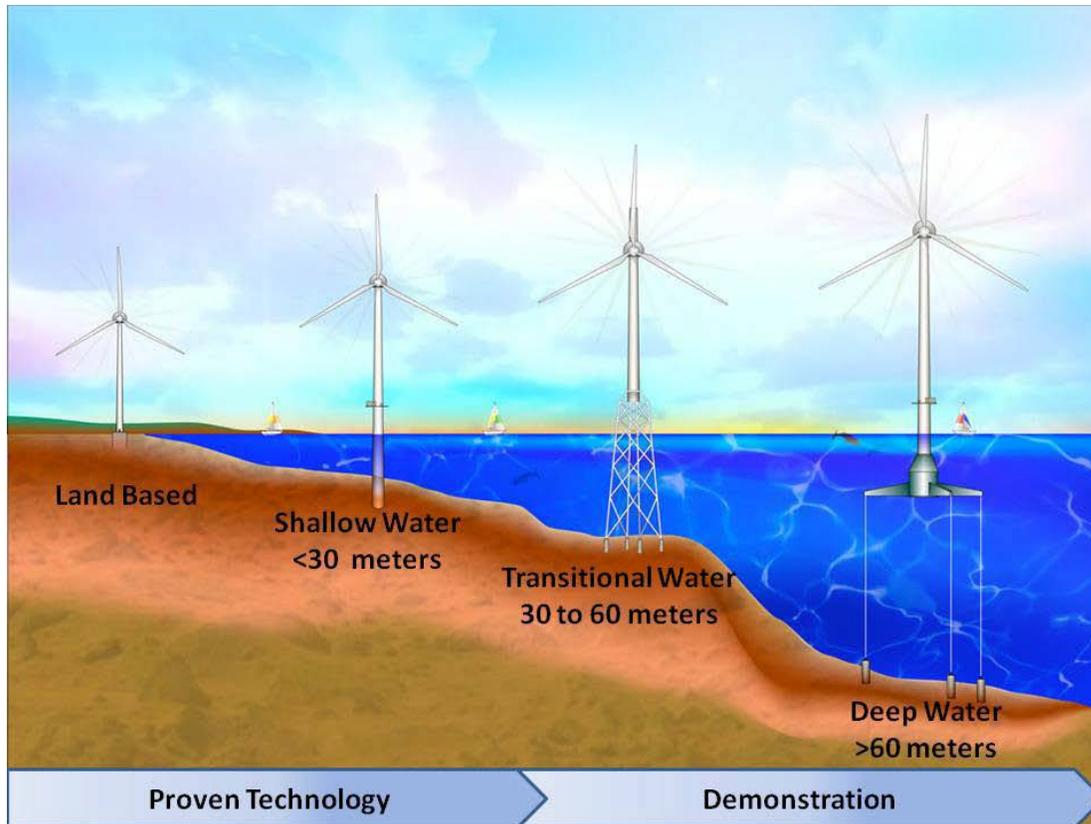
148 At greater than 60 meters depth (200 feet), bottom-fixed structures are no longer economically
149 feasible and therefore require floating foundations that are moored to the bottom. These designs
150 include floating semi-submersibles, tension leg, and spar buoy (Musial & Ram, 2010) (Figure 2.10.1-2).
151 The anchor and mooring systems will vary by floating project. For example, the Coos Bay WindFloat
152 project, which uses a floating semi-submersible design, is planning to use vertical load anchors
153 commonly used in the oil and gas industry (Principle Power, Inc., 2013). Figure 2.10.1-3 shows the
154 projected variations in offshore wind foundation designs by depth.

155



156

157 **Figure 2.10.1-2. Offshore wind floating designs. Source: Department of Energy**



158
159
160

Figure 2.10.1-3. Diagram displaying example differences in offshore wind technology types by depth. Source: Musial and Ram (2010)

161 *Wave energy*

162 Wave energy is categorized as a type of marine hydrokinetic energy (MHK) technology. MHK
163 technologies convert energy from a moving fluid, in this case a wave, into electricity (Augustine et al.,
164 2012). Wave energy technology is in the early stages of development and is not as advanced as offshore
165 wind. Many different wave technology designs are currently under development and testing in the U.S.
166 and around the world (Augustine et al., 2012; Van Cleve et al., 2013). The following summaries describe
167 some of the technology types for wave energy (2012). Figure 2.10.1-4 provides a visual of these
168 technology types.

169 **Point absorbers** extract kinetic energy from the movement of a buoy relative to the ocean floor with
170 the rise and fall of waves. This movement is converted to electrical energy either through a linear or
171 rotary generator.

172 **Overtopping devices** allow waves to lift water over a barrier, which fills a reservoir that is drained
173 through a hydro-turbine. They are often described as a low-head hydropower facility because they
174 convert the potential energy of the elevated water in the upper reservoir to generate power much like a
175 conventional hydropower dam.

176 **Oscillating water columns** are partially submerged structures. Air fills the upper part of the
177 structure above the water level. Incoming waves are funneled into the structure from below the
178 waterline, causing the water column within the structure to rise and fall with the wave motion. This
179 alternately pressurizes and depressurizes the air column, pushing and pulling it through an air turbine
180 mounted in a portal in the top of the column structure.

181 **Attenuators** capture wave-energy with a principal axis oriented parallel to the direction of the
182 incoming wave. They convert the energy created by the relative motion of the articulated bodies of the
183 device as the wave passes along it.

184 **Inverted pendulum devices** use the surge motion of waves to rotate a large, hinged paddle back and
185 forth. The flapping motion drives hydraulic pumps that in turn drive electrical generators. Alternatively,
186 linear generators are used to directly convert the wave energy into electrical energy.

187 An additional wave device type, the **M3 Nearshore Wave Energy Device** as described in the Pacific
188 Northwest National Laboratory (PNNL) energy suitability analysis for Washington, is a pressure device
189 that sits below the ocean surface and gathers energy from the pressure created in the sea column from
190 passing waves (Van Cleve et al., 2013).

191 As described by Van Cleve et al. (2013), wave energy devices are designed for various depths, with
192 some devices designed for the coastline and in shallow waters (<10 meters or 32 feet) with other
193 designed for mid-water depths and water depths of up to 125 meters (410 feet).

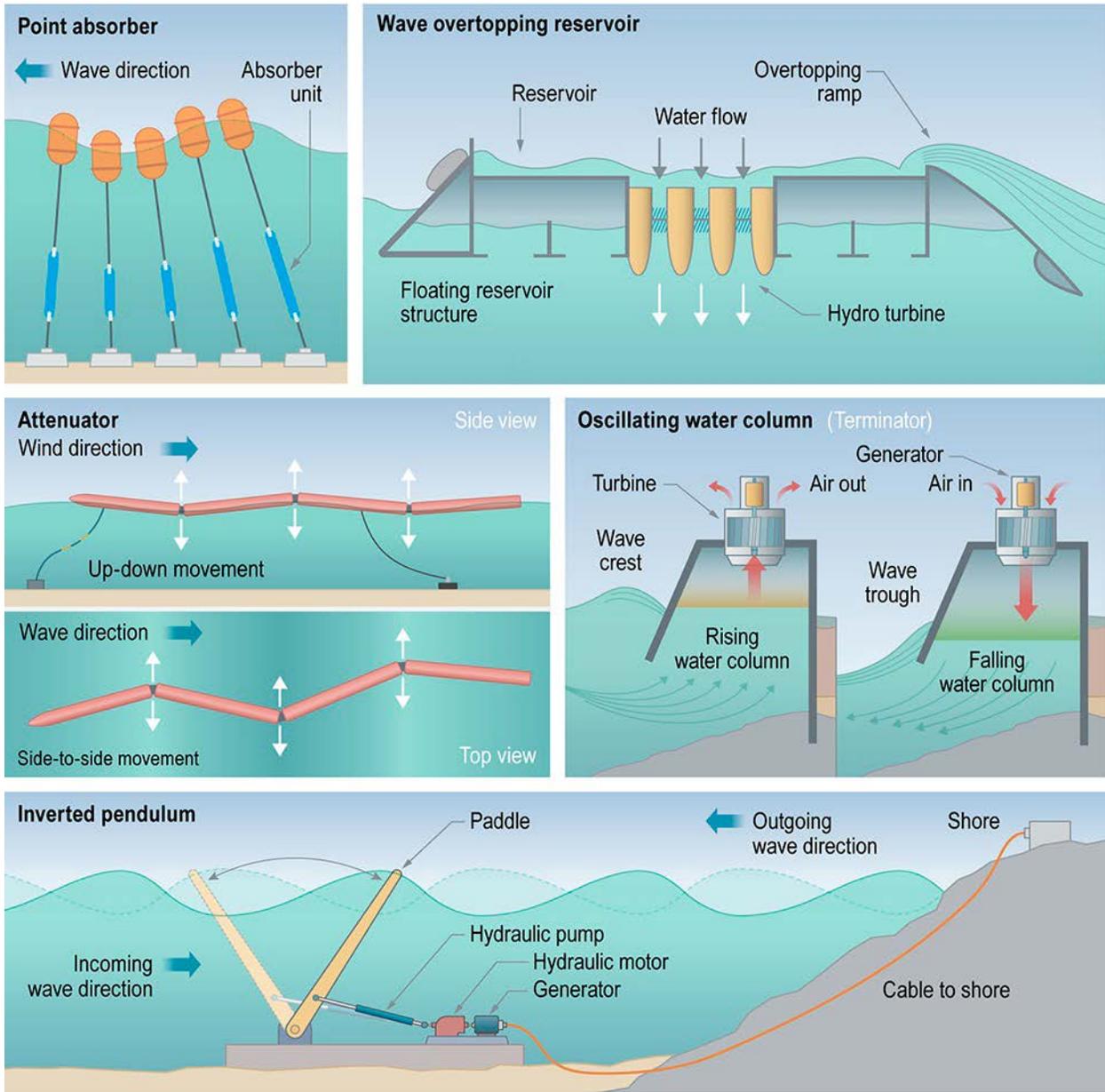
194 Mooring technology and configurations will vary by project and technology type, and will be
195 influenced by device array configurations and whether or not the project is motion-dependent (i.e.,
196 point absorber) or motion-independent (i.e., overtopping device) (Benjamins et al., 2014).

197 *Tidal current energy*

198 Tidal current energy is also categorized as a MHK technology by converting energy from a moving fluid
199 into electricity⁵. Tidal turbines essentially work in the same manner as wind turbines, except they
200 extract energy from flowing water instead of air. Similar to wave energy technology, tidal current energy
201 technology is also in the early stages of development and has several different technology types and
202 configurations (Augustine et al., 2012). Examples of tidal current technologies are shown in Figure
203 2.10.1-5. Tidal turbines require relatively strong currents to produce significant amounts of electricity.
204 Depths of turbine deployment are dependent upon technology type and site factors. Tidal turbines sited
205 below a commercial shipping lane will require at least 15 to 25 meters (49-82 feet) of overhead
206 clearance and first-generation deployments have generally been outside of shipping channels (Polagye,
207 Van Cleve, Copping, & Kirkendall, 2011).

208

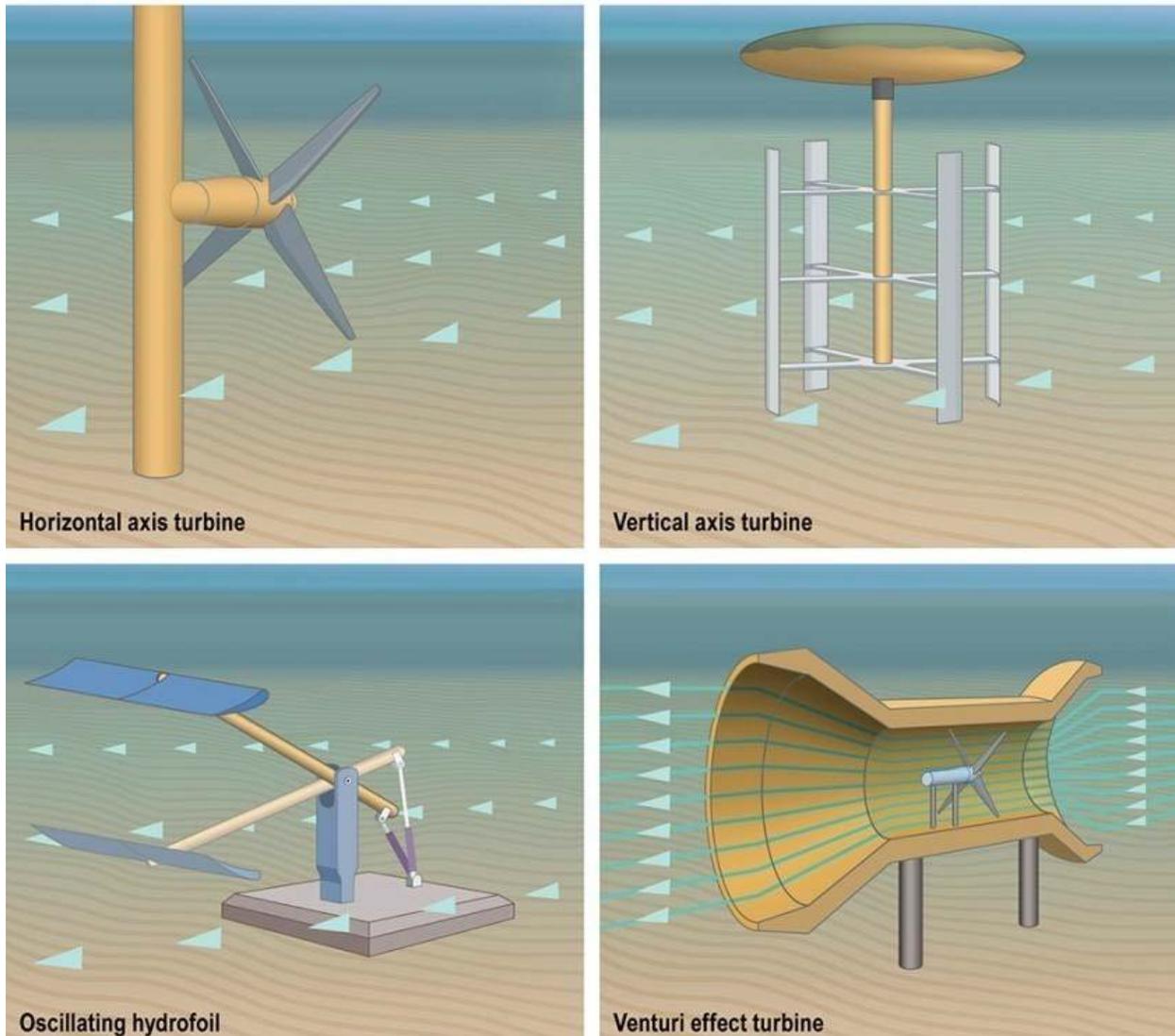
⁵ Tidal range technologies (also known as tidal barrages) are conventional hydropower in the marine environment and are not addressed within the Marine Spatial Plan.



209

210

Figure 2.10.1-4. Wave energy technology types. Source: Augustine (2012).



211

212

Figure 2.10.1-5. Primary technology types for tidal current energy devices. Source: Augustine (2012).

213

Related Infrastructure

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Marine renewable energy will require energy transmission and support infrastructure. Energy transmission infrastructure will include cables from the device and submarine transmission cables to bring the energy to shore, along with shore-based substations to connect the energy to the electricity grid. Support infrastructure requirements will include ports, specialized service vessels, and likely coastal based manufacturing facilities (Musial & Ram, 2010).

219

Energy transmission infrastructure

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The exact energy transmission infrastructure technology requirements will depend upon the specific energy project. Common elements of existing offshore wind energy infrastructure include inter-array electric power cables, transformer stations to collect the power and step-up the voltage, long-distance transmission cables, and onshore substations to connect the energy with the electricity grid (Navigant

224 Consulting, Inc., 2014). Wave and tidal device arrays will also have these basic components (Boehlert,
225 McMurray, & Tortorici, 2008; Polagye et al., 2011).

226 Underwater power transmission cables are made up of a conductive material, such as copper or
227 aluminum, and are surrounded by insulation (Bergstrom et al., 2012). Electricity flowing through the
228 long-distance transmission cables is either Alternating Current (AC) or Direct Current (DC). Efforts to
229 develop effective and efficient long-distance transmission technologies for both high voltage AC and DC
230 are underway (Navigant Consulting, Inc., 2014). Transmission cables will either be buried or weighted
231 along the seafloor depending upon sediment type and risk to the cable (Bergstrom et al., 2012). If the
232 sediment type allows, cables can be buried from 1 to 3 meters (3 to 10 feet) deep to insulate and
233 protect the cable (Polagye et al., 2011). When the cable approaches shore, Horizontal Directional Drilling
234 (HDD) may be used to make landfall at an onshore substation by crossing under sensitive nearshore
235 areas (Polagye et al., 2011).

236 Another important part of the energy transmission infrastructure is the availability of onshore
237 substations and connections to the land transmission grid. The distance from marine renewable energy
238 projects to land-based substations and the transmission grid will influence where energy projects can be
239 feasibly sited (Van Cleve et al., 2013). These substations must also be capable of accepting additional
240 electricity loads for distribution (electricity “on-ramps”), and therefore existing substations and
241 transmission lines may need upgrades to accommodate added capacity (Industrial Economics, Inc.,
242 2014).

243 Marine renewable energy developers continue to face challenges and complications to overcome
244 transmission capacity and efficiency constraints for bringing the energy to shore and integrating it into
245 the grid (Navigant Consulting, Inc., 2014). Some developers are exploring the option of providing non- or
246 limited-grid connected, site-based energy for remote coastal communities or for powering other nearby
247 uses such as aquaculture or desalinization. Examples include a wave buoy array that provides electricity
248 to a military station on an island in Australia, where the energy is used to help power a desalination
249 plant (Yee, 2015), and a company in Scotland testing wave energy to provide electricity to finfish farms
250 (Mercador Media, 2014). The Makah Bay Offshore Wave Energy Pilot Project is a local example of
251 interest in providing site-based energy for remote communities within the MSP Study Area.

252 *Support infrastructure*

253 Marine renewable energy projects will require various types of maritime support infrastructure for
254 construction, operation, and decommissioning of devices. Distances to service ports, deepwater ports
255 with sufficient overhead clearance (offshore wind), and helicopter operations (offshore wind) were
256 identified by PNNL to be contributing attributes to suitable locations for marine renewable energy
257 projects (Van Cleve et al., 2013). Specialized vessels will also likely be required (particularly for shallow
258 water offshore wind) for installation, operation, maintenance, and decommissioning. Under the Jones
259 Act, only U.S. flagged vessels are allowed to serve marine renewable energy projects (Musial & Ram,
260 2010).

261 *Potential benefits and use compatibilities*

262 *Potential benefits of marine renewable energy*

263 Marine renewable energy has the potential to provide many benefits to Washington’s local coastal
264 communities, the state, and the nation. Commonly cited benefits to marine renewable energy include
265 providing a cleaner, renewable energy source to replace conventional carbon-emitting energy sources,

266 providing opportunities for economic development, diversifying the energy portfolio, and increasing
267 energy security.

268 **Cleaner, renewable energy**

269 Marine renewable energy is considered a clean energy source because it does not burn carbon rich
270 fuel sources (a.k.a. fossil fuels) which, as a result, emit carbon into the atmosphere and contribute to
271 climate change and ocean acidification (Boehlert et al., 2008; Musial & Ram, 2010; Polagye et al., 2011).
272 Clean energy can displace the use of traditional, fossil fuel energy sources and thereby mitigate climate
273 change and reduce the risk of catastrophic spills associated with fossil fuel extraction and transportation
274 (Polagye et al., 2011). Marine renewable energy is considered “renewable” because it is continuously
275 produced from the interactions of the sun-water cycle and geography, unlike depletable inputs of oil,
276 natural, gas, or uranium. Offshore wind and wave energy are a form of solar energy, and tidal energy is a
277 result of gravitational force between the earth, moon, and sun (Augustine et al., 2012).

278 Washington State has a history of producing and obtaining its electricity from renewable energy
279 sources. In 2012, Washington produced about 84% of its total annual electricity consumption from
280 renewable sources. Hydropower (dams) accounted for 77% of total electricity consumed, land-based
281 wind accounted for 6%, and other renewable accounted for about 1% (Washington State Department of
282 Commerce, 2014b). The Renewable Energy Portfolio Standard, enacted in 2006, is an example of
283 Washington’s commitment to increase energy availability from clean, renewable energy sources. The
284 Washington Department of Commerce administers a Clean Energy Fund for Washington research
285 institutions to develop or demonstrate clean energy technologies (Industrial Economics, Inc., 2014).

286 **Economic development**

287 According to the U.S. Department of Energy, NREL, and the Navigant Consortium⁶, offshore wind has
288 the potential to significantly contribute to the U.S. domestic manufacturing sector and create high-
289 paying, stable jobs (Musial & Ram, 2010; Navigant Consulting, Inc., 2013b, 2014). A domestic offshore
290 wind industry is estimated to create direct jobs in manufacturing, installation and decommissioning, and
291 maintenance and operations. These jobs can represent temporary and permanent positions.

292 At this time, it is difficult to estimate how many new jobs a marine renewable energy project in
293 Washington will create because these numbers are based upon project-specific details, such as project
294 size, project type, infrastructure update requirements, and others. Some of these jobs may be locally
295 sourced, while others may be sourced throughout the region, state, country, or internationally. NREL
296 estimates that most of the labor for the U.S. offshore wind industry will be sourced locally or regionally
297 (Musial & Ram, 2010). It is possible that a marine renewable energy project may displace jobs from
298 other industries (e.g., commercial fishing) due to direct space conflict and other factors (see Potential
299 human use conflicts), causing further uncertainty related to the economic effects from marine
300 renewable energy within the region. Once a specific project is proposed, it may be possible to perform a
301 jobs cost-benefit analysis to provide a more accurate estimation of the type of economic effect a project
302 may have on the local community and the State.

303 Washington has already gained economic benefit from the WindFloat Pacific project in Oregon from
304 Washington based companies participating in the development, permitting, and siting of the project. In

⁶ The Navigant Consortium is led by Navigant Consulting, Inc. Other members include the American Wind Energy Association, the Great Lakes Wind Collaborative, Green Giraffe Energy Bankers, National Renewable Energy Laboratory (NREL), Ocean & Coastal Consultants, and Tetra Tech EC, Inc. (Navigant Consulting, Inc., 2014).

305 addition, some Washington based companies are or will be suppliers of components for floating
306 offshore wind installations (A. Weinstein, personal communication, May 15th, 2015).

307 *Diverse energy portfolio and increased energy security*

308 Another commonly cited benefit of marine renewable energy development is the diversification of
309 the energy portfolio (Copping et al., 2013; Musial & Ram, 2010; Navigant Consulting, Inc., 2014). The
310 U.S. is actively pursuing a broad suite of domestic energy developments, from expanding domestic oil
311 and gas operations, to investing in both renewable and fossil fuel energy technology development
312 (Department of Energy, 2012). A diverse energy portfolio will increase national energy security by
313 reducing reliance on foreign energy sources (Department of Energy, 2012; Musial & Ram, 2010). NREL
314 estimates that offshore wind has the potential to contribute significantly to the U.S. clean energy
315 portfolio (Musial & Ram, 2010; Schwartz et al., 2010).

316 Marine renewable energy has the potential to provide energy near coastal demand centers (Musial
317 & Ram, 2010). Transmission infrastructure updates would be required, and there is active interest on
318 the Atlantic coast in developing a comprehensive offshore transmission plans for offshore wind projects
319 (Navigant Consulting, Inc., 2014). Some rural Washington coastal communities have also recognized this
320 potential benefit and are looking to increase their local energy supply. The majority of coastal
321 communities, including tribal communities, are currently the end of the line for energy transmission and
322 power supply from the grid can become unreliable during high demand periods (Industrial Economics,
323 Inc., 2014). The former Makah Bay Offshore Wave Pilot Project planned to produce energy for up to 150
324 homes on the Makah Reservation (Federal Energy Regulatory Commission, 2006) to improve energy
325 resilience. Some experts have indicated that small-scale community based projects continue to have
326 some potential in the MSP Study Area in the near future (10 to 15 years) (Industrial Economics, Inc.,
327 2014), yet the cost may be a limiting factor for the near term (A. Weinstein, personal communication,
328 May 15th, 2015).

329 *Potential compatible uses*

330 Properly designed and sited marine renewable energy projects have the potential to be compatible
331 in space and time with specific ocean uses. While there are few direct on-the-ground examples of
332 compatible uses due to the limited deployment of marine renewable energy projects, a number of
333 potentially compatible ocean uses have been identified. Examples of current uses that may be
334 compatible include recreational fisheries, tourism activities, fishing exclusion zones, and some types of
335 aquaculture. Opportunities for compatible uses will likely depend on project type (offshore wind, wave,
336 or tidal), size, and other factors.

337 Boehlert et al. (2008) and Bergstrom et al. (2014) state that renewable energy projects are very
338 likely to act as Fish Aggregation Devices (FADs). Recreational fisheries may benefit from targeting their
339 efforts near a project site, as this type of activity and benefit has been reported around offshore oil and
340 gas platforms in the Gulf of Mexico (Bureau of Ocean Energy Management, 2012b). This benefit may be
341 influenced by potential exclusion zones around project sites.

342 Boehlert et al. (2008) and Bergstrom et al. (2014) discussed the possibility of marine renewable
343 energy co-existing with fishing exclusion zones since a project may exclude some commercial and
344 recreational fishing. The FAD effect combined with fishing exclusion may act as a fish protection area
345 and possibly boost some fish populations. The potential for energy projects to be co-located with
346 currently established and future fishing exclusion areas will be influenced by the goals of the fishing
347 exclusion area and the ability of the energy project to meet those goals.

348 Tourists may be interested in viewing renewable energy projects, either from land or by boat, which
349 could attract tourists to an area with an energy project. Studies reviewed in Musial and Ram (2010)
350 found that some land-based and offshore wind projects have boosted the tourism industry within a
351 project area. Shipping may also be compatible with offshore wind farms and tidal current energy arrays.
352 Depending on the separation distance between wind turbines, it is possible that shipping lanes could be
353 located within offshore wind sites (Industrial Economics, Inc., 2014). Tidal current devices may be sited
354 below commercial shipping lanes, if there is an overhead clearance of 15 to 25 m (49-82 feet) (Polagye
355 et al., 2011). Stakeholders also mentioned the possible benefit of improved search and rescue
356 operations in ocean waters surrounding energy projects (Feb WCMAC meeting summary).

357 In regards to marine renewable energy compatibility with future uses of the ocean, Buck (2010)
358 discussed the potential for co-location of offshore wind with offshore shellfish aquaculture. The
359 foundation structures for offshore wind may provide an opportunity for anchoring, protecting, and
360 accessing shellfish cultured in the ocean environment. Using marine renewable energy to provide
361 electricity to aquaculture operations is also a prospect currently under development (Mercador Media,
362 2014).

363 Potential environmental impacts

364 Potential effects to the marine environment from marine renewable energy are a key concern to
365 many scientists, regulators, and stakeholders, and the industry. While active research is working to
366 study, monitor, and model potential environment effects from marine renewable energy deployments
367 in ocean and coastal waters, relatively little is known about the level of actual impact that these devices
368 may have when deployed at substantial scale (Bergstrom et al., 2014; Boehlert et al., 2008; Clark,
369 Schroeder, & Baschek, 2014; Copping et al., 2013; Musial & Ram, 2010; Polagye et al., 2011; Sotta,
370 2012).

371 Multiple efforts around the world are establishing a scientific knowledge base about offshore wind,
372 wave, and tidal current devices and their potential impacts to the marine environment. Among the most
373 notable is the Tethys database hosted by PNNL which serves as a clearinghouse for information about
374 offshore wind, wave, and tidal environmental research, literature reviews, and other data from around
375 the world (Pacific Northwest National Laboratory, 2015). Annex IV, an international partnership
376 connected with Tethys, produced a report with a series of case studies analyzing existing information
377 about MHK (Copping et al., 2013). In 2016, Annex IV released a report on the state of the science about
378 the environmental impacts of renewable energy as an update to the 2013 report (Copping et al., 2016).
379 A variety of other reports from experts in the Pacific Northwest, United States, and other countries are
380 also referenced here.

381 In general, these reports have identified and discussed numerous potential environmental effects
382 and impacts, yet there is often relatively high uncertainty (i.e., a potential effect may actually be
383 significant or may turn out to be inconsequential). Limited deployments of marine renewable energy
384 projects, mostly at pilot and small-scales, make studying potential effects and increasing certainty
385 difficult. Overall, the literature generally agrees that the majority of potential effects are of low concern
386 for small-scale projects, and the impacts from multiple large-scale commercial operations, while
387 possible, are uncertain (Bergstrom et al., 2014; Boehlert et al., 2008; Clark et al., 2014; Copping et al.,
388 2013; Musial & Ram, 2010; Polagye et al., 2011).

389 The following sections review the primary potential effects discovered in the literature and are
390 organized generally by impacting mechanism, also known as a stressor. The information review focused
391 mainly on comprehensive summary reports accessed from the Tethys database. Many potential
392 environmental effects identified are common among wind, wave, and tidal devices, while others are

393 more technology specific. The following review presents potential effects generally for marine
394 renewable energy and any predicted effects specific to a device are highlighted. Possible environmental
395 effects, predicted level of impact, and uncertainty as discussed in the literature are described for each
396 impacting mechanism when available.

397 *Noise*

398 Acoustic disturbance (a.k.a. noise) is a potential effect of marine renewable energy devices in the
399 ocean and coastal environment. Noise can be generated from sources such as construction activities,
400 machinery and moving parts (such as moving turbine blades or generators within wave buoys), wave
401 and wind interactions, and strum noises from mooring cables (Bergstrom et al., 2014; Boehlert et al.,
402 2008; Polagye et al., 2011). Noise from construction, particularly noise generated from pile driving, is the
403 source of noise most commonly cited within the literature as having the largest potential for negative
404 impact to marine animals. Pile driving creates intense, pulsed noise, has been observed to cause
405 avoidance behavior in marine mammals, and is likely to cause mortality and tissue damage in fish (as
406 cited in (Bergstrom et al., 2014; Sotta, 2012). Pile driving may be used for monopile and jacket
407 foundation installations for offshore wind (relatively shallow water) (Bergstrom et al., 2014), and
408 possibly tidal current devices, also depending on the water depth (Polagye et al., 2011).

409 Mitigation techniques presented in the literature to reduce harm to marine animals from
410 construction sound include slow ramp-up for pile driving, bubble curtains, and acoustic deterrents
411 (Polagye et al., 2011). Bergstrom et al. (2014) summarizes mitigation measures for construction
412 activities including avoiding important recruitment areas for marine mammals and fish and timing
413 construction activities outside of key migration time periods. New pile driving technologies have also
414 been developed that inherently reduce noise generation without secondary mitigation measures
415 (Reinhall & Dahl, 2011).

416 The operational sources of noise (machine operation, strum, wave and wind interactions, etc.) are
417 expected to be low frequency and low intensity. Some marine animals may be sensitive to low
418 frequency sounds, such as baleen whales (gray and humpback whales) and fish. It is possible that these
419 low frequency sounds could either deter or attract whales, which could restrict migration corridors,
420 reduce feeding areas, or increased susceptibility to predation by killer whales. Fish may experience
421 behavior changes or loss of sensory capabilities. Fish thought to be particularly noise-sensitive include
422 salmon, sardines, herring, rockfish, midshipman (*Porichthys* sp.), and a number of other groundfish
423 species (Boehlert et al., 2008). Hearing thresholds and responses of whales, pinnipeds, and fish are
424 uncertain (Copping et al., 2013).

425 Low frequency, continuous sounds may be masked by environmental background noise. Devices will
426 likely be located in high energy areas subject to relatively high background noise (e.g., waves, rain,
427 bubbles and spray, sediment movement) (Boehlert et al., 2008; Copping et al., 2013; Polagye et al.,
428 2011). Isolating and measuring sound generation and propagation from marine renewable energy
429 devices is difficult, particularly in high energy environments (Copping et al., 2013, 2016). Experts
430 recommend that baseline studies of background noise, field observations, and sound modeling be used
431 to determine the nature of the sound produced from marine renewable energy device arrays (Boehlert
432 et al., 2008; Copping et al., 2016; Polagye et al., 2014, 2011).

433 Mitigation methods to reduce the effect of operation noise from wave energy devices presented in
434 Boehlert et al. (2008) include varying the array design to reduce synchronous sound (additive noise),
435 thicker mooring cables to reduce the frequency of cable strum, cable anti-strum devices, and developing
436 wave technology with noise reduction designs.

437 Some marine animals may not be able to detect sound produced by renewable energy devices, or
438 on the other hand, could even be attracted to the devices (Boehlert et al., 2008). Animals unable to hear
439 the device arrays, animals that become confused as a result of multiple sound sources, or animals
440 attracted to the devices may be at increased risk for collision and injury. The use of sound “pingers” has
441 been considered as an acoustic deterrent method for marine mammals (Copping et al., 2013).

442 The Annex IV case study on acoustic disturbance of MHK devices summarizes field, laboratory, and
443 modeling studies for determining noise effects and risk to marine animals. Based on this case study,
444 Copping et al. (2013, 2016) conclude that the limited available information suggests that animals are
445 unlikely to be killed or seriously injured as a result of noise disturbance from operation or construction
446 activities. There is higher uncertainty around the behavior, hearing shifts, or migratory effects from
447 noise disturbance. Copping et al. (2013, 2016) indicate it is unlikely that individual devices or small
448 arrays will have large-scale effects on animal behavior or survival and most concerns are related to the
449 uncertainty around additive noise from larger device arrays. More data will need to be collected as
450 additional devices are deployed.

451 *Entanglement*

452 Entanglement of marine megafauna (whales, sharks, pinnipeds, and other large animals) in mooring
453 lines of marine renewable energy devices is another commonly expressed environmental concern, yet
454 there is little direct evidence to substantiate this concern (Benjamins et al., 2014; Boehlert et al., 2008;
455 Industrial Economics, Inc., 2014; Polagye et al., 2011). Two recent literature searches performed by
456 Benjamins et al. (2014) and Kropp (2013) concluded that marine renewable energy devices pose a
457 relatively low to modest risk of entanglement to large marine animals.

458 Benjamins et al. (2014) assessed reports of entanglement for a wide variety of large marine animals
459 encompassing fisheries and other marine activities throughout the world. They also reviewed marine
460 renewable energy mooring system designs and created a qualitative risk assessment approach to assess
461 relative risk to marine animal groups. The authors concluded that for most animal groups, entanglement
462 in marine renewable energy moorings is not likely to pose a major threat. They did indicate that baleen
463 whales may be at greatest risk due to their size and foraging habits. The authors also cautioned that
464 relative risk may be influenced by mooring configuration, with catenary moorings having the greatest
465 relative risk and taut moorings have the lowest risk (Benjamins et al., 2014).

466 Benjamins et al. (2014) also concluded that the large majority of entanglement reports to date are
467 associated with ropes from fishing gear, with very few reports of large marine animals becoming
468 entangled in moorings or cables of any kind. The authors stated that a greater risk posed by renewable
469 energy device moorings may come from entanglement and bycatch in derelict fishing gear caught on
470 moorings or energy devices, as this gear will continue to capture and likely kill animals.

471 A similar study by PNNL (Kropp, 2013) assessed entanglement risk to baleen whales, particularly
472 gray whales, from potential wave energy parks along the U.S. West coast. Kropp (2013) assessed
473 biological, behavioral, and migratory patterns of whales. The study described how whales become
474 entangled in slack fishing lines, in which the slack in the fishing lines wraps around whale body parts.
475 Kropp (2013) stated that moorings for wave energy devices would not have sufficient slack to entangle a
476 whale. The study concluded that entanglement with wave energy device moorings in Oregon waters
477 should not be a significant issue for baleen whales.

478 *Electromagnetic Fields*

479 Electromagnetic fields (EMF) can be produced by underwater energy transmission cables. The types
480 of EMFs emitted include an electric field, an induced magnetic field, and induced electrical field created
481 from the movement of water through the magnetic field. Cables can be shielded to prevent direct
482 electric field emissions, but the induced magnetic and electric fields cannot be completely shielded. AC
483 and DC underwater cables, therefore, will emit induced electric and magnetic fields. There is significant
484 uncertainty around the strength of the EMF emissions from marine energy cables, which will likely vary
485 between projects (Woodruff, Cullinan, Copping, & Marshall, 2013). The strength of the EMF field is
486 related directly the intensity of the source current and attenuates with distance from the cable (Polagye
487 et al., 2011; Sotta, 2012; Woodruff et al., 2013). EMF may also be emitted from in-water generating
488 devices themselves as well as transformer substations (Boehlert et al., 2008; Polagye et al., 2011).

489 Scientists and regulators have identified concerns about EMF effects on marine animals, particularly
490 for animals that use natural electric or magnetic fields to locate prey and mates, avoid predators, or
491 orient for migration. Species known to use electro-reception include elasmobranchs (e.g. sharks and
492 rays), lampreys, sturgeons, and decapod crustaceans (e.g. Dungeness crab). Species known to use
493 natural magnetic fields include elasmobranchs (e.g. sharks and rays), bony fishes (e.g. salmon and tuna),
494 marine mammals, mollusks, and arthropods (Boehlert et al., 2008; Woodruff et al., 2013).

495 PNNL (Schultz, Woodruff, Marshall, Pratt, & Roesijadi, 2010; Woodruff et al., 2013) conducted
496 preliminary laboratory studies to assess what potential effects EMF may have on fishes and
497 invertebrates. Studied species included Coho salmon, Dungeness crab, Atlantic halibut, and American
498 lobster. Studies included testing for behavior modification, food and predator detection, and
499 developmental delays. These studies found limited evidence for significant differences between exposed
500 and control groups, yet many of the studies were inconclusive due to sample sizes and husbandry
501 challenges (Schultz et al., 2010; Woodruff et al., 2013). A study in progress on the U.S. East coast is
502 currently assessing potential EMF impacts from high voltage DC cables to elasmobranch and American
503 lobster movement and migration (King et al., in progress). It is important to note that there are already
504 many submarine cables in the ocean associated with land-based energy transmission, yet studying the
505 biological effects of these cables is difficult and conclusions are highly speculative (Bergstrom et al.,
506 2012; Normandeau Inc., Exponent Inc., Tricas, & Gill, 2011).

507 Overall, literature summaries, environmental effects workshops, and limited empirical evidence
508 indicate that EMF may have a relatively low potential impact to species, with likely localized effects.
509 However, there is a high level of uncertainty surrounding the sensitivity and response of many marine
510 species to EMF (Bergstrom et al., 2014; Boehlert et al., 2008; Schultz et al., 2010; Woodruff et al., 2013).
511 Mitigation measures discussed in the literature include shielding and burying the cables to reduce
512 potential exposure (Boehlert et al., 2008). However, more recent reports contradict this suggestion
513 because burial does not actually reduce the EMF, but only increases the distance between the species
514 and the cable. This lowers the maximum EMF encountered in the water column, but for some species
515 this may make the EMF more attractive (Copping et al., 2016).

516 *Marine animal strikes*

517 Offshore wind and tidal current energy devices operate with rotating blades. Stakeholders and
518 regulators are concerned with the potential for marine animal strikes with turbine blades (or other
519 similar moving parts). Species identified that may be at risk from interaction with tidal turbine blades
520 include sea otters, pinnipeds (e.g. seals and sea lions), whales, sea turtles, fish, and diving birds (Copping
521 et al., 2013). Birds and bats are also at risk from strikes with wind turbines (Flowers, Albertani, Harrison,
522 Polagye, & Suryan, 2014).

523 An Annex IV case study (Copping et al., 2013) examined available information to estimate the effects
524 of interactions between tidal turbine blades and marine animals. The case study included monitoring
525 studies for potential marine mammal displacement at a tidal turbine site in Northern Ireland; fish
526 interactions with tidal turbines in Maine, New York, and Scotland; fish survival after passing through a
527 turbine in Minnesota; laboratory studies with fish; and mammal modeling encounters. Copping et al.
528 (2013) concluded that the current limited information provides no evidence that direct interactions of
529 marine mammals or fish with tidal turbine blades has caused harm to the animals, and results have not
530 suggested that major effects should be expected as more devices are deployed. In the 2016 Annex IV
531 update report, the authors again confirm no observed instances of marine mammals, fish, diving
532 seabirds, or other marine mammals colliding with an operational tidal turbine (Copping et al., 2016).
533 The authors do recommend that new technical methods need to be developed and implemented to
534 observe the interactions of marine animals and turbines (Copping et al., 2016)

535 A study by PNNL assessing the potential and severity of an injury to a killer whale from a tidal
536 turbine in Admiralty Inlet, Puget Sound suggested that strike risk was low, and the worst-case strike
537 injury results would possibly be equivalent to bruising, although the injury data were limited and
538 associated with high uncertainty (Carlson et al., 2014). Diving birds may be attracted to prey
539 congregating around tidal turbines and therefore may be at risk of tidal turbine strike, but there is not
540 much evidence to determine the level of risk (Copping et al., 2013; Sotta, 2012).

541 Offshore wind turbines may pose a risk to flying birds and bats. Information from bird strike risk
542 mostly comes from land-based wind farms, where the impact of bird strikes is largely site specific.
543 Studies suggest that birds are at higher risk of strike from wind turbines during storms, at night, or
544 during other periods of low visibility (Musial & Ram, 2010; Sotta, 2012). Bird flight height and diving
545 behavior also likely influences strike risk (Flowers et al., 2014; Musial & Ram, 2010; Sotta, 2012).
546 Monitoring and modeling studies of European and commissioned U.S. offshore wind sites indicate a
547 relatively low impact to birds from turbine strikes. Some monitoring studies in Europe suggest that many
548 birds avoid flying through offshore wind farms and the collision rates are low (Flowers et al., 2014;
549 Musial & Ram, 2010; Sotta, 2012). Birds strikes with wave energy devices, while possible, are considered
550 by Sotta (2012) to be less likely than strikes with offshore wind turbines.

551 Limited information is available to assess the impact to birds from wind farm lighting. According to
552 Musial and Ram (2010), no studies have documented negative impacts to birds from wind farm lighting.
553 The authors do reference the behavioral attraction of nocturnal birds to offshore oil and gas platform
554 lights, which suggests there may be an increased risk of strike to nocturnal birds. Wave energy workshop
555 participants identified a strike risk to birds from lighting on wave energy devices as a potential high
556 impact (Boehlert et al., 2008).

557 Bird strike risk reduction and mitigation measures highlighted by Musial and Ram (2010) include
558 monitoring and understanding transient and resident bird behaviors, siting in areas that avoid high-
559 density and migratory waterfowl areas, breeding areas, and migratory pathways of concern, and careful
560 siting to avoid potential cumulative impacts.

561 Bat strikes with offshore wind turbines are also a concern, as this has been an issue with land-based
562 wind turbines. There is limited information regarding bats and offshore wind farms, but it is known that
563 bats do migrate over water. A monitoring study in Scandinavia suggested that bats did not avoid
564 turbines when hunting for insects (Musial & Ram, 2010). Flowers et al. (2014) are currently developing a
565 remote monitoring system to detect bird and bat interactions with offshore wind turbines.

566 *Effects on biological environment*

567 Marine renewable energy devices and associated moorings will create novel static structures within
568 the marine environment. The presence of new structures can create a reefing effect, otherwise known
569 as a fish aggregation device (FAD), where fish opportunistically congregate around these devices. FADs
570 can be considered to have either a positive or negative effect on marine communities, depending on fish
571 management goals and trophic interactions that occur as a result of the FAD. Some fish populations may
572 increase, as the physical structure provides physical refuge and food from biofouling organisms. Other
573 fish may experience increased susceptibility to predation, as predators may opportunistically target
574 areas with high concentrations of prey. Predators could include fish, sharks, mammals, and seabirds
575 (Bergstrom et al., 2014; Boehlert et al., 2008; Copping et al., 2013; Polagye et al., 2011; Sotta, 2012).

576 Overall, there is high agreement within the literature that marine energy devices will act as FADs,
577 yet there is significant uncertainty surrounding what the exact interactions and influences this may have
578 on individual species and the community (Boehlert et al., 2008; Copping et al., 2013; Polagye et al.,
579 2011; Sotta, 2012).

580 As mentioned above, marine renewable energy devices and associated hard structures will also be
581 subject to biofouling. Biofouling can increase populations of a variety of organisms, including mussels,
582 sponges, kelp and other algae, and other sessile organisms. These organisms can provide food for fish
583 and other predators. However, it is possible that these devices can provide habitat for non-native and
584 invasive species colonization (Boehlert et al., 2008; Musial & Ram, 2010; Sotta, 2012). Invasive species
585 have been documented on offshore wind turbines in Denmark and Sweden (as cited in (Musial & Ram,
586 2010).

587 Physical presence of marine energy device arrays may also influence migration patterns of marine
588 species, including fish, mammals, and birds. Energy devices could create a physical barrier to migration,
589 act as deterrent for animals actively avoiding the arrays, or could possibly attract some animals along
590 their migration route thereby altering migration behavior. There is a significant level of uncertainty
591 around this potential impact. Recommendations include avoiding major migratory routes when siting
592 marine energy installations (Boehlert et al., 2008; Copping et al., 2013; Polagye et al., 2011).

593 Anchors, cables, and fixed foundations may directly disturb bottom habitat through placement and
594 removal of the equipment. This effect was not discussed in detail within the literature, and in general
595 effects were predicted to be low and localized (Boehlert et al., 2008; Polagye et al., 2011).

596 *Effects on physical environment*

597 Marine renewable energy devices are designed to extract energy from the marine environment, and
598 the resulting decreased energy could influence physical processes. The physical presence of these
599 devices could also affect physical processes such as wave propagation and water flow. Limited research
600 is available on the impacts of marine renewable energy devices on the physical environment, and most
601 concerns are highly speculative and restricted to large-scale deployments (Clark et al., 2014; Copping et
602 al., 2013).

603 Concerns identified in the Annex IV case study (wave and tidal energy) include alterations to
604 sediment transport and deposition, changes in tidal ranges and flushing rates of oxygenated seawater in
605 enclosed waterbodies, changes in water movement that effect distribution of planktonic larvae or
606 marine plant propagules, and changes in water column mixing. The authors noted that many of these
607 potential effects would likely only occur when device arrays extract very large amounts of energy from
608 the system (Copping et al., 2013). The majority of physical effects from single and pilot scale device
609 deployments will likely be immeasurable, and measuring effects, even from large-scale deployments
610 may be difficult, given natural variability. Effects might not be seen for years or decades after

611 deployment, and can be difficult to distinguish from natural variations in conditions. Copping et al.
612 (2013) highlight that baseline measurements of oceanographic conditions in high energy environments
613 (the environments most suitable for energy devices) is limited due to challenges of deploying
614 equipment. Modeling may be the best tool for understanding potential oceanographic effects from
615 large-scale energy deployments, but current challenges exist for model validation (Copping et al., 2013).

616 Summary reports suggest that commercial-scale tidal current arrays in particular may influence
617 water quality when placed in estuaries. These effects will likely be highly site specific. Modeling
618 techniques for estimated energy changes are limited and there is much uncertainty surrounding the
619 magnitude of impact to water quality (e.g., dissolved oxygen, temperature, salinity, water exchange,
620 etc.) and habitat (Copping et al., 2013; Polagye et al., 2011).

621 Authors conducting a comprehensive review of research and modeling of offshore wind farms in the
622 Baltic and North Seas came to similar conclusions for offshore wind effects on the physical environment
623 (Clark et al., 2014). This study identified many similar physical effect concerns (wave propagation, water
624 column mixing, sediment transport, etc.), and some additional wind related concerns. For example,
625 offshore wind farms will produce a wind wake, but is it unclear to what affect this may have on the
626 physical environment (i.e. wave propagation, given that wave generation occurs over large areas). Clark
627 et al. (2014) stated that impacts are uncertain (especially for large offshore wind farms), the current
628 accuracy of modeling is limited, and that most research indicates that any effects are either
629 undetectable or remain within the footprint of the offshore wind farm.

630 Washington stakeholders specifically raised concerns about changes in wave action and sediment
631 transport (February WCMAC Meeting summary). Current monitoring of offshore wind farms in Europe
632 suggest that effects on wave action and sediment transport are generally localized and limited to the
633 footprint of the offshore wind farm. Models of far-field (long distance) wave action and sediment
634 transport effects from offshore wind farms vary in their results, with predictions ranging from no effect
635 to reductions in beach width. The authors highlight that the disagreement between studies emphasizes
636 that effects are poorly understood (Clark et al., 2014). The Annex IV case study for MHK devices also
637 highlighted several modeling studies with highly variable results, generally influenced by energy device
638 type and size of project array. The larger the array, the more potential for effects on wave action and
639 sediment transport. However, current models are associated with high levels of uncertainty and directly
640 measuring these effects will be difficult (Copping et al., 2013), particularly given the natural variability in
641 coastal processes associated with storm events.

642 *Chemical contaminants*

643 Exposure to chemicals from marine renewable energy devices and operations is discussed in the
644 literature as a potential concern. Polagye et al. (2011) divides possible chemical contaminants into two
645 categories: fuel and hydraulic fluid spills from accidents and collisions, and slow release of anti-fouling
646 chemicals into the environment. Hydraulic fluid leaks from devices are considered to be unlikely due to
647 precautionary measures to contain fluids in the event of a leak during operation or maintenance, and
648 therefore are considered to be of low concern (Musial & Ram, 2010; Polagye et al., 2011). Large oil spills
649 from collisions (i.e. supply vessels, etc.) would likely have a high impact on fish, birds, habitats, and
650 marine mammals, yet precautionary safety and response measures should limit the likelihood and
651 extent of a large spill (Polagye et al., 2011).

652 Anti-biofouling chemicals may be continuously released into the marine environment. The effects
653 will be dependent upon the specific chemicals used, and therefore the local and community effects are
654 highly uncertain. Avoiding and minimizing the use of toxic anti-fouling chemicals (e.g., employing non-
655 toxic foul release coatings) is recommended where feasible (Polagye et al., 2011).

656 Another factor related to chemical exposure is the possibility of chemicals becoming released into
657 the water column from project placement or cable trenching over contaminated sediments. The
658 potential effect is highly site specific and depends upon the contaminants present in the sediment.
659 Avoiding contaminated sites for project and cable locations is recommended to avoid this potential
660 impact (Polagye et al., 2011).

661 Potential impacts on human uses

662 Marine renewable energy has the potential to conflict with current and future uses of the ocean,
663 thereby potentially impacting marine industries, local communities, and the state. Some of these
664 conflicts are spatial in nature, meaning that the physical presence and use of ocean and coastal space
665 will directly conflict with other uses.

666 Spatial conflicts

667 Spatial conflicts include interactions for usage of space. This can either be direct conflicts in space
668 that may result in temporary or permanent displacement, increases in time or cost to complete an
669 activity, or impacts that result from visual presence within a viewshed. Spatial conflicts may directly
670 impact the economics of the affected industry, which could lead to hardships within the industries and
671 the local communities which depend upon these activities. The MSP can be used to address spatial
672 conflicts by considering these conflicts and identifying areas of high and low conflict to avoid and
673 minimize impacts.

674 Direct displacement of fishing, shipping, and other activities

675 Marine renewable energy device arrays will take up physical ocean space. The amount of space
676 needed for arrays will depend upon project specific factors such as device type, number of devices, array
677 configuration, and mooring designs. The physical placement of these devices may displace current ocean
678 uses, most notably fishing and shipping activities (Industrial Economics, Inc., 2014). The extent of
679 displacement impact will depend upon project size and location. Offshore wind and wave device arrays
680 placed within established shipping lanes could pose a direct safety conflict. Marine renewable energy
681 devices could be sited to avoid shipping lanes, or lanes could be adjusted around project locations. Some
682 stakeholders have indicated that depending upon spacing between offshore wind turbines, it is possible
683 that shipping and other navigation uses could operate between the turbines (Industrial Economics, Inc.,
684 2014). However, floating offshore wind installations would likely not be able to allow commercial
685 shipping in between turbines due to the larger ocean floor footprint from moorings (A. Weinstein,
686 personal communication, May 15th, 2015). Shipping and tidal current energy could potentially be
687 compatible, if the turbines had at least 15 to 25 meters (49-82 feet) of overhead clearance within a
688 shipping lane (Polagye et al., 2011).

689 Marine renewable energy projects may also directly conflict with commercial and recreational
690 fishing activities (Industrial Economics, Inc., 2012). According to Bergstrom (2014), fisheries are not
691 routinely excluded from offshore wind farms in Europe, but movements may be restricted for safety
692 reasons. In the U.S., the first offshore wind farm, Block Island Wind Farm off the coast of Rhode Island,
693 started commercial operations in December 2016. The U.S. Coast Guard established a 500-yard safety
694 zone around each of the wind-turbine foundations while they were being constructed. Now that
695 construction is completed the restrictions have been lifted and boats are free to transit as close to the
696 turbines as they wish. The U.S. Coast Guard is the agency responsible for setting safety exclusion zones
697 if necessary in the future at Block Island or at other offshore wind farms.

698 Particular fisheries, possibly due to gear type differences, may be subject to more
699 displacement/exclusion than others. Impacts to various fisheries may also vary due to the nature of the
700 fishery (highly localized versus a mobile pelagic fishery) and the type of displacement they experience.
701 Navigation conflicts may include increased transit times to fishing grounds and possibly increased risk of
702 collisions with device support vessels. Transmission cables may also pose a conflict with fisheries,
703 particularly those fisheries which use bottom-contact gear equipment (Industrial Economics, Inc., 2012).

704 It is impossible to know at this point to what extent the impact to Washington fisheries would be, as
705 this will be highly dependent upon project specifics, such as location, project size, mooring
706 configuration, and device type. Spatial conflicts with fisheries may result in decreased catch, increased
707 transit times and fuel consumption, and loss of gear. This could put economic stress on the industry, and
708 may result in reductions in fishing jobs, decreases in jobs that rely on the fishing industry (seafood
709 processors, maritime support, etc.), and impacts to the broader community.

710 BOEM has developed best management practices (BMPs) and avoidance and mitigation measures to
711 foster compatible uses within offshore wind energy areas and decrease conflicts with fishermen. Several
712 best management practices have been developed for the U.S. East coast (Ecology and Environment, Inc.,
713 2014). These include a recommendation for a fisheries communication and outreach plan for
714 communicating between the fishing industry and the project developer. Another recommended BMP is
715 the use of siting considerations to avoid conflict by meeting with local fishing groups to avoid key fishing
716 locations and seasons, maximize fishing access, communicate construction schedules, and discuss cable
717 routing. Safety standards are another BMP, and would include recommendations for marking, radio,
718 lighting, etc. as well as procedures for emergency events. An environmental monitoring BMP includes
719 monitoring procedures and incident reporting requirements. The final recommendation is the
720 consideration of financial assistance to mitigate hardships to fishermen and support continued fishing.
721 Possibilities for monetary support may include financial assistance with gear improvements, port facility
722 updates (e.g., freezers, storage facilities, etc.), fuel subsidies, or enhancing fisheries research (Ecology
723 and Environment, Inc., 2014).

724 A study of several U.S. ocean regions (including the Pacific Northwest), which identified numerous
725 potential conflicts and avoidance and mitigation measures upon which BOEM's BMPs were based,
726 suggested that each local region may desire a tailored set of BMPs and mitigation measures to meet
727 local circumstances. The report identified that commercial fishing stakeholders in the Pacific Northwest
728 strongly preferred conflict avoidance over mitigation, and emphasized the fishermen's desire to be
729 involved in the decision making process (Industrial Economics, Inc., 2012).

730 Other current ocean uses that may potentially conflict with marine renewable energy over direct
731 use of ocean space include recreational activities, research activities, military operations, dredge
732 disposal, archaeological and historical sites, and permanent infrastructure. Recreational boating may
733 need to alter travel and destination patterns and there may be an increased risk to safety. Wave energy
734 technologies which utilize surf waves may directly conflict with established surfing locations. Research
735 activities with repeated sampling transects may also be affected if an energy array is placed along or
736 near transects. Presence of marine renewable energy devices may alter data and disrupt long term
737 baseline monitoring and scientific surveys (Industrial Economics, Inc., 2012).

738 Marine renewable energy devices may also pose a direct space conflict if sited within military
739 practice zones and other frequently used military areas. Other designated areas, including dredge
740 disposal zones and navigation channels, may also experience direct conflict if energy devices are located
741 within or along frequently trafficked areas associated with these zones. Areas with permanent
742 infrastructure, such as seafloor cables, may also be affected by marine renewable energy projects
743 (Industrial Economics, Inc., 2012).

744 Potential direct spatial conflicts with historic, cultural, and archaeological sites are possible if
745 projects are located on or directly near such sites (Industrial Economics, Inc., 2012). Construction,
746 foundations, and moorings may damage historic resources. BOEM and other federal agencies are
747 required under Section 106 of the National Historic Preservation Act to identify and assess impacts to
748 historical resources. BOEM's regulations in 30 CFR 585, specifically regarding renewable energy leases
749 on the outer continental shelf, require a site assessment to identify historic properties. State Historic
750 Preservation Office consultations will also be required if the project occurs in state waters.

751 A space use conflict assessment funded by BOEM identified several potential avoidance and
752 mitigation measures for a variety of uses, including many discussed above. The primary strategies
753 identified for avoiding and mitigating conflict that could apply generally to several user-group conflicts
754 included: spatial conflict avoidance through avoiding high use and high values areas, communication and
755 stakeholder engagement to identify specific conflicts and avoidance/mitigation strategies, coastal and
756 marine spatial planning, spatial analysis to understand areas of high economic and environmental value,
757 and minimizing impacts through project design and construction. Environmental assessments,
758 mitigation funds and subsidies, stock enhancements, research, emergency response plans, and other
759 strategies were also presented (Industrial Economics, Inc., 2012).

760 Viewshed and tourism conflicts

761 Marine renewable energy projects may have varying degrees of visual impact along coastal or ocean
762 viewsheds. How visible a project is will depend on the type of device (which influences the height and
763 size of an array), distance from shore or other highly used ocean areas, and visibility of an area (i.e., fog
764 and haze vs. a clear day). Due to the height and size of wind turbines, offshore wind will likely have the
765 greatest potential impact on a viewshed, followed by wave energy. Within offshore wind structures,
766 floating offshore wind will have the most flexibility to reduce viewshed impacts, as it can be sited
767 farthest from shore. Tidal current energy may have little potential impact on a viewshed because the
768 majority or entirety of the device will be located below the sea surface, with the exception of possible
769 surface platforms or foundations.

770 Viewshed impacts are difficult to estimate. Local residents, tourists, and individuals from marine
771 industries may have different perspectives and tolerances for viewshed alteration by marine renewable
772 energy devices. Communities in Washington (February WCMAC meeting summary), the U.S. East coast,
773 and Europe have expressed concerns related to the potential impact to tourism as a result of an altered
774 viewshed. Evidence to date suggests that offshore wind farms in Europe have had little to no negative
775 impact on tourism, and some European communities saw increases in tourism as people travelled to see
776 operating offshore turbines (as cited in (Musial & Ram, 2010). Studies from Europe also suggest that
777 individuals may become accustomed to the view change over time, exhibiting less resistance to a project
778 once it became operational. The ultimate effects of marine renewable energy projects on tourism will
779 likely be highly site specific and therefore potential impacts are associated with a significant amount of
780 uncertainty (Musial & Ram, 2010).

781 Another concern related to viewshed is the potential impact on property values. No studies were
782 available on offshore wind impacts to property values. U.S. based studies cited in Musial and Ram (2010)
783 on land-based wind farms revealed that properties located within the viewshed of a wind farm had
784 comparable property values to similar properties outside the viewshed. It remains unclear what effect
785 offshore wind farms or other marine energy projects may have on U.S. coastal property values (Musial &
786 Ram, 2010).

787 In addition, particularly pristine or culturally important viewsheds may experience more of an
788 impact from the visual presence of marine renewable energy (Musial & Ram, 2010). Onshore

789 substations and other new or expanded shore-side support infrastructure may also contribute to an
790 altered coastal viewshed.

791 [Use conflicts from physical effects](#)

792 While marine renewable energy devices may directly conflict in space with many ocean uses, there
793 is also the potential for conflicts with users that rely upon ocean energy resources, such as waves for
794 surfers, wind for sailing activities, and coastal zone mixing for water quality. As described within the
795 “Effects on the physical environment” section, energy devices work by extracting energy from the
796 environment, which can reduce the energy within the system. Offshore wind turbines may create a wind
797 wake, which may alter the leeward wind dynamics from an offshore wind farm (Clark et al., 2014). This
798 may impact sailing activities, with likely more impacts the larger the offshore wind array (the more wind
799 energy extraction), although these effects are uncertain. Offshore wind foundations and wave energy
800 devices may also remove energy from waves, which could influence wave behavior (wave height,
801 direction, etc.) (Boehlert et al., 2008; Clark et al., 2014; Copping et al., 2013) and potentially affect surf
802 for surfing and other wave related user activities (Industrial Economics, Inc., 2012).

803 Energy extraction may also influence the surf mixing zone, tidal ranges, oxygen exchange, and water
804 exchange. If these processes were altered, there may be affects to water quality and habitat along the
805 nearshore, particularly for commercial-scale tidal current energy within semi-enclosed water bodies
806 (i.e., estuaries) (Boehlert et al., 2008; Copping et al., 2013; Polagye et al., 2011). This could potentially
807 impact coastal aquaculture and recreational shellfishing, which rely on natural physical processes to
808 maintain water quality and optimal shellfish growing conditions, although it is currently unclear how
809 likely or to what extent the impacts would be.

810 Impacts on water circulation, water quality, wave alterations, and other physical processes are
811 highly uncertain (Clark et al., 2014; Copping et al., 2013; Polagye et al., 2011), and therefore so are the
812 potential impacts to current uses that rely upon physical ocean processes. As mentioned earlier, small-
813 scale and pilot projects in general are anticipated to have no measurable impact on physical processes,
814 and high uncertainty surrounds the potential physical impact of large-scale commercial operations.
815 Models may provide the best opportunity to predict the potential level of impacts (Clark et al., 2014;
816 Copping et al., 2013; Polagye et al., 2011).

817 [Potential conflicts with future uses](#)

818 Marine renewable energy devices may also conflict with potential future and expanded ocean uses.
819 In particular, conflicts may exist between future sand and gravel mining operations, new dredge disposal
820 locations (Industrial Economics, Inc., 2012), and possibly some types of offshore aquaculture (i.e.,
821 current technology for finfish aquaculture). It is unknown at this time what the likelihood of these
822 potential conflicts would be.

823 [Permitting marine renewable energy](#)

824 Marine renewable energy projects require a number of authorizations including licenses, leases,
825 permits, and consultations. These actions are performed by several federal, state, and local agencies,
826 often in coordination. This is a complex process that varies depending on the type of proposed project
827 (offshore wind, tidal, or wave) and location (state, federal, tribal, or marine sanctuary waters). Agencies
828 are working on refining the complex process and interagency interactions for marine renewable energy
829 projects. The following describes the primary federal authorities for authorizing marine renewable
830 energy projects in ocean waters.

831 *Bureau of Ocean and Energy Management (BOEM)*

832 BOEM has the authority to issue leases, easements, and rights of way for all renewable energy
833 development (including offshore wind, wave, and tidal) on the Outer Continental Shelf (OCS). The OCS
834 lies between the State's jurisdiction (3 nautical miles) and the Economic Exclusive Zone (200 nautical
835 miles). BOEM has a flexible process for establishing leases for renewable energy which generally occurs
836 in four phases: planning and analysis, leasing, site assessment, construction and operations (Bureau of
837 Ocean Energy Management, 2014).

838 The Outer Continental Shelf Renewable Energy Program does not give BOEM the authority to issue a
839 lease within the National Marine Sanctuary System (30 CFR 585.204). However, this does not necessarily
840 mean that marine renewable energy projects cannot occur within the OCS of the Olympic Coast National
841 Marine Sanctuary. Other federal agencies, such as the Federal Energy Regulatory Commission (FERC)
842 and U.S. Army Corps of Engineers (Corps), are able to issue authorizations for marine renewable energy
843 projects in Sanctuary waters.

844 BOEM can be the National Environmental Policy Act (NEPA) lead agency for preparing
845 Environmental Impact Statements/Environmental Assessments for proposed projects on the OCS (40
846 CFR Parts 1500-1508; (FERC and U.S. Department of Interior, 2009). This means that, on the OCS,
847 outside of the Marine Sanctuary, BOEM is the lead agency for evaluating and coordinating
848 environmental review to ensure that the lease will not significantly affect the environment. BOEM
849 coordinates with several federal, state, and local authorities, as well as the public, throughout the NEPA
850 process. The NEPA process is completed prior to authorizing any lease, easement, or right of way. BOEM
851 and FERC have agreed to cooperate on the NEPA process for wave and tidal energy projects within the
852 OCS (FERC and U.S. Department of Interior, 2009).

853 *Federal Energy Regulatory Commission (FERC)*

854 FERC is an independent federal agency that regulates the interstate transmission of electricity,
855 natural gas, and oil. FERC is responsible for licensing the construction and operation of hydrokinetic
856 projects (wave and tidal) in state and federal waters. Some types of projects may conduct limited testing
857 without obtaining a FERC license (Federal Power Act, 18 CFR Parts 4 and 5). FERC does not have
858 authority over offshore wind power projects. FERC does have the authority to issue licenses for wave
859 and tidal projects within Marine Sanctuaries (Bureau of Ocean Energy Management, 2012a).

860 FERC is the NEPA lead agency for wave and tidal projects in State waters (0 to 3 nautical miles), and
861 wave and tidal projects within Marine Sanctuaries. FERC and BOEM have an agreement to work together
862 in the NEPA process for wave and tidal projects within the OCS. Environmental analysis during the
863 license phase of the project may be led by FERC with BOEM as a cooperating agency or with FERC and
864 BOEM as co-leads. The two agencies have agreed that FERC will not issue a license in the OCS until
865 BOEM has issued a lease to the applicant (FERC and U.S. Department of Interior, 2009).

866 *U.S. Army Corps of Engineers (Corps)*

867 The Corps is responsible for issuing permits under Section 10 of the Rivers and Harbors Act for any
868 construction that will affect the navigable capacity of any waters of the United States. This includes
869 wind, wave, and tidal projects in state and federal OCS waters. It is possible that a project authorized by
870 FERC may not require a Section 10 permit from the Corps (Federal Power Act, 33 CFR Part 221.1(f)(1)).

871 Under Section 10 authority, the Corps is likely the NEPA lead agency for marine renewable energy
872 projects that do not fall under BOEM or FERC federal authority. An example of this may be any offshore

873 wind projects that are proposed within State waters, or possibly any offshore wind projects proposed
874 within the Marine Sanctuary (since BOEM does not have the authority to offer leases within Marine
875 Sanctuaries, and FERC does not have authority for wind projects). Federal agencies do have the option
876 to choose which agency is the NEPA lead (40 CFR Parts 1500-1508). Therefore it is possible that another
877 federal agency may take the lead when BOEM or FERC does not have authority.

878 The Corps is also responsible for issuing permits under Section 404 of the Clean Water Act for
879 dredge and fill actions in any waters of the United States. This approval may be required to install
880 marine renewable energy structures or devices in the marine environment.

881 Marine Renewable Energy Technical Suitability within the Plan Study Area

882 To support the MSP, PNNL produced a 2013 report, which analyzed potential technical suitability of
883 various offshore wind, wave, and tidal current energy devices within the MSP Study Area. The report
884 included a series of maps, as required by RCW 43.372.040(6)(c), which indicated the relative technical
885 suitability of devices by location⁷. PNNL created these maps by evaluating site suitability using several
886 criteria⁸, which were grouped into three categories: site quality, shore-side support, and grid
887 connection. The analysis evaluated potential technical suitability only⁹, and did not take into account
888 potential conflicts and considerations with current ocean uses (Van Cleve et al., 2013).

889 This section presents the maps and key results in the PNNL report for technical suitability of marine
890 renewable energy with Plan waters. For further details on the analysis methods, results, and maps,
891 please see the original report by Van Cleve et al. (2013).

892 Offshore wind energy suitability

893 Offshore wind energy assessments suggest that Washington has significant wind resources (Lopez et
894 al., 2012; Schwartz et al., 2010). Van Cleve et al. (2013) assessed technical suitability for three offshore
895 wind technology types: monopile (nearshore), tripod and jacket (mid-depth), and floating platform
896 (deepwater). Three maps illustrating potential relative suitable locations for tripod and jacket, monopile,
897 and floating foundation technologies are shown in Maps 42, 43, and 44 respectively.

898 In general, the southern half of the Study Area shows relatively higher areas of suitability than the
899 northern half for all offshore wind foundation types. Areas offshore of Grays Harbor and Cape
900 Disappointment show higher suitability for all three types of offshore wind, and floating offshore wind
901 also shows higher suitability around Cape Flattery (Van Cleve et al., 2013).

902 Wave energy suitability

903 A report by EPRI (2011) estimates that Washington has significant wave resources. Wave energy
904 technical suitability in the MSP Study Area was analyzed by Van Cleve et al. (2013) in four device groups:
905 nearshore, nearshore M3, mid-depth, and deepwater wave. Maps 45, 46, 47, and 48 show the potential
906 suitable locations for deepwater, mid-depth, nearshore, and nearshore M3 wave devices, respectively.

⁷ The suitability score was calculated using attribute scores and weighted models divided by a potential maximum suitability score. The maps summarize relative suitability based on these scores.

⁸ Specific criteria analyzed were energy resource potential, depth, substrate, distance to substation, distance to shore, distance to transmission line, distance to service port/airport, and distance to deepwater port.

⁹ Technical suitability was based off on input from the current marine renewable energy industry. Suitability may change as technologies mature.

907 Similar to site suitability patterns for offshore wind, all wave device groups displayed the highest
908 relative suitability locations mostly in the southern half of the Study Area, particularly offshore from
909 Grays Harbor and Cape Disappointment. High suitability areas were also located offshore from Cape
910 Flattery (Van Cleve et al., 2013).

911 *Tidal current energy suitability*

912 Tidal current energy suitability is limited within the MSP Study Area. The suitability assessment
913 combined all tidal current energy device types to create one tidal energy site suitability map, shown in
914 Map 49. Van Cleve et al. (2013) identified one area at the Mouth of the Columbia River as having the
915 potential for medium to low percent suitability for tidal current energy. All other areas showed no
916 suitability. Van Cleve et al. (2013) did state that in the future potential sites may be discovered in Grays
917 Harbor and Willapa Bay, particularly with new technologies optimized for lower current speeds.

918 *Key results for suitability*

919 PNNL assessed relative technical suitability for marine renewable energy sites based on economic
920 and site feasibility factors; it did not assess suitability based on conflicts with current uses or ecological
921 habitats. Suitability in this analysis is relative, meaning that a site with high suitability may not
922 necessarily be an appropriate site. However, this analysis provides a valuable first look at what areas
923 may be possible based on technical factors. The suitability results show a greater number of areas with
924 higher suitability for renewable energy development in the southern half of the Washington coast than
925 the northern half and many sites are suitable for more than one device type (Maps 42-49). Van Cleve et
926 al. (2013) indicate that the primary driver of this pattern for offshore wind and wave technologies is grid
927 connectivity, i.e. the lack of supporting electrical infrastructure, including transmission lines and
928 substations along the northern mid-section of the coast (Map 50). The authors note that distance to
929 shore support (service ports and deepwater ports) also influences this pattern and that areas most
930 suitable for marine renewable energy development are within 25 miles of the coast. Tidal current
931 energy has limited suitability within the MSP Study Area primarily due to lack of sufficient tidal flows for
932 analyzed devices (Van Cleve et al., 2013).

933

934 *Future Trends and Factors for Marine Renewable Energy*

935 Several drivers and barriers exist for the marine renewable energy industry in Washington State.
936 Significant offshore wind and wave energy resources exist within the MSP Study Area (EPRI, 2011; Lopez
937 et al., 2012; Schwartz et al., 2010), and many areas have high potential technical suitability for wind and
938 wave energy devices (Van Cleve et al., 2013), which could contribute to satisfying Washington State's
939 Renewable Energy Portfolio Standard. Marine renewable energy projects may also stimulate economic
940 development and provide high-paying, stable jobs (Musial & Ram, 2010; Navigant Consulting, Inc.,
941 2013b, 2014).

942 However, the marine renewable energy industry is relatively new, and there are several economic,
943 technological, and logistical barriers to its development (Augustine et al., 2012; Navigant Consulting,
944 Inc., 2014; Van Cleve et al., 2013). Regional and locally specific factors, along with community concerns
945 and high use of Washington's ocean space, add to the barriers for local development of marine
946 renewable energy projects. A sector analysis (Industrial Economics, Inc., 2014) produced specifically for
947 the MSP concluded that the likelihood of marine renewable energy development is limited over the next
948 20 years. There are currently no marine renewable energy projects operating or under development
949 within the MSP Study Area.

950 *Potential within the MSP Study Area*

951 The technical suitability study by PNNL (Van Cleve et al., 2013) and the sector analysis by Industrial
952 Economics, Inc. (2014) provide valuable information specific to the MSP Study Area. As discussed earlier
953 in this chapter, PNNL's suitability analysis revealed a greater number of areas with higher suitability for
954 marine renewable energy development in the southern half of the Study Area compared to the northern
955 half. The primary driver of this pattern is the lack of grid infrastructure and distance to ports along the
956 northern mid-section of the coast (Van Cleve et al., 2013). The presence of the Olympic Coast National
957 Marine Sanctuary (OCNMS) along the northern half of the coast also lowers the likelihood for marine
958 renewable energy projects (Industrial Economics, Inc., 2014), particularly for commercial-scale
959 developments. However, marine renewable energy projects that are owned by a tribe could possibly be
960 permitted within the OCNMS (15 CFR Part 922).

961 While the southern half of the MSP Study Area may be more technically suitable for marine
962 renewable energy development (support and grid infrastructure), this area is also subject to heavy
963 ocean use from marine industries including shipping and non-tribal fisheries. This may be a significant
964 limiting factor for marine renewable energy development in the southern half of the MSP Study Area.

965 Experts have expressed mixed views with regards to commercial and small-scale projects. Some
966 experts feel that small-scale, community based projects may be possible within the MSP Study Area,
967 particularly for tribal or other local communities looking to increase their energy reliability (Industrial
968 Economics, Inc., 2014). However, technology challenges and current high energy costs associated with
969 small-scale projects limit the economic feasibility of local community projects. While commercial-scale
970 projects may reduce the cost of energy, other factors such as limited experience in the U.S., significant
971 initial investments in grid infrastructure and support infrastructure, conflicts with users, and other
972 market factors limit the commercial-scale potential along Washington's Pacific coast over the next 20
973 years (Industrial Economics, Inc., 2014).

974 Of the marine renewable energy resources discussed, offshore wind was reported by Industrial
975 Economics, Inc. (2014) to have the highest likelihood for development within the MSP Study Area over
976 the next 20 years. The primary reason for this assessment was the advanced offshore wind technology,
977 relative to wave and tidal current devices. Locations near Grays Harbor, a deepwater port, may be
978 particularly favorable for offshore wind (Industrial Economics, Inc., 2014). Floating offshore wind is
979 possibly the most likely technology type (A. Weinstein, personal communication, May 15th, 2015).
980 Despite the abundant offshore wind resource, areas with potentially high technical suitability, and
981 relative advanced stages of offshore wind technology development, Industrial Economics, Inc. (2014)
982 reported that offshore wind development is still likely limited along Washington's Pacific coast over the
983 next 20 years.

984 Past project proposals for small-scale community wave projects as well as the wave device testing
985 sites in Oregon exemplify the interest in wave technology within the Pacific Northwest. However, given
986 that the technology is still in its infancy, it is highly unlikely that commercial-scale wave energy projects
987 will be developed within the next 20 years (Industrial Economics, Inc., 2014), with more possibility for
988 small-scale projects, especially for remote communities.

989 Tidal current energy has limited technical suitability within the MSP Study Area (Van Cleve et al.,
990 2013) and the technology is still quite new. Therefore, tidal energy development in the MSP Study Area
991 is highly unlikely within the next 20 years (Industrial Economics, Inc., 2014).

992 *Key Barriers*

993 **Cost**

994 Cost has been identified as a primary barrier to marine renewable energy development in
995 Washington, the U.S., and around the world (Industrial Economics, Inc., 2014; Navigant Consulting, Inc.,
996 2014). Stakeholders are also concerned about how these projects will influence the cost of energy to
997 consumers. In Washington, offshore wind, wave, and tidal current energy are currently not cost
998 competitive with other sources of energy (Industrial Economics, Inc., 2014; Musial & Ram, 2010;
999 Renewable Northwest, 2007). The Pacific Northwest currently has relatively low electricity prices due to
1000 abundance of hydropower dams in the region (Musial & Ram, 2010). In 2013, Washington had the
1001 lowest residential electricity prices in the nation (U.S. Energy Information Administration, 2014).

1002 Many factors influence the life-cycle costs of marine renewable energy such as initial and operating
1003 costs, and cost of capital. (Musial & Ram, 2010; SI Ocean, 2013). Operation and maintenance costs also
1004 represent a significant portion of cost due to the logistics of operating in the marine environment (SI
1005 Ocean, 2013). Other factors that influence the cost of energy include the price of conventional energy
1006 (particularly natural gas), demand for power (i.e., increased demand from decommissioning coal power),
1007 and competition with industries that use similar resources (offshore oil and gas construction and
1008 manufacturing) (Navigant Consulting, Inc., 2014).

1009 Significant investments in technology, transmission infrastructure, and other development factors
1010 are needed within the marine renewable energy sector. Investment risk is also relatively high, due to the
1011 novelty of the industry. Marine renewable energy currently requires incentives to be competitive with
1012 other energy sources, as many utility districts will likely be unwilling to pay higher premium prices. Costs
1013 are expected to decrease over time as technology advances and experience is gained (Augustine et al.,
1014 2012; Industrial Economics, Inc., 2014; Navigant Consulting, Inc., 2013a, 2014).

1015 Ultimately, the cost competitiveness (or current lack thereof) is the primary challenge to U.S. offshore
1016 wind development. U.S. federal and state incentive programs, such as research development grants and
1017 renewable portfolio standards, are currently needed to stimulate the industry (Navigant Consulting, Inc.,
1018 2014). Some stakeholders are concerned about possible energy price increases due to marine renewable
1019 energy development, and are skeptical of investing public dollars for initial investments and accepting
1020 risk with perceived limited local benefit. Local PUDs may be unwilling to pay the premium prices
1021 associated with marine renewable energy development in the near term (Industrial Economics, Inc.,
1022 2014).

1023 **Infrastructure requirements**

1024 Support and transmission infrastructure requirements to support marine renewable energy are
1025 another major barrier (Musial & Ram, 2010; Navigant Consulting, Inc., 2014), particularly for rural
1026 coastal Washington (Industrial Economics, Inc., 2014). All device types (offshore wind, wave, and tidal)
1027 will require existing onshore substations to be updated and adapted to serve as “on-ramps” for energy
1028 integration into the grid (Industrial Economics, Inc., 2014). Current integration of land-based wind
1029 indicates that integration of marine renewable resources is possible.

1030 Support infrastructure will be required to install and service marine renewable energy projects and
1031 these requirements will depend on technology type. Offshore wind requires deepwater ports (channels
1032 deeper than 30 feet) (Van Cleve et al., 2013), as well as large assembly areas, and sufficient offloading
1033 equipment¹⁰ (Musial & Ram, 2010). Washington currently does not have existing facilities to support
1034 offshore wind, yet there are potential locations where infrastructure could be updated (Industrial
1035 Economics, Inc., 2014). Navigant Consulting, Inc. (2014) suggests that public investment in port

¹⁰ Construction and equipment requirements will vary between offshore wind foundation technology types.

1036 infrastructure could significantly support offshore wind development, benefit other water
1037 transportation industries, and decrease long-term costs of renewable energy.

1038 Marine renewable energy will require integration into the electricity grid. It is a variable resource,
1039 energy generation is not constant throughout time, which creates challenges for integration into the
1040 grid. The Northwest electricity industry¹¹ has adapted its grid infrastructure to be able to integrate
1041 approximately 11,500 MWs of land-based wind resources as of 2015 (Northwest PowerPool, 2015),
1042 which indicates the capability to integrate marine renewable energy resources, particularly in light of
1043 greater capacity factors observed for offshore wind than for terrestrial wind (Navigant Consulting, Inc.,
1044 2014; Northwest Power and Conservation Council, 2010).

1045 The majority of the Washington coast is relatively rural and may not be able to absorb additional
1046 quantities of new offshore generated electricity through existing infrastructure, therefore updates to
1047 transmission infrastructure will be required to connect energy generated in the ocean into local PUDs
1048 and the larger transmission grid¹² (Industrial Economics, Inc., 2014). This will add to the initial costs of
1049 marine renewable energy development and will ultimately be reflected in the electricity rate (Navigant
1050 Consulting, Inc., 2013a). Some stakeholders may be skeptical as to whether the investment into these
1051 updates will benefit the local communities and are concerned about the ability of offshore transmission
1052 technology and grid connections to be successful and efficient.

1053 [Regulatory uncertainty](#)

1054 Regulatory uncertainty is a primary barrier for marine renewable energy development in the U.S.
1055 (Navigant Consulting, Inc., 2014). Multiple agencies are involved in the complex permitting process, and
1056 the timeframe, specific authorities and requirements, siting process, and other conditions are
1057 continuously being adjusted as agencies learn about this new ocean use. This creates a lengthy, costly,
1058 and uncertain process for developers. BOEM is currently working to improve their outer continental
1059 shelf leasing process (Bureau of Ocean Energy Management, 2014), and several agencies have entered
1060 into formal agreements with each other to outline authorities, responsibilities, and cooperation
1061 protocols (i.e. (Bureau of Ocean Energy Management, 2012a; Federal Energy Regulatory Commission &
1062 State of Washington, 2009; FERC and U.S. Department of Interior, 2009). As more projects are proposed
1063 and permitted, the regulatory process will likely improve. Also, the MSP may serve to reduce some
1064 uncertainty by providing a framework for permit coordination.

1065 [Conflicts with current uses](#)

1066 Spatial conflict with current ocean uses is another barrier to marine renewable energy in
1067 Washington. As described in the section “Potential human use conflicts”, marine renewable energy may
1068 directly conflict with several key marine industries, such as fishing, recreation, and shipping (Industrial
1069 Economics, Inc., 2012, 2014), which are frequent and important users of the Washington coast (Section
1070 2.4, Section 2.6, and Section 2.7 respectively). This may lead to economic stress and significant impacts
1071 to these industries and the surrounding communities. The potential impacts of displaced ocean space to
1072 these current uses may strongly influence development. Recommendations within the MSP are based
1073 on information about conflicts with ocean users. These recommendations may influence the location,
1074 extent, and process for marine renewable energy development. It is a goal of this Marine Spatial Plan to

¹¹ The Northwest electricity industry includes organization such as BPA, Puget Sound Energy, and other major local, state, and regional utility organizations.

¹² Transmission updates are often necessary for the incorporation of land-based wind energy as well, and have been performed with the expansion of this industry.

1075 protect existing sustainable uses while encouraging economic opportunities that recognize the
1076 aspirations of coastal communities.

1077 **Environmental concerns**

1078 As described in the “Potential environmental impacts” section, there are many possible yet
1079 uncertain effects to the marine environment from marine renewable energy projects. This uncertainty
1080 may affect public perception and influence regulatory review of proposed projects, such as increased
1081 likelihood for additional environmental studies and monitoring requirements. There are also unknown
1082 mitigation requirements and uncertainties around the effectiveness of mitigation measures.
1083 Environmental uncertainty can increase cost and time for developers and increase resistance from
1084 stakeholders and environmental regulatory agencies. Environmental research at field test sites, in
1085 laboratories, and through models are filling in the many data gaps, yet many unknowns will remain until
1086 full-scale projects are deployed and monitored for several years (Bergstrom et al., 2014; Boehlert et al.,
1087 2008; Copping et al., 2013; Navigant Consulting, Inc., 2014; Polagye et al., 2011).

1088

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1 2.10.2 Offshore Aquaculture

2 A potential new use of Washington’s Pacific coastal waters is offshore aquaculture. Aquaculture, the
3 culture or growing of fish, shellfish, or other aquatic plants and animals, has been a part of Washington’s
4 landscape for thousands of years. Current aquaculture activities are important sources of food and
5 livelihood for many Washingtonians, including native peoples.

6 No aquaculture activities are currently taking place outside of the estuaries on Washington’s Pacific
7 coast. The potential expansion of aquaculture activities into ocean waters beyond the estuaries
8 becomes increasingly possible due to technological advancements. The expansion of aquaculture into
9 deeper, offshore waters is driven by the ever increasing demand for high quality protein and the limited
10 space and suitability of coastal waters (Lovatelli, Aguilar-Manjarrez, & Soto, 2013; Rubino, 2008).
11 Whether there is a future for offshore aquaculture will depend upon several factors, including feasibility
12 of locations, technological advancements, economic potential, and compatibility with existing uses.

13 Summary of history and current use

14 Offshore aquaculture

15 There are many different ways to define offshore aquaculture. Some definitions use specific depth,
16 distance, and exposure ranges (Lovatelli et al., 2013), while others use jurisdictional boundaries (e.g.
17 federal waters). For the purposes of the MSP, the term ‘offshore aquaculture’ will be used to describe
18 any new aquaculture operation within the designated Study Area yet outside of the coastal estuaries.
19 Regardless of distance from shore, the exposure of Washington’s Pacific coast to waves, storms, swells,
20 and currents would pose the challenges and require the technologies consistent with offshore
21 aquaculture.

22 Coastal aquaculture

23 Coastal aquaculture is highly prevalent in Washington. Coastal aquaculture along Washington’s
24 Pacific coast can be defined as aquaculture within estuaries, including Willapa Bay and Grays Harbor. As
25 a state, Washington is ranked first by the U.S. Department of Agriculture in sales of aquaculture
26 products. Coastal aquaculture on Washington’s Pacific Coast consists mainly of Pacific oysters
27 (*Crassostrea gigas*) and Manila clams (*Venerupis philippinarum*) (Industrial Economics Inc., 2014). These
28 shellfish are cultured using methods such as bottom culture, longlines, flip bags, and racks. For more
29 information about coastal aquaculture operations on Washington’s Pacific coast, please see Section 2.5
30 Aquaculture in this report as well as the Aquaculture Sector Analysis (Industrial Economics Inc., 2014)
31 and Economic Analysis report (Taylor, Baker, Waters, Wegge, & Wellman, 2015).

32 Coastal aquaculture, in general, has many economic and logistical advantages over offshore
33 aquaculture, including limited exposure to storms, continuous access for operations, and close proximity
34 to facilities (processing, storage, etc.) (Lovatelli et al., 2013). However, the potential for higher water
35 quality and more space for larger operations at offshore sites make offshore aquaculture a future
36 opportunity for the aquaculture industry (Knapp, 2013).

37 Current and emerging offshore technologies

38 Offshore aquaculture is still in its infancy. Operations around the world currently employ a limited
39 number of technologies and techniques at offshore facilities. However, there are examples of successful

40 offshore commercial production facilities as well as prototypes being tested for a variety of aquaculture
41 species (Forster, 2008; Lovatelli et al., 2013).

42 While hundreds of species are currently raised in freshwater, land based, and coastal aquaculture
43 facilities, only a few have the potential to be produced offshore at a commercial scale (Lovatelli et al.,
44 2013). Each species has its own specific husbandry techniques and technology needs. The following
45 sections briefly describe the current and emerging technologies for each of three species categories
46 (finfish, shellfish, and marine plants) to provide context to what offshore aquaculture could look like in
47 the MSP Study Area.

48 *Finfish*

49 Atlantic salmon (*Salmo salar*) have been commercially cultivated in net pens in Puget Sound since
50 the 1970's (Ladenburg & Sturges, 1999), and British Columbia is also home to a major Atlantic salmon
51 aquaculture industry (Fisheries & Ocean Canada, 2013). Atlantic salmon are also successfully cultivated
52 in deep water and weather exposed sites in Norway and Chile (Holmer, 2013). Given the commercial
53 market success of Atlantic salmon (Lovatelli et al., 2013) and the presence of Atlantic salmon cultivation
54 in the Pacific Northwest, Atlantic salmon may be a likely candidate for offshore aquaculture in
55 Washington. A few current and emerging cage designs are suitable for offshore finfish cultivation,
56 utilizing various materials and structural systems. The following is a brief discussion of two main types of
57 cage designs for finfish: surface and submersible cages.

58 *Surface cages*

59 Surface cages, or net pens, have continuous surface exposure and cannot be submerged under the
60 water. These cages often are composed of netting which is flexible and attached to a floating collar at
61 the water's surface. This flexible collar will float and bend to adapt to rough waves (Forster, 2008). The
62 use of floating net cages has been conducted at many exposed and offshore sites, yet there are
63 limitations to their use. Strength and endurance of the cages are limited, and there are issues with
64 volume loss, worker safety, and other operational limitations at exposed offshore sites (Ladenburg &
65 Sturges, 1999). It is anticipated that nearshore net pen technology will continue to evolve and be
66 adapted for offshore operations.

67 There are also rigid platform cages with surface access designed to resist waves through the
68 strength of the structure (Forster, 2013). Another design is to have mobile platforms utilizing a barge or
69 ship system, but this is quite costly and would need to be vast in size (Ladenburg & Sturges, 1999).

70 While surface cages are more exposed to rough sea surface conditions compared to submersible
71 cages, they are highly attractive because there is easy surface access for operations (Ladenburg &
72 Sturges, 1999).

73 *Submersible cages*

74 Submersible and semi-submersible cages are designed so that the surface of the fish cage is
75 submerged for extended periods of time or specifically during rough seas. These designs are intended to
76 minimize exposure to storms. There are several operational designs for submersible cages, some with
77 rigid outer structures and some with nets and a central spar (Ladenburg & Sturges, 1999). The cages are
78 brought to the surface for servicing operations such as harvesting and cleaning. Ocean Spar
79 Technologies, a company based in Washington, has designs for nearshore and offshore submersible
80 finfish culture cages. A Russian cage technology called the Sadco-Shelf Submersible Cage has been
81 located up to 50 miles offshore (Ladenburg & Sturges, 1999).

82 An advantage of a submersible cage design is that it can withstand an increasing range of exposed,
83 rough sea conditions. It has been speculated that as technology for remote monitoring and operations
84 improves, submerged cage methods may dominate offshore aquaculture in the future (Forster, 2008), as
85 long as they are cost effective at commercial scales.

86 *Shellfish*

87 The two main coastal aquaculture shellfish currently grown in Washington are Pacific oysters
88 (*Crassostrea gigas*) and Manila clams (a.k.a. Japanese carpet shell) (*Venerupis philippinarum* also
89 referenced as *Ruditapes philippinarum*). Small amounts of blue mussels (*Mytilus edulis* and other
90 subspecies) and Kumamoto oysters (*Crassostrea sikamea*) have also been cultivated in Grays Harbor and
91 Willapa Bay in recent years (Industrial Economics Inc., 2014).

92 Blue mussels and other mussel species have been tested at offshore sites in the Mediterranean,
93 Atlantic Canada, New Zealand, and northeastern United States of America (Lovatelli et al., 2013).
94 Mussels and scallops are cultured using longlines. Floating submersible longlines are moored to the
95 bottom, and the shellfish are attached to the lines or grown in net bags (Forster, 2008, 2013). Several
96 longline techniques have been adapted to a variety of offshore conditions (Forster, 2013; Lovatelli et al.,
97 2013).

98 The technology is further along for offshore shellfish aquaculture than for finfish aquaculture.
99 Shellfish extract food from the water column, which facilitates the option of growing them in harsh
100 environments. However, shellfish aquaculture is not without challenges. The weight of the shellfish as
101 they grow can influence the appropriate depth of the lines and vertical motion can cause mussel
102 detachment (Lovatelli et al., 2013).

103 *Marine plants*

104 Marine plants dominate the global aquaculture industry by tons produced, but fall beneath both
105 finfish and crustacean aquaculture for unit value (Lovatelli et al., 2013). Offshore seaweed culture is
106 similar to that of shellfish. The seaweeds are attached to submerged longlines with floats that are
107 moored to the bottom. Because of light requirements, however, the surface area required to grow
108 seaweed in the ocean is likely greater than for finfish and shellfish and therefore adds to the challenge
109 of cultivating seaweed offshore (Forster, 2013).

110 *Potential benefits and use compatibilities*

111 *Seafood demand and food security*

112 In 2012, commercial aquaculture contributed half of the world's seafood. The United States imports
113 about 80-90% (by value) of its seafood, and half of that is from international aquaculture (Interagency
114 Working Group on Aquaculture, 2014). Domestic marine aquaculture supplies about 1.5% of American
115 seafood demand (Rubino, 2008). The overall seafood trading deficit in 2012 was about \$11 billion
116 (Interagency Working Group on Aquaculture, 2014).

117 Offshore aquaculture presents an opportunity to expand domestic aquaculture to meet increasing
118 domestic and global seafood demand. The growing world population combined with health expert
119 recommendations for the benefits of seafood consumption will continue to increase demand for
120 seafood, while wild capture fisheries will be unable to meet this rising demand (Rubino, 2008).
121 Aquaculture increases seafood supply and reduces supply uncertainty. An expanded domestic
122 aquaculture industry can provide Americans with healthy, consistent, and affordable seafood products

123 (Interagency Working Group on Aquaculture, 2014; Rubino, 2008). Offshore aquaculture may have a
124 greater potential to meet this demand compared to coastal aquaculture, as limitations on space and
125 high occurrences of competing uses are more pronounced in coastal and estuarine waters (Rubino,
126 2008).

127 *Food health and environmental health*

128 There are many potential advantages to offshore aquaculture in the United States and in
129 Washington's waters. Offshore aquaculture products will be subject to U.S. and Washington State health
130 and environmental regulations and enforcement (just as current coastal aquaculture is), whereas other
131 countries have a wide range of health and environmental regulations and oversight. Offshore
132 aquaculture products grown in the U.S. could help meet the increasing demand by American consumers
133 for access to safe, local, and sustainable seafood products.

134 Offshore aquaculture is usually located in deep waters, generally with well-mixed water and
135 currents which can dilute nutrients and particles generated by finfish. In addition, because they are
136 located further from shore, they will be subjected to reduced exposure to land-based pollutants
137 compared to coastal aquaculture (Holmer, 2013; Knapp, 2008a). The Pacific Northwest coast has clean,
138 naturally productive water, which is advantageous to growing healthy seafood and healthy products for
139 consumers (Langdon, 2008). Offshore sites may also pose a reduced risk of transmitting diseases and
140 parasites to native fish populations, especially if sited away from major migration, feeding, and
141 spawning areas (Holmer, 2013).

142 *Economic impacts*

143 Offshore aquaculture in Washington has the potential to contribute to the local, state, and national
144 economy. Even though offshore aquaculture is trending more toward remotely operated facilities,
145 employees will still be needed for site operations, husbandry, maintenance, monitoring, transportation,
146 and seafood processing. The Pacific Northwest, especially Washington State, has a strong history of
147 coastal aquaculture (Anderson & Forster, 2008; Industrial Economics Inc., 2014), and therefore may be
148 well suited to provide local and regional expertise to offshore operations. Local shellfish and salmonid
149 husbandry knowledge may be advantageous for successful offshore operations (Rust, Langan, &
150 Goudey, 2008). There are also potential opportunities for commercial fishermen to become involved
151 with offshore aquaculture, such as through jobs in navigation utilizing current vessel ownership and
152 knowledge of ocean conditions. For example, the commercial offshore finfish operations in Hawaii and
153 Puerto Rico were started by individuals with commercial fishing backgrounds (Rubino, 2008; Valderrama
154 & Anderson, 2008).

155 The potential economic benefits of offshore aquaculture are not restricted to just the on-site
156 operations. Offshore aquaculture also has the potential to support working waterfronts and other
157 industry-related facilities (Valderrama & Anderson, 2008). Washington's coast has seafood processing
158 and distribution systems in place which may benefit from increases in seafood product. There are also
159 local and regional feed and deep water cage suppliers (Anderson & Forster, 2008; Ladenburg & Sturges,
160 1999). In addition, the West Coast has a strong seafood demand, which adds to a competitive advantage
161 compared to producers in other locations (Anderson & Forster, 2008).

162 The overall impact of upstream and downstream products and services (cage manufacturing,
163 juvenile supply, processing, restaurants, etc.) may be five to ten times larger than the jobs and wages at
164 an offshore facility. This would include local, statewide, and national economic benefits (Knapp, 2008b).
165 With a strong history of aquaculture and commercial fishing as well as existing infrastructure to support

166 aquaculture activities, Washington's coast may be well positioned to realize many potential local and
167 regional economic benefits associated with offshore aquaculture.

168 *Potential use compatibilities*

169 The use of ocean space for offshore aquaculture has the potential to be compatible or have limited
170 conflict with some established and future uses. As mentioned above, the aquaculture industry, as well
171 as existing ports, processing facilities, and other marine infrastructure may benefit from offshore
172 aquaculture along Washington's coast (Anderson & Forster, 2008). Another potential compatible use is
173 the co-location of offshore aquaculture with Marine Protected Areas (MPAs) or other protected
174 sanctuaries. Finfish cages have been documented to act as fish aggregation areas for wild fish seeking
175 either the feed from the operation or refuge from predators (Holmer, 2013; Price & Morris, 2013). Some
176 studies have shown that wild fish presence at finfish cages helps to reduce benthic impacts (Price &
177 Morris, 2013). There may be an opportunity to place these cages in locations already under fishing
178 restrictions (L. E. Buck, 2012), provided there is no significant negative impact to the surrounding
179 habitats or organisms. MPAs and offshore aquaculture may also be conflicting uses, which is discussed
180 further in the Potential Impacts section.

181 A potential compatible use is marine renewable energy. Combining renewable energy structures
182 with mussel and seaweed aquaculture may be feasible (Holmer, 2013), but further exploration and
183 testing is necessary.

184 As offshore aquaculture operations are located further from shore, it is expected that fewer space
185 and use conflicts will occur (Knapp, 2008a). Decreased visual impact from facilities the farther they are
186 located from shore is but one example of this (Ladenburg & Sturges, 1999).

187 *Potential impacts and use conflicts*

188 *Ecological impacts*

189 Many of the environmental concerns associated with marine aquaculture relate to finfish
190 aquaculture specifically, and some impacts are predicted to decline when locating aquaculture at
191 deeper, offshore sites. Water quality impacts such as increased levels of phosphorus, nitrogen, and
192 turbidity are generally not detected at offshore sites (Price & Morris, 2013). In general, water quality
193 impacts have been greatly reduced at coastal finfish aquaculture sites over the past 20 years due to
194 increases in feeding efficiency and food composition. Well-flushed, offshore sites in deep water are
195 expected to have no observable impact to water quality (Price & Morris, 2013).

196 One of the main concerns with finfish aquaculture is the effect of excess food particles and feces
197 accumulating on the seafloor. Changes in benthic chemistry and community composition have been
198 observed beneath and adjacent to coastal finfish cages. However, this effect may be reduced by
199 appropriate siting in well-flushed, erosional areas as well as remediated through following practices.
200 Offshore sites are expected to exhibit lesser changes to the sediment, yet appropriate siting to minimize
201 changes to the sediment is highly recommended (Holmer, 2013; Price & Morris, 2013). Offshore sites
202 should also avoid deep-sea sensitive habitats, as they may take longer to recover (Holmer, 2013). Larger
203 and more numerous aquaculture facilities may also have an impact as there may be a potential for
204 benthic effects from cumulative nutrient loading, especially in poorly flushed areas (Price & Morris,
205 2013).

206 Another topic of concern is the interactions between the aquaculture structures and other marine
207 organisms, such as sharks, pinnipeds, seabirds, and wild fish. Wild fish may aggregate around fish cages

208 and may be attracted by the feed or use the structure for protection from predators. There is little
209 published literature on the interactions between sharks, seabirds, and pinnipeds (Price & Morris, 2013).
210 Fish cages can influence marine mammal behavior and cause injury, stress, or death by entanglement.
211 Pinnipeds can also cause financial losses to the fish facilities through direct predation, or by causing
212 stress and escapement of fish from predator attacks (Price & Morris, 2013).

213 In general, to avoid interactions and predation from pinnipeds and other marine species, experts
214 suggest that finfish cages be sited away from known aggregation areas, migration routes, and haul-out
215 sites. Strong and taut predator exclusion nets will decrease risk to the cultivated fish and to predators.
216 Also, practices such as removing dead fish may reduce the attraction from sharks (Price & Morris, 2013;
217 Sims, 2013). Best management practices for aquaculture facilities such as taut nets and anchor lines,
218 predator resistant cages, and limited underwater lighting is expected to minimize negative interactions
219 with wildlife (Nash, Burbridge, & Volkman, 2005).

220 Chemical contaminants such therapeutants¹, antibiotics, and anti-foulants² are consistently
221 identified as concerns for marine aquaculture, but the use of these products has drastically declined
222 over the past 20 years (Price & Morris, 2013). While the risk from these chemicals is considered to be
223 lower than in the past, further research is recommended on impacts to non-target organisms (Price &
224 Morris, 2013). Heavy metals from cages can also accumulate under cages. Studies show these
225 concentrations to be low and heavy metals are typically bound to the sediment (Price & Morris, 2013).

226 Potential disease and parasite transmission from cultured fish to wild fish is a concern (Holmer,
227 2013; Leonard, Kent, & Banks, 2008). State and federal regulations are in place to prevent novel diseases
228 from entering Washington's waters, as well as prevent disease spread in the event of an outbreak (RCW
229 77.60; RCW 77.115; WAC 220-76; WAC 220-77; 9 CFR 53.10; 9 CFR 71.2; 9 CFR 93.900-906). Offshore
230 sites are also expected to have a reduced risk of transmitting diseases and parasites because of the
231 potential increased distance between the operations and if they are sited away from major wild fish
232 migration routes (Holmer, 2013).

233 *Economic impacts*

234 One of the economic concerns associated with offshore aquaculture is the market effect on wild
235 capture fisheries. Certain aquaculture products will directly compete in the market for wild capture
236 fisheries. This effect has already been seen with global Atlantic salmon coastal aquaculture competing
237 with wild capture salmon fisheries. Increases in Atlantic salmon availability may reduce overall salmon
238 prices, which benefits the consumer, but negatively impacts wild capture salmon fishermen. This impact
239 is expected to be temporary (Knapp, 2008b). It has been hypothesized that cultured Atlantic salmon may
240 create niche markets for wild caught salmon, which may increase demand and create a premium price
241 for wild capture fish (Knapp, 2008b; Valderrama & Anderson, 2008). As seafood becomes more readily
242 available, consumers may be more receptive to seafood and this in itself will increase overall demand.
243 As demand increases, including demand from a growing population, the effects of higher supply from
244 aquaculture will likely be partially offset and, therefore, reduce the decline in fish prices (Knapp, 2008b).

245 Regardless of Washington's participation in offshore aquaculture or aquaculture operations in
246 general, world demand for seafood is increasing. Other countries will likely boost aquaculture
247 production to meet this demand, and the competition with wild capture fishermen will then occur

¹ Therapeutants are medications used to treat parasitic, viral, fungal, and bacterial infections as well as to treat aquaculture facilities (Price & Morris, 2013).

² Anti-foulants are treatments used to control or eliminate the growth of marine organisms on aquaculture cages, ropes, and structures. (Price & Morris, 2013).

248 whether or not cultured seafood is domestic or international. Experts speculate that the specific
249 economic effects of domestic aquaculture on domestic fishermen will be relatively small compared to
250 the larger effects of the growing global aquaculture industry (Knapp, 2008b).

251 *Potential use conflicts*

252 Offshore aquaculture has the potential to conflict with some current and future uses of
253 Washington's ocean. Some concerns related to spatial conflicts include: competition with commercial
254 fisheries, recreational fisheries, recreational activities (boating, aesthetics, etc.), shipping, military uses,
255 cable installation, marine animal migration routes, mining, dredging, and dredge disposal (L. E. Buck,
256 2012; Hildenbrand & Feldner, 2008). The cages, longlines, and moorings create space and safety
257 conflicts for navigation, fishing equipment, and SCUBA diving. An offshore operation in Hawaii has
258 established restrictions on these types of activities within the site (Sims, 2013). Offshore aquaculture
259 may also pose a space conflict with marine renewable energy (Hildenbrand & Feldner, 2008), in the
260 event that aquaculture and energy operations are not compatible. However, offshore aquaculture and
261 marine renewable energy may be compatible due to the potential for these uses to occupy the same
262 spatial footprint by utilizing shared support infrastructure (B. H. Buck, Ebeling, & Michler-Cieluch, 2010).

263 Potential environmental conflicts, which are most often associated with finfish aquaculture, include
264 marine reserves, sensitive habitats, and marine animal migration routes. Potential impacts to benthic
265 communities and possible negative interactions with fish and other marine species may be in conflict
266 with the goals of marine reserves. In addition, mooring lines from cages and longlines may pose a risk of
267 animal entanglement. Interactions of seabirds, pinnipeds, and other marine mammals with offshore
268 aquaculture may pose conflicts, particularly along major migration routes and aggregation sites (Price &
269 Morris, 2013).

270 *Potential along Washington's Pacific Coast*

271 Currently, no offshore aquaculture exists along Washington's Pacific coast. However, there is
272 potential for future offshore aquaculture. Washington currently has coastal shellfish and finfish
273 commercial aquaculture operations, ports and other marine infrastructure, and oceanographic
274 conditions generally favorable to support offshore aquaculture (Anderson & Forster, 2008; Industrial
275 Economics Inc., 2014). The realization of offshore operations, however, largely depends upon economic
276 feasibility as well as available technology for safe and quality aquaculture operations (Forster, 2013;
277 Knapp, 2013). Whether and where offshore aquaculture facilities are located along the Washington
278 coast will depend upon factors including cost-effective technological feasibility, environmental
279 considerations, and social acceptance. Some key factors to consider include:

- 280 • **Depth-** Depth is a limiting factor for where offshore aquaculture can be located. Mooring
281 technology is available up to 100 m (Kapetsky, Aguilar-Manjarrez, & Jenness, 2013) and most
282 sites may be restricted 75 m or shallower due to prohibitive mooring costs (Forster, 2013). On
283 the other hand, deeper water generally indicates fewer environmental impacts. So depending
284 upon the size and intensity of the operation, minimum depth thresholds may be encouraged
285 to minimize environmental conflict (Price & Morris, 2013).
- 286 • **Space Conflicts-** As mentioned above, space conflicts with existing and future uses may occur.
287 Therefore, locating offshore aquaculture at locations that will avoid significant conflict with
288 established users such as commercial fisheries and recreational activities is an important
289 factor to consider.
- 290 • **Conditions suitable to culture a selected species-** The oceanographic and physical conditions
291 of a site must be suitable to successfully culture a commercially profitable species.

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- **Access to ports, processing facilities and markets-** Access to ports and existing marine infrastructure is critical for commercial success. It will be more profitable, and therefore feasible, for offshore aquaculture to build off of existing structure than to create new ports, facilities, and transport to markets. Offshore operations are unlikely to be located more than 25 nautical miles from existing ports (Jin, 2008; Kapetsky et al., 2013).
 - **Proximity to sensitive habitats-** Finfish aquaculture may have an impact to sensitive habitats directly below or down drift of the cages. Therefore, locating these sites to avoid particularly sensitive habitats such as corals or seagrass is an important environmental factor (Holmer, 2013; Price & Morris, 2013). Offshore shellfish or marine plant growing operations should also avoid any shade impact to light sensitive habitats such as seagrass (Holmer, 2013).
 - **Well flushed, erosional sediments (finfish)-** Environmental impacts are expected to be minimal at well sited offshore locations. Siting for offshore finfish aquaculture should be in areas with deep, well flushed waters over erosional sediments to avoid environmental impacts (Price & Morris, 2013).

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A forum was hosted in 2008 by Oregon State University to discuss the potential of offshore aquaculture in the Pacific Northwest. Some of the advantages identified by participants for offshore aquaculture in the Pacific Northwest include optimal water temperatures, suitable substrate for moorings, and naturally productive waters. Other advantages of this region related to services include salmonid hatchery and husbandry experience, local and regional feed and deep water cage suppliers, and existing seafood processing and distribution systems. The forum also referenced the strong seafood market demand in the Pacific Northwest (Anderson & Forster, 2008).

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While it was recognized that there is real potential in Pacific Northwest waters, some challenging factors exist such as the number of stormy days along this coast, competition concerns by the commercial fishing industry, and environmental concerns from the public (Anderson & Forster, 2008). Participants indicated the need for access to cost effective technology (Rust et al., 2008) and a better understanding of potential disease transmission and animal interactions with offshore aquaculture (Leonard et al., 2008).

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The availability of culture technology that can withstand the conditions off the Washington coast at a cost effective price is a main determinant of commercial offshore aquaculture feasibility. Safe and consistent access for workers is also a key factor as well as clear state and federal regulations for offshore operations (L. E. Buck, 2012; Forster, 2013; Rubino, 2008). As technology continues to evolve, materials become more reliable and affordable, coastal sites become limited, and seafood demand increases, the more likely aquaculture will expand into offshore waters (Knapp, 2008a, 2013).

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1 2.10.3 Dredging and Dredge Disposal

2 Dredging and dredge disposal are essential activities that are already ongoing in the MSP Study
3 Area. They are included in this section of the MSP to address the potential for expansion of this use in
4 the future. The MSP provides an opportunity to guide state and federal regulatory authorities on
5 locating future disposal sites to avoid conflict with existing uses and maximize beneficial use of dredged
6 material.

7 Summary of history and current use

8 Dredging is essential for port and harbor access and navigational safety. Navigation channels and
9 harbors naturally fill up with sand and mud over time. Dredging removes this material, which is then
10 disposed of at in-water or on-land locations. Without dredging, navigation channels and harbors can
11 become unsafe for navigation or inaccessible altogether. The commerce brought in through shipping
12 and access to ports and marinas is an important part of the Washington Pacific coast region and
13 statewide economy (Dredged Material Management Program, 2012). Therefore, dredging plays a critical
14 role among the established and expanded uses of Washington's marine waters.

15 Dredging and dredge disposal have had a long history along Washington's Pacific coast. Congress
16 first authorized jetty construction and maintenance dredging for federal navigation channels in Grays
17 Harbor and the Mouth of the Columbia River in the late 1800s. These navigation channels have been
18 deepened over time to accommodate large, deep-water cargo vessels. The U.S. Army Corps of Engineers
19 (Corps) is responsible for maintenance dredging of the navigation channels in Grays Harbor (Map 51)
20 and the Mouth of the Columbia River (Map 52). The navigation channel in Grays Harbor supports the
21 Port of Grays Harbor terminals and facilities. The Mouth of the Columbia River navigation channel
22 supports several ports along the Columbia River.¹

23 Several small ports with harbors and marinas along the MSP Study Area also require dredging to
24 maintain boat access for commercial and recreational fisheries, aquaculture, and other uses. There are
25 four small port facilities within Willapa Bay (Map 53). The Port of Willapa Harbor owns and operates
26 Raymond Port Dock, Bay Center Marina, and Tokeland Marina. The Port of Peninsula operates the
27 marina at Nahcotta. Two tribal-owned facilities also occur within the MSP Study Area, the Quinault
28 Marina in Ocean Shores and the Quileute Marina in La Push (Map 30).

29 The disposal of dredged material is a critical component of dredging activities. Dredged material is
30 disposed of at in-water or upland sites. Disposal of material at in-water sites is generally the
31 economically preferred alternative. Sediment disposed at nearshore sites can provide opportunities to
32 keep the sediment near the coast to replenish beaches. Sediments determined to be unsuitable for in-
33 water disposal, such as sediments from chemically contaminated sites, are disposed of at approved
34 upland locations (Dredged Material Management Office, 2013).

35 The Washington Department of Natural Resources (DNR) manages six in-water disposal sites within
36 the MSP Study Area, four for Grays Harbor (Map 51) and two for Willapa Bay (Map 53). All of these sites
37 are categorized as dispersive, meaning that dredged material will eventually disperse and leave the
38 immediate site as opposed to staying in place. Actively used sites are monitored by the Corps regularly
39 for volume capacity and other parameters (Dredged Material Management Office, 2013).

¹ Ports along the Columbia River are outside of the MSP Study Area.

40 Beneficial use sites are disposal locations where dredge material is deposited for some specific
41 beneficial purpose or reuse of the material², such as erosion mitigation or dune restoration. There are a
42 few beneficial use sites within the MSP Study Area, including two nearshore DNR/Corps managed sites
43 at Grays Harbor and a couple of on-shore beneficial use projects (e.g. Quillayute River and Shoalwater
44 Bay). State and federal regulatory agencies as well as regional sediment management teams such as the
45 Lower Columbia Solutions Group encourage the beneficial use of dredge material over deep water
46 disposal (Dredged Material Management Office, 2013; Oregon Solutions, Cogan Owens Cogan, & Oregon
47 State University Institute of Natural Resources, 2011).

48 Flow lane disposal is an alternative in-water disposal method for approved dredged material. Flow
49 lane disposal sites are located within natural scour channels; allowing the sediment to disperse from the
50 site. This alternative is generally done within the Columbia River and for some dredge disposal in Willapa
51 Bay since 2009 (Dredged Material Management Office, 2013).

52 Three in-water disposal sites are established within or directly adjacent to the Study Area at the
53 Mouth of the Columbia River. Two of these sites, including a deep water site, are managed by the
54 Environmental Protection Agency (EPA) and the other is managed by the Corps and authorized for use
55 through the Washington Department of Ecology (Ecology).

56 The State of Washington recognizes the importance of dredging and properly managed disposal of
57 dredge material. Policy recommendations made by the Washington State Ocean Policy Work Group in
58 Washington's Ocean Action Plan (Office of the Governor, 2006) include: requiring the beneficial use of
59 dredged materials where appropriate to deal with chronic erosion, minimizing impacts to navigation and
60 other marine resources, regional coordination and planning, and using best available science to make
61 decisions.

62 *Grays Harbor*

63 The federal government first authorized navigation improvements to the Grays Harbor navigation
64 channel in 1896. The Corps constructed the North and South Jetties and began dredging activities in the
65 early 1900s. The channel was maintained at -30 feet Mean Lower Low Water (MLLW) until it was
66 deepened to -36 feet MLLW in 1990 (U.S. Army Corps of Engineers, 1982, 2014b). The Corps continues
67 to be responsible for annual navigation channel maintenance in Grays Harbor. Although the channel is
68 currently maintained at -36 feet MLLW, it is legislatively authorized to a depth of -38 feet MLLW (U.S.
69 Army Corps of Engineers, 2014b). In October 2016, dredging began to deepen the navigation channel to
70 -38 feet MLLW and is expected to be completed in late 2018 (see Future Trends and Factors for
71 Dredging and Dredge Disposal).

72 The Corps uses six sites for disposal of the Grays Harbor navigation channel maintenance dredging
73 material (Map 47). Four of these sites are DNR in-water disposal sites. The Point Chehalis open water
74 dispersal site is the most heavily used site for dredge disposal (U.S. Army Corps of Engineers, 2014b).
75 This 229.6 acre site is greater than 50 feet deep, located north of Point Chehalis and includes part of the
76 navigation channel. The second DNR authorized open water dispersal site is the South Jetty site. This site
77 is 55.1 acres and about 50 feet deep, located directly north the South Jetty's western portion (Dredged
78 Material Management Office, 2013). Material dredged from the inner harbor is generally placed here.
79 Material is diverted to the Point Chehalis site when the South Jetty site reaches capacity (U.S. Army
80 Corps of Engineers, 2014b).

² There are upland beneficial uses of dredged material, but these are not discussed within the MSP as they are not related to the MSP Study Area.

81 Two nearshore beneficial use sites are managed by the DNR and the Corps in Grays Harbor. The
82 South Beach beneficial site receives sediment from the Bar Channel navigation segment in an attempt to
83 slow erosion along South Beach and the south side of the South Jetty. Material is generally placed at -35
84 to -45 feet MLLW. The second nearshore beneficial use site is the Half Moon Bay site (Map 47). The
85 purpose of this site is to maintain a stable beach profile in the high-energy conditions of Half Moon Bay
86 (U.S. Army Corps of Engineers, 2014b).

87 The fifth in-water disposal site is the 3.9 Mile Southwest Ocean site managed by the EPA (Map 47).
88 This offshore deep-water site is used very infrequently and is currently listed as inactive in the 2013
89 Dredge Material Management Program (DMMP) user manual (Dredged Material Management Office,
90 2013).

91 The sixth site is the Point Chehalis revetment extension mitigation site, which is an upland shore site
92 just above Mean Higher High Water (MHHW) managed by the Corps. Dredged material is placed to
93 cover the Point Chehalis revetment extension and is predicted to erode over time to contribute
94 sediment to the local nearshore system (U.S. Army Corps of Engineers, 2014b). Periodically, sediment
95 has been excavated from this site to nourish the dune along Half Moon Bay and South Beach shorelines
96 to address the risk of a breach at the South Jetty (U.S. Army Corps of Engineers, 2014b).

97 The Port is responsible for dredging the terminals and marina boat basin. The terminals are
98 currently dredged every year using a contractor. The dredge material is disposed at the Point Chehalis or
99 South Jetty DNR disposal sites. The Westport Marina was last dredged during its expansion in 1980. The
100 Port is planning to dredge the boat basin in 2016 utilizing a hydraulic suction pipeline dredge and will
101 dispose the material at the Point Chehalis WDNR site (M. Horton, personal communication, October 22,
102 2104). The Corps is also planning on dredging the two federally authorized entrance channels into
103 Westport Marina in 2016. The material will be disposed at the current Grays Harbor DNR managed in-
104 water disposal sites (U.S. Army Corps of Engineers, personal communication, September 29, 2014)

105 *Mouth of Columbia River*

106 Congress first authorized the federal navigation channel at the Mouth of the Columbia River (MCR)
107 in 1884. The Corps maintains three jetties to stabilize the navigation channel. The navigation channel is
108 maintained at -55 feet MLLW on the north side and -48 feet MLLW on the south side of the channel. The
109 bar at the Mouth of the Columbia River is considered to be the second most dangerous bar crossing in
110 the world. The jetties and surrounding areas are subject to frequent and intense storms, and chronic
111 erosion of the area has occurred since completion of jetty construction in 1939 (Oregon Solutions et al.,
112 2011).

113 The Corps dredges approximately four million cubic yards of sand every year. This material is
114 disposed of at four in-water disposal sites nearby. Two are nearshore sites within Washington waters,
115 which include the Shallow Water Ocean Disposal Site managed by the EPA located two miles offshore
116 from the MCR, and the North Jetty Site (a Corps designated site) located about 200 feet south of the
117 North Jetty. An EPA managed Deep Water Site is located about six miles offshore from the MCR. About
118 one third of the dredged material from the MCR was disposed at the Deep Water Site between 2005
119 and 2011 (Oregon Solutions et al., 2011; U.S. Army Corps of Engineers, 2014a). Material is placed at the
120 Deep Water Site when the other sites have reached capacity or when weather conditions or operational
121 constraints preclude the use of the nearshore sites. Dredged material disposed at the Deep Water Site is
122 effectively removed from the nearshore and, therefore, is considered an unsustainable use of sand
123 material in an eroding system (Oregon Solutions et al., 2011).

124 Concerns for long-term erosion of the MCR jetties, spits, and nearby beaches prompted a 2011
125 Regional Sediment Management Plan (RSMP) that proposed an expanded network of nearshore disposal
126 sites. The Lower Columbia Solutions Group (LCSG), a bi-state collaboration of public and private parties,
127 drafted the plan. Proposed locations included sites on the Washington and Oregon Pacific coasts
128 (Oregon Solutions et al., 2011). While the MCR navigation channel dredging and current dredge disposal
129 sites are outside of the MSP Study Area, the 2011 RSMP identified two locations within the Study Area
130 as potential sites to be a part of an expanded sediment management network (Oregon Solutions et al.,
131 2011).

132 To date, on-shore placement at Benson Beach is the only 2011 RSMP proposed beneficial use site
133 within the MSP Study Area to receive dredge material from the MCR. Benson Beach is located directly
134 north of the North Jetty (Map 52). The 2011 RSMP recommended Benson Beach because this location
135 was expected to have the greatest benefits for beach and drift restoration in the area. A demonstration
136 project placed approximately 400,000 cubic yards of dredged material from the MCR onto the Benson
137 Beach intertidal area in 2010. Funding for the project came from the State of Washington (\$1.69 million)
138 and the Corps (\$1.8 million) (Oregon Solutions et al., 2011). Disposal at Benson Beach has not occurred
139 since the 2010 demonstration project. Costs and safety concerns are barriers to the future use of this
140 site.

141 *Shoalwater Bay project*

142 The Shoalwater Bay Shoreline Erosion Protection project utilizes dredging for a purpose other than
143 navigation. The Shoalwater Bay Indian Reservation has important subtidal and tidal lands for the tribe's
144 shellfish harvesting within North Cove in northern Willapa Bay. The tribe also has important
145 infrastructure on a narrow strip of reservation land along the coast in this area. A natural dune system
146 on Graveyard and Empire Spits historically protected North Cove from flooding and storm events. Due to
147 changes in adjacent shoreline geomorphology, the dunes are no longer accreting sand and are now
148 eroding. The dune system was breached and the Shoalwater Reservation flooded from storm and tidal
149 events in 1999, 2006, and 2007 (U.S. Army Corps of Engineers, 2009).

150 To protect the Shoalwater Bay Indian Reservation land, shellfish habitat, and adjacent areas from
151 future flood damage, the Corps funded a project to rebuild the protective dune system. This involved
152 dredging just north of the Willapa Channel offshore from North Cove using a large pipeline dredge. The
153 dredged material was placed on the dune system to add height and close the breach areas. The plan
154 called for about 600,000 cubic yards of material during construction to be placed on a total of 47 acres.
155 According to the project plan, maintenance of this project is expected to occur about every five years by
156 removing about 250,000 cubic yards of material dredged just offshore in the Willapa Bay channel and
157 adding to the dune (U.S. Army Corps of Engineers, 2009). The project began in 2012, took two years to
158 complete construction, and is currently being monitored.

159 *Small port dredging and disposal along the Washington coast*

160 Small ports are a vital part to ocean activities and prosperity of the Washington coast. Small ports
161 contribute hundreds of millions of dollars annually to the economy (Pacific County Economic
162 Development Council, 2013). The maintenance dredging of small harbors is an economic and political
163 issue, and to a great degree influenced by federal funding and decisions. It is not within the scope or
164 power of the MSP to address federal funding for small harbors. However, context for small port funding,
165 as well as descriptions of WA's small coastal ports within and directly adjacent to the Study Area is
166 provided recognizing their importance to the coast and for their influence on dredging and dredge
167 disposal activities.

168 **Federal funding for small ports**

169 For the past several years small coastal harbors have had to compete directly with larger coastal
170 ports across the nation for federal funding. This has resulted in variable and uncertain funding for small
171 port dredging (U.S. Army Corps of Engineers, personal communication, September, 2014). Dredging
172 operations are expensive as costs include not only the dredge equipment and operation (G. Glenn,
173 personal communication, October 22, 2014), but there are additional costs for sediment testing, fees for
174 in-water dredge disposal at DNR sites (WAC 332-30-166), as well as costs for upland disposal. This can
175 create a significant challenge for small ports to secure adequate funding for maintaining access channels
176 to their harbors (R. Chaffee, personal communication, October 1, 2014).

177 Small ports face consequences when harbor entrance channel maintenance dredging is delayed or
178 discontinued. In some small harbors, up to 100% of harbor activities have been reported to be dredge
179 dependent. Significant consequences such as the relocation or closure of businesses, loss of jobs, and
180 impacts to fisheries and recreation industries are expected if dredging for small harbors was to cease or
181 be delayed (Pacific County Economic Development Council, 2013).

182 Appropriated funds for federal navigation projects are filled by the Harbor Maintenance Trust Fund.
183 All coastal ports compete for funding from this pool of revenue. However, small (low-use) ports have the
184 challenge of competing against high- and moderate-use ports for funding. The Water Resources Reform
185 and Development Act of 2014 included new provisions for small harbors, which may lead to a certain
186 portion of the overall Harbor Maintenance Trust Fund being allocated to small harbors. In 2014,
187 Congress appropriated funds to finance navigation channel dredging for small ports across the country,
188 including some of the small ports within and adjacent to the Study Area for 2014 (U.S. Army Corps of
189 Engineers, personal communication, September, 2014).

190 Additional discussion of ports and marinas can be found in Section 2.4 Commercial, Recreational,
191 and Tribal Fisheries and Section 2.7 Marine Transportation, Navigation, and Infrastructure.

192 **Port of Willapa Harbor**

193 Formed in 1928, the Port of Willapa Harbor developed port facilities for shipping lumber and other
194 forest products as well as fishing and oyster vessels. The Port owns and operates three water access
195 facilities within Willapa Bay that require various frequencies of dredging for navigation maintenance:
196 Tokeland Marina, Bay Center Marina, and the Raymond Port Dock (Map 53). Currently, the Port facilities
197 support the timber industry, commercial and recreational fishing, oyster harvesting, tourism, retail,
198 offices, and other industrial services (“Port of Willapa Harbor,” n.d.).

199 The Corps historically dredged a federal navigation channel and harbor entrance channels in Willapa
200 Bay, first authorized in 1892, and worked with the Port to keep the Port facilities dredged for shipping
201 and boat access. The Corps activities included the main channel which dredged the bar at the mouth of
202 Willapa Bay and continued to the Willapa River, as well as a few connection channels to harbors within
203 the Bay. In 1975 the Corps discontinued the dredging of the main channel over the bar at the mouth of
204 the Bay to the Willapa River due to funding restrictions. Since then, commercial ocean vessels have not
205 been able to access the ports of Willapa Bay. The Corps continued to dredge the entrance channels
206 connecting the marinas to the naturally deep channel of Willapa Bay until the early 2000s (Ott, 2011).

207 The Port of Willapa Harbor secured a grant and loan to purchase a small hydraulic suction dredge in
208 2009. They have used this dredge to maintain the boat basin at Tokeland Marina, as well as the entrance
209 channel which connects Tokeland to the deepwater channel. Recent dredging at Tokeland and the
210 associated entrance channel has taken place in the 2010, 2011, and 2012 seasons. The learning curve of
211 operating their own dredge required three seasons of operations to initially dredge the marina, but their

212 long term plan is to dredge once about every four years. The most recent dredging activity at Tokeland
213 was in the 2014-15 season (R. Chaffee, personal communication, October 1, 2014).

214 The Bay Center boat basin is located within the federally authorized channel at the Palix River in
215 Willapa Bay (R. Chaffee, personal communication, October 1, 2014). Bay Center was last dredged by the
216 Corps in 2002 (Coast & Harbor Engineering, 2011). Dredging at Bay Center using the Port's dredge
217 occurred in the 2013-14 season, and the Port anticipates that it will be dredged approximately every
218 four years (R. Chaffee, personal communication, October 1, 2014). The Port is also looking into dredging
219 at the Raymond Port Dock. Funding for dredging comes from the Port of Willapa Harbor budget. The
220 Port is planning to work with local partners to utilize the Port's dredge at city, Port, and private docks
221 throughout Willapa Bay (Coast & Harbor Engineering, 2011; R. Chaffee, personal communication,
222 October 1, 2014).

223 When the Corps was actively dredging in Willapa Bay, two DNR in-water sites were used: Cape
224 Shoalwater and Goose Point (Map 53) (Coast & Harbor Engineering, 2011). Both of these sites are open-
225 water dispersive sites (Dredged Material Management Office, 2013). In addition, an upland disposal site
226 at Tokeland was historically utilized, but this site has reached capacity (R. Chaffee, personal
227 communication, October 1, 2014). The Port now uses flow lanes to dispose of dredged material from the
228 boat basins and entrance channels. The flow lanes are directly adjacent to the project areas, located in
229 deep water with natural scour and sediment transport. The use of flow lanes is beneficial to the Port
230 because transport of material to the DNR sites is either infeasible or impractical for the small dredging
231 equipment (Coast & Harbor Engineering, 2011), and flow lanes are much more cost effective than
232 upland disposal (R. Chaffee, personal communication, October 1, 2014).

233 Work has been started by the Port to identify flow lanes near other city, Port, and private water-
234 dependent facilities throughout Willapa Bay for future maintenance dredging operations (Coast &
235 Harbor Engineering, 2011). The only recent funding from the Corps has been for sediment
236 characterization of potential dredge locations throughout the Bay (R. Chaffee, personal communication,
237 October 1, 2014).

238 [Port of Peninsula](#)

239 The Port of Peninsula owns a commercial facility in Nahcotta, WA located on the Willapa Bay side of
240 the Long Beach Peninsula (Map 53). The Port of Peninsula shares a similar history with the Port of
241 Willapa Harbor in regards to Corps support for dredging. Dredging of the Willapa Bay bar and main
242 channel was discontinued in 1975 and the Corps suspended dredging of the Ports' entrance channels in
243 the early 2000s due to budget constraints (R. Chaffee, personal communication, October 1, 2014). The
244 Port of Peninsula was last dredged in 2005. Historically, the Corps has disposed of dredged material at
245 the Goose Point open water DNR site or at an upland location at Nahcotta.

246 An analysis for suitability of a future flow lane disposal site near the Port has been conducted (Coast
247 & Harbor Engineering, 2011). Due to the increased significance of the shellfish and fish landings at the
248 port, the Port of Peninsula hopes to work with the Corps on future dredging needs. The Port or Corps
249 may work with the Port of Willapa Harbor or the Port of Ilwaco to utilize their small dredges for future
250 maintenance dredging operations at Nahcotta (Cook, 2012; M. Delong, personal communication,
251 October 8, 2014).

252 [Quinault Marina](#)

253 The Quinault Tribe owns the marina at Ocean Shores, WA near the north side of the mouth of Grays
254 Harbor. The marina is currently closed due to needed dredging and infrastructure repairs, although
255 some small vessels still use it (J. Schumacker, personal communication, November 11, 2016).

256 Quileute Harbor Marina

257 The Quileute Tribe owns a harbor in La Push, WA located in the northern section of Washington's
258 Pacific Coast at the mouth of the Quillayute River (Map 54). The Quileute Port Authority works with the
259 Corps for maintenance dredging of the navigation channel and harbor. The channel and harbor are
260 generally dredged by the Corps about every two years. The most recent dredging activity was in 2011
261 and 2014. The source of federal funding for dredging is similar to that of other small ports (U.S. Army
262 Corps of Engineers, personal communication, September, 26, 2014).

263 Dredged material is disposed at a couple of locations. The dredge material from the outer channel is
264 placed at an upland location and the material from the inner channel and harbor is placed on the ocean
265 side of Rialto Beach Spit for beneficial use (U.S. Army Corps of Engineers, personal communication,
266 September, 26, 2014) and occasionally near the jetty near First Beach for jetty maintenance and
267 protection.

268 Significant ports outside of the Marine Spatial Plan Study Area

269 The Port of Ilwaco, Port of Chinook, and Port of Neah Bay are located outside of the MSP Study
270 Area, yet provide critical services to important uses within the Study Area and contribute significantly to
271 coastal economy. Each of these ports rely on dredging to maintain their activities and services to
272 support the local and regional communities of Washington's Pacific coast. However, because the
273 dredging and dredge disposal for these ports do not occur within the MSP Study Area they are not
274 discussed further here. Each of these ports is included in Section 2.7 Marine Transportation, Navigation,
275 and Infrastructure.

276 Related infrastructure

277 *Dredging and dredge disposal methods and equipment*

278 Material is dredged from navigation channels and harbors utilizing dredge equipment such as a
279 hydraulic suction or clamshell dredge. The material is then stored either in hopper dredges or on barges,
280 which can transport the sediment to disposal sites (U.S. Army Corps of Engineers, 2014b). Smaller
281 dredges have a limited transport distance (Coast & Harbor Engineering, 2011). A number of methods
282 can be used to release dredge material into a disposal site such as bottom-dump, dispersed spraying,
283 and pump ashore.

284 Bottom-dump disposal

285 Barges and hopper dredges have designs for releasing the dredged material from the hull, otherwise
286 known as bottom-dump. Bottom-dump barges and hopper dredges release the material within the
287 boundaries of the in-water disposal sites. This method of disposal can be performed at open-water and
288 nearshore beneficial use sites. However, safely navigating these large vessels at the shallow beneficial
289 use sites can be a challenge (Oregon Solutions et al., 2011; U.S. Army Corps of Engineers, 2014b).

290 The bottom-dump disposal method at shallow, beneficial use sites can cause mounding of the
291 material, which can result in significant wave amplification. Mound height is influenced by vessel speed,
292 water depth, and discharge technique (open or partially open bottom doors). Thin-layer dispersal (also
293 referred to as enhanced dumping) through the bottom-dump disposal method can be achieved by
294 moving the vessel during disposal, thereby reducing the mounding of sediment on the seafloor. Safety
295 considerations generally require that the hopper dredge start at the closest point to the shore and travel
296 away from the shore perpendicularly into the waves (U.S. Army Corps of Engineers, 2012a). The Lower

297 Columbia Solutions Group recommended thin-layer dispersal of no more than 12 cm mound depth at
298 the MCR proposed nearshore shallow sites (Oregon Solutions et al., 2011).

299 Pump-ashore disposal

300 Pump-ashore disposal is the placement of material directly onshore. This is achieved by mixing the
301 sediment with water to create a slurry and hydraulically pumping the slurry through a pipeline to the
302 onshore site (U.S. Army Corps of Engineers, 2014b). While pump-ashore disposal has many benefits,
303 including replenishing eroding beaches, protecting jetties, and avoiding in-water mounding and
304 associated wave-amplification, there are significant operational and financial challenges compared to
305 traditional (bottom-dump) disposal approaches (Oregon Solutions et al., 2011).

306 Dispersed spraying of reliquified sand (rainbow spray)

307 Dispersed spraying of reliquified sand, also known as rainbow spray or pump-off disposal, is a
308 method which mixes the dredged sediment from a hopper dredge with water to create a slurry. The
309 slurry is then sprayed over a disposal area. This method has been recognized by the LCSG to minimize
310 the mounded layer of sediment at nearshore disposal sites, thereby reducing the risk to benthic species
311 and navigational safety. However, the time it takes to dispose of dredged material through this method
312 is significantly longer than a traditional bottom-dump approach, and is therefore much more costly.
313 There is also limited dredge equipment capable of this spray disposal method. Therefore the practical
314 use of reliquified sand is limited (Oregon Solutions et al., 2011).

315 Jetties

316 River outlets along the WA coast often consist of areas with very shallow, shifting sands. Before
317 manmade alterations to Grays Harbor and the MCR there was no defined channel suitable for safe,
318 consistent navigation. Jetties were built to focus a defined, deep water channel for navigation access at
319 the Mouth of Grays Harbor and the MCR. The MCR has three jetties (north, south, and jetty "A") and
320 Grays Harbor has two (north and south).

321 Jetties are hard structures, built on shallow shoals and extend like fingers out into the water. Jetties
322 work by forcing the water flow between them, thereby restricting the entrance for the water. Because
323 of these narrowed zones, the constricted water flow flushes out the shallow sand bars. This induced,
324 deeper channel increases suitability for navigation. Maintenance requirements include repairing the
325 jetties over time if they become damaged from storms or erosion as well as dredging of any shoals that
326 may form despite the presence of the jetties.

327 Jetties at the MCR and the Mouth of Grays Harbor have impacted sediment movement along the
328 WA coast. It can be difficult to determine the exact magnitude of these changes, simply because little
329 was known about the geomorphology of this area before the jetties were constructed. However, it is
330 clear that the presence of some of these jetties has facilitated coastal land accretion, which now
331 supports infrastructure, such as the City of Ocean Shores. Therefore, jetty maintenance is not only
332 critical for navigation, but also to communities that rely on the jetty's physical alteration of coastal
333 landforms (G. Kaminsky, personal communication, September 10, 2014).

334 Groins look similar to jetty structures, but serve a different function. Groins are structures
335 perpendicular to the shore that are intended to affect sediment migration along the shore. They
336 improve sediment retention in some areas along the coast, but can increase erosion in other areas.
337 Unlike jetties, they are not intended to focus water flow for a navigation channel. Other structures such
338 as revetments and wave diffraction structures can be associated with jetties and harbors, and essentially
339 serve to protect these areas from waves, storm damage, and erosion.

340 [Beneficial use disposal sites](#)

341 Beneficial use of dredged material is the placement of material at a site for a specific benefit
342 (Dredged Material Management Office, 2013). Uses for beneficial placement can be broad, such as
343 placement for erosion control, dune reconstruction, beach nourishment, and other productive purposes.
344 Disposal of dredged material at offshore, deep water disposal sites, such as the EPA-designated Deep
345 Water Ocean Disposal Site at the MCR, effectively removes the sediment from the nearshore system.
346 This removal of natural sediment from a system can “starve” coastal beaches and nearshore areas of
347 sand, reduce protection from erosion, coastal storms and flooding, and impact marine habitat (Oregon
348 Solutions et al., 2011).

349 Nearshore and onshore beneficial use sites are intended to keep the sediment within the nearshore
350 system. For larger projects, such as Grays Harbor and MCR, a network of sites is used to optimize the
351 opportunities for beneficial placement of material, and minimize the use of deep-water sites. Beneficial
352 sites are typically chosen with the goal to maximize benefits to beach erosion protection, habitat
353 improvements, and jetty protection while also minimizing the conflicts to users of the area; all the while
354 remaining cost effective (Oregon Solutions et al., 2011; U.S. Army Corps of Engineers, 2012b, 2014b).
355 Dredging projects may also use beneficial placement for dune enhancement or other local projects (e.g.
356 Shoalwater Bay) (U.S. Army Corps of Engineers, 2009). Beneficial placement in support of beach habitat
357 and to mitigate beach erosion may also positively influence recreational users (U.S. Army Corps of
358 Engineers, 2012a).

359 Depending upon the location and disposal methods, placement of material at beneficial use sites
360 can be more time consuming, require additional equipment, experience timing constraints, have safety
361 and logistical considerations, and have higher costs. Site capacity, weather, and user conflicts also create
362 additional challenges to nearshore and onshore beneficial placement compared to deep water
363 placement. User conflicts for nearshore beneficial use sites include wave amplification due to mounded
364 material in shallow water and concerns related to impacts on Dungeness crab (Oregon Solutions et al.,
365 2011; U.S. Army Corps of Engineers, 2014b)(see Human use conflicts with disposal).

366 Onshore beneficial use sites, such as material placed at Benson Beach, have added benefits of
367 avoiding user conflicts for navigation and minimizing potential impacts to Dungeness crab and the
368 fishery. Onshore projects, however, are typically estimated to have higher costs and time requirements
369 and different equipment needs than nearshore projects, creating additional challenges for the
370 consistent and effective use of onshore sites (Oregon Solutions et al., 2011; U.S. Army Corps of
371 Engineers, 2012a).

372 [Disposal site capacity and sediment dispersal](#)

373 Dredge disposal sites utilized by the Corps are actively monitored and managed for capacity. Open
374 water sites are designed to be dispersive, meaning that the sediment placed there will disperse over
375 time, ideally allowing for the continued long-term use of the site for annual dredge disposal (U.S. Army
376 Corps of Engineers, 2014a). The amount of dredged material that can be placed in an open water
377 placement site is limited by the site’s capacity to accumulate and disperse the material without
378 adversely affecting the environment or navigation. Capacity is assessed through a number of
379 parameters, including historical baseline data, wave models, and present conditions. The natural
380 environment (waves, storms, etc.) can influence the dispersion rates on short term and long-term scales
381 as well as be variable within site boundaries (U.S. Army Corps of Engineers, 2014a).

382 [Flow lane disposal](#)

383 Flow lane disposal is the spreading of dredge materials in deepwater locations with natural scour.
384 Sediment disposed in flow lanes is dispersed and is intended to have no measurable impact to
385 bathymetry or the environment (Coast & Harbor Engineering, 2011). Therefore, issues related to
386 sediment mounding are typically not a concern for flow lane sites. Considerations for flow lane sites
387 include depth, bathymetry, flow velocity data, bottom sediment characteristics, and volumes of dredge
388 to be disposed (Coast & Harbor Engineering, 2011). Along the Pacific coast of WA, flow lanes are used
389 for projects with relatively small volumes of dredged material, such as harbor and entrance channel
390 dredging in Willapa Bay and port entrance channel dredging in the Columbia River (Dredged Material
391 Management Office, 2013; R. Chaffee, personal communication, October 1, 2014; U.S. Army Corps of
392 Engineers, personal communication, September, 2014).

393 Impacts from dredge disposal

394 Environmental impacts from dredge disposal

395 The study of dredge disposal impacts to ocean habitat and species has a long history on the
396 Washington coast. The Lower Columbia Solutions Group (LCSG) has compiled over a decade of research
397 and findings from policy workshops related to environmental disposal concerns in the Mouth of the
398 Columbia River region. Their key findings presented in the Mouth of the Columbia River Regional
399 Sediment Management Plan (Oregon Solutions et al., 2011) are summarized below. Additional
400 environmental details from other Washington Pacific coast dredge disposal sites are included when
401 available.

402 Dungeness crab

403 Dungeness crab (*Metacarcinus magister*) is the species of primary concern from both biological and
404 economic perspectives (Oregon Solutions et al., 2011). The Dungeness crab fishery is a well-established
405 fishery that contributes tens of millions of dollars annually to Washington's coastal economy (Industrial
406 Economics Inc., 2014). Heavy use by the Dungeness fishing fleet occurs in the southern portion of the
407 MSP Study Area, in water depths generally less than 150 feet near the MCR region. The MCR is also
408 important breeding and nursery habitat for Dungeness crab (Oregon Solutions et al., 2011).

409 Nearshore placement of dredge material is expected to contribute to the local nearshore system at
410 the MCR when placed 65 feet deep or less. The LCSG recommended placing dredge material nearshore
411 and onshore for beneficial use to maintain the sediment budget and control erosion. Because nearshore
412 areas at the MCR are heavily used by Dungeness crab and crab fishermen, fishermen and others have
413 concerns related to the effect that nearshore dredge disposal may have on the crab populations in these
414 areas (Oregon Solutions et al., 2011).

415 Highlighted concerns within the 2011 MCR Regional Sediment Management Plan (RSMP) include:
416 direct burial, loss of refuge for immature crab, loss of stable mature food supply for 'Harvest Ready'
417 crab, fragmentation of fishing grounds, and any large reductions in production over time (Oregon
418 Solutions et al., 2011). Laboratory studies have been conducted to determine mortality by direct burial
419 of crabs by disposed material. The 2011 RSMP described the results of a laboratory study where younger
420 crabs (age 2) had a higher mortality (47% female; 20% male) than older crabs (age 3; nearly 0%). The
421 2011 RSMP indicated that laboratory experiments can be difficult to extrapolate to the field, and it is
422 expected that crab survival will be higher due to effects from surge currents and variations in sediment
423 deposition rates (Oregon Solutions et al., 2011).

424 Operational considerations for minimizing impacts to Dungeness crabs include thin-layer sediment
425 dispersal methods, and avoiding areas with large aggregations or migration routes. Commercial size and

426 breeding adults are of the most concern, so the 2011 RSMP recommended that crab population
427 monitoring efforts at potential disposal sites focus on these age groups (Oregon Solutions et al., 2011).

428 The LCSG acknowledged limitations to the currently available data as well as incomplete scientific
429 data on crab, but felt that there is enough information to recommend proceeding with the identified
430 disposal activities within the RSMP (Oregon Solutions et al., 2011). Benthic video surveys are being
431 conducted in the proposed North Head Site region to observe the presence of Dungeness crab and other
432 benthic and epibenthic organisms. In addition, there are ongoing studies to monitor Dungeness crab
433 mortality and behavior during disposal events at a nearshore beneficial use site on the Oregon side of
434 the MCR. These studies include video surveys of crab in response to disposal events, monitoring the
435 deposition of the dredge material, and acoustic tagging of crab to track crab survivability and behavioral
436 response. This information will be used to ground truth laboratory tests on the effects of dredge
437 disposal on Dungeness crab, and will inform disposal methods and future locations, including the
438 proposed North Head Site (U.S. Army Corps of Engineers, personal communication, September, 25,
439 2014).

440 The concerns and discussions surrounding Dungeness crab in the 2011 RSMP were focused around
441 the proposed nearshore sites and no specific mention was made in relation to the proposed onshore
442 sites (Oregon Solutions et al., 2011). In a 2012 Environment Assessment by the Corps for the Benson
443 Beach site, Dungeness crab were not listed as a concern for Benson Beach onshore dredge disposal
444 placement (U.S. Army Corps of Engineers, 2012a).

445 In regards to Grays Harbor, the Corps implements mitigation measures to avoid placement of
446 dredge material in areas with high concentrations of crabs and to avoid interference with the crab
447 fishery. The Corps follows the 1998 Revised Crab Mitigation Strategy Agreement uses best management
448 practices to avoid, minimize, and mitigate impacts to crab (U.S. Army Corps of Engineers, 2014b).

449 **Razor clams and other benthic species**

450 Within the LCSG, some participants raised concerns on the effects of Razor clams (*Siliqua patula*)
451 from dredge disposal. Concerns were related to subtidal razor clams because of their limited ability to
452 move horizontally (Oregon Solutions et al., 2011). A study by Vavrinec, Kohn, Hall, & Romano (2007)
453 testing adult razor clam mortality with dredge material burial showed 100% razor clam survival in
454 sediment burial up to 12 cm (~4.7 inches). This study also indicated that limiting disposal to 12 cm every
455 24 hours would minimize the impacts to razor clams (Vavrinec et al., 2007). A 2009 science and policy
456 workshop reported that intertidal razor clams on eroding beaches may benefit from onshore dredge
457 disposal that provides additional sand for habitat (Oregon Solutions et al., 2011).

458 The LCSG mentioned some concern within the RSMP for a little known clam species
459 *Tresuspajaroana*, as there is a potential occurrence of this clam in the proposed MCR nearshore disposal
460 sites (Oregon Solutions et al., 2011).

461 Science and policy workshops summarized by the LCSG in the 2011 report indicated that because
462 benthic species distributions are patchy and variable, sediment disposal would likely have a minor effect
463 on benthic species. They did emphasize, however, that sediment should be similar in size to the
464 naturally occurring sediment to minimize impacts (Oregon Solutions et al., 2011).

465 The Corps reports that effects from disposal impacts on benthic species such as polychaetes,
466 mollusks, and enchinoderms is temporary and therefore of low concern for current disposal activities
467 because of the invertebrates' ability to rapidly recolonize. The Corps expects the expansion in disposal
468 material volume due to deepening of the Grays Harbor channel to have a minor additional impact (U.S.
469 Army Corps of Engineers, 2014b).

470 The Corps indicated that there may be some impact to slow and immobile benthic organisms at Half
471 Moon Bay beach and South Beach sites during sand placement for addressing a South Jetty breach risk.
472 The Corps, however, does not expect impacts to razor clams or Dungeness crab due to low abundances
473 in this area and the location of material placement in the high intertidal zone (U.S. Army Corps of
474 Engineers, 2012b).

475 *Marine fish, birds, and mammals*

476 Not much is known about the behavioral or direct effects of sediment disposal on Washington
477 migratory fish species such as juvenile salmon and green sturgeon. The LCSG (Oregon Solutions et al.,
478 2011) anticipated that the potential impacts to these species are likely low, as these species can move
479 away from the affected area. The 2011 RSMP recommends monitoring for salmon, as well as other
480 species such as flatfish and bottom fish. Due to the variability of these populations in specific areas,
481 dredge disposal effects may be difficult to determine. Effects on fish from turbidity in the MCR areas are
482 not expected to be significant because the grain size of the disposal material is similar to the natural
483 sediment material (Oregon Solutions et al., 2011).

484 The 2011 RSMP indicated that direct impacts to marine bird species, such as the ESA listed marbled
485 murrelet, or other bird species such as the common murre, cormorants, and others are expected to be
486 limited and not significant. The main concern stems from losses of prey in the foraging grounds. Dune
487 dependent species such as the ESA listed snowy plover and streaked-horned lark may benefit from
488 nearshore disposal placement in the MCR region (Oregon Solutions et al., 2011).

489 Not much is known or anticipated with regards to potential impacts of dredge disposal on marine
490 mammals. The RSMP anticipated a low potential impact to marine mammals from dredge disposal at
491 MCR locations, and simply recommended that disposal activities be timed to avoid gray whale
492 migrations (Oregon Solutions et al., 2011).

493 *Human use conflicts with disposal*

494 *Dungeness crab fishery*

495 The uncertainty surrounding the effects of dredge disposal on Dungeness crab in shallow water
496 has driven concerns about dredge disposal in areas heavily used by crab fishermen. Representatives
497 within the Dungeness crab fishing industry have voiced strong concerns about the potential effects of
498 dredge disposal from the MCR at the proposed North Head site. While the Lower Columbia Solutions
499 Group identified the North Head site as a beneficial use area (Oregon Solutions et al., 2011), the disposal
500 site has not been established due to concerns from representatives from the Dungeness crab industry
501 (R. Mraz, personal communication, September 10, 2014; U.S. Army Corps of Engineers, personal
502 communication, September 25, 2014).

503 The Lower Columbia Solutions Group Regional Sediment Management Plan identified Dungeness
504 crab research and monitoring as a key priority (Oregon Solutions et al., 2011). As described in the
505 Environmental Impacts section, there are several ongoing studies related to monitoring Dungeness crab
506 responses to dredge disposal. The Corps will use these results to better understand what impacts
507 disposal operations have on Dungeness crab in the ocean (U.S. Army Corps of Engineers, personal
508 communication, September 25, 2014).

509 The Regional Sediment Management Plan for the MCR also included recommended management
510 practices for reducing the risk to Dungeness crab such as: dispersing materials with a low percentage of
511 fine sediment; dispersing sediment that is highly compatible with native sediment; avoiding “hot spots”
512 of very high aggregations of crabs; and using thin layer dispersal practices and minimizing multiple

513 applications over short periods of time. The LCSG encourages the use of an adaptive management plan
514 that utilizes baseline and ongoing crab monitoring data to inform disposal in the MCR network of sites
515 (Oregon Solutions et al., 2011).

516 Concerns over the impacts of dredging and dredge disposal on Dungeness crab have also influenced
517 management decisions in Grays Harbor. The Corps utilizes mitigation measures to avoid disposal in
518 areas with high concentrations of crab and to avoid interference with the crab fishery. To help
519 determine which disposal site is used, the Corps conducts pre-disposal crab surveys at the two beneficial
520 use sites South Beach and Half Moon Bay, and considers the presence of crab pots in the South Beach
521 area (U.S. Army Corps of Engineers, 2014b).

522 [Navigational safety](#)

523 Dredge disposal has the potential to influence wave height due to mounding of the dispersed
524 material, which can have effects on navigation safety (Oregon Solutions et al., 2011). Wave amplification
525 has occurred historically at MCR sites, and navigational safety is a key priority in disposal site capacity
526 management. The joint EPA/Corps Site Management and Monitoring Plan for the Lower Columbia
527 dredging and disposal activities requires the avoidance of dredge material mounding that could cause
528 excessive wave amplification. Results from science/policy workshops summarized in the MCR Regional
529 Management Plan recommended that a maximum threshold of 10% wave amplification resulting from
530 mounded disposed material over baseline conditions should not be exceeded (Oregon Solutions et al.,
531 2011).

532 The EPA and the Corps, through the Site Management and Monitoring Plan and Annual Use Plans,
533 requires bathymetry and disposal location monitoring and reporting for managing disposal activities.
534 The Corps coordinates their Annual Use Plan with state agencies and the public, and notifies key crab
535 fisherman who routinely fish in the disposal sites two weeks in advance of dredge disposal work (Oregon
536 Solutions et al., 2011).

537 To address navigational safety at an expanded network of disposal sites (current and proposed
538 disposal sites) for the MCR, the Regional Sediment Management Plan (Oregon Solutions et al., 2011)
539 outlined a research and monitoring program that includes the following five strategies:

- 540 1. pre- and post-disposal bathymetric surveys,
- 541 2. assessing whether mound induced wave amplification has exceeded a maximum threshold
542 of 10% over baseline conditions, including the use of wave models,
- 543 3. utilizing thin layer dispersal and/or respraying of reliquified sand disposal methods,
- 544 4. monitoring of shoaling in the MCR navigation channel, and
- 545 5. ongoing wind and wave modeling and monitoring.

546 These recommendations were created to facilitate the use of nearshore beneficial use sites, such as
547 the proposed North Head site, while limiting the risk to navigational safety (Oregon Solutions et al.,
548 2011). The 2011 RSMP stated that there was general agreement that onshore placement of dredge
549 materials would avoid mounding and wave amplification. No navigational safety concerns were
550 mentioned in the literature specific to onshore beneficial placement or flow lane disposal.

551 [Recreation and Tourism](#)

552 The 2012 Environmental Assessment produced by the Corps for the onshore Benson Beach site did
553 indicate that there may be temporary impacts to recreational uses of Cape Disappointment State Park
554 during dredge disposal activities. The construction site will likely include a number of restrictions and
555 park users may be negatively impacted by construction noise. During this time, recreational activity may

556 be reduced and there may be an impact on tourism income to nearby communities. The Corps does
557 state that this impact would be temporary and also indicates that recreation and tourism would benefit
558 in the long-term by reducing long-term erosion impacts (U.S. Army Corps of Engineers, 2012a).

559 Permitting requirements

560 The management of dredge disposal is important for human and environmental health and safety in
561 Washington's waters. Between 2000 and 2012, 21.2 million cubic yards of dredged material were
562 disposed at the Grays Harbor and Willapa Bay disposal sites (Dredged Material Management Program,
563 2012), and about 48.6 million cubic yards of dredged material were disposed at the MCR sites (U.S. Army
564 Corps of Engineers, 2014a).

565 State and federal agencies work together to evaluate and manage dredge material disposal. Disposal
566 sites in Washington waters are designated by one of three agencies: the EPA, Corps, or WDNR. The
567 specific process for disposal permits and authorizations varies slightly depending on which agency
568 designated the site and who the project proponent is (Corps or private entity). However, environmental
569 review for water quality, physical effects, and species consultations are always performed, regardless of
570 the disposal project.

571 To help coordinate the various agencies involved in managing, permitting, and authorizing disposal
572 sites, two interagency teams have been developed in Washington to evaluate sediment suitability for in-
573 water disposal and help streamline disposal regulations. The Washington Dredged Material
574 Management Program (DMMP) includes experts from the Corps, U.S. Environmental Protection Agency
575 (EPA), Ecology, and DNR and reviews dredge projects within the Corps Seattle District (Dredged Material
576 Management Office, 2013). The Portland Sediment Evaluation team, which is similar to the DMMP,
577 evaluates and coordinates sites at the MCR (L. Inouye, personal communication, October 9, 2014). These
578 teams require sediment evaluation which generally includes a site history analysis, and possibly
579 chemical and biological testing of the material to be dredged. Sediment evaluation requirements must
580 be met prior to obtaining any permits (Dredged Material Management Office, 2013).

581 Regardless of who designates the disposal site, dredging and disposal operations require approval
582 from various federal, state, and local authorities. The federal permits include Rivers and Harbors Act
583 Section 10 permits and Water Quality Act Section 404 permits issued through the Corps. An Endangered
584 Species Act Section 7 consultation with the NOAA National Marine Fisheries Service and possibly the
585 U.S. Fish and Wildlife Service is also required. For dredge disposal from maintenance dredging activities
586 performed by the Corps, such as for the Grays Harbor navigation channel and MCR, the Corps does not
587 issue itself permits, but public notices, federal consultations, and all state requirements are complied
588 with (Dredged Material Management Office, 2013).

589 Several state agencies play a regulatory and policy role in dredge disposal. In addition to
590 participating on the DMMP and the Portland Sediment Evaluation Team, Ecology issues a 401 Water
591 Quality Certification, a Coastal Zone Management Act consistency determination, and reviews any
592 relevant local permits that may apply under the local Shoreline Master Program (SMP). The Washington
593 Department of Fish and Wildlife (WDFW) may require a Hydraulic Permit Approval. The WDNR requires
594 project proponents to obtain a disposal site use authorization prior to disposal, if utilizing a WDNR
595 authorized site. Local governments, through their local SMP, may require a Shoreline Substantial
596 Development Permit, Exemption Letter, or a Conditional Use Permit (Dredged Material Management
597 Office, 2013; Office of the Governor, 2006).

598 Once all appropriate permits and authorizations are issued, the Corps requires submission of a
599 dredging and disposal quality assurance plan. The Corps may hold a pre-dredge conference with the

600 applicant and other regulatory agencies to review the final disposal plans (Dredged Material
601 Management Office, 2013). For the Corps' dredging operations at the MCR, Ecology and the EPA require
602 the Corps to submit their Annual Use Plan prior to disposal (L. Randall, personal communication,
603 October 14, 2014). Regulatory agencies must issue all required permits and authorizations before
604 dredging and disposal begins (Dredged Material Management Office, 2013).

605 Flow lane disposal permitting is slightly different from other disposal methods. Ecology does require
606 401 Water Quality certifications for flow lanes. Other required permits depend upon whether or not it is
607 a Corps project or a port/private operation (L. Randall, personal communication, October, 14, 2014). In
608 either circumstance, project-specific analysis is mandatory for flow lane disposal and agencies must
609 approve of this alternative under the NEPA/SEPA process (Dredged Material Management Office, 2013).
610 Consultation with the DMMP or Portland Sediment Evaluation Team is also required, and may include a
611 turbidity simulation for the flow lane disposal (Dredged Material Management Office, 2013). Project
612 proponents can be responsible for monitoring for increases in turbidity outside of an established mixing
613 zone (R. Chaffee, personal communication, October 1, 2014).

614 Dredge disposal on tribal land also has a tribal authority nexus. In the MSP Study Area, the Corps
615 works with the Quileute Tribe for dredging and disposal in the Quilleyute River at La Push. The tribe
616 issues a yearly permit to the Corps to authorize disposal locations (Quileute Tribe, 2014).

617 [Water quality standards](#)

618 Water quality for public health and environmental protection is a strong concern within
619 Washington. In-water disposal of dredged material must adhere to federal and state water quality
620 standards. These water quality parameters include dissolved oxygen, turbidity, and contaminants [WAC-
621 173-201(A)]. The DMMP and Portland Sediment Evaluation Team also have specific standards related to
622 testing for contaminated dredge material. In-water sediment disposal may also be required to meet the
623 Washington State Sediment Management Standards (Dredged Material Management Office, 2013).

624 [Site selection](#)

625 Selecting and managing disposal sites is a complex process with many human use and
626 environmental considerations. As described above, several agencies are involved in designating and
627 managing disposal sites, and each agency has its own authority and considerations. For example, DNR
628 uses a number of environmental considerations when selecting and authorizing disposal sites, such as
629 avoiding unique habitats, utilizing sites with similar substrate to that being disposed, protecting known
630 fish nursery, migration, and harvest areas, and protecting aquaculture installations [WAC 332-30-166].
631 Despite differences in agency authority and mandates, human use and environmental concerns are
632 often addressed, although occasionally through different mechanisms depending upon the relevant
633 authorities.

634 [Future trends](#)

635 [Grays Harbor](#)

636 The Port of Grays Harbor requested that the Corps deepen the navigation channel from -36 feet
637 MLLW to the legislatively authorized depth of -38 feet MLLW. This is because the current depth of -36
638 feet MLLW narrows the tidal window for deep-draft vessels to call to port. As a result, vessels are often
639 partially loaded or experience tidal delays (U.S. Army Corps of Engineers, 2014b). In 2015, the Corps
640 approved construction, and construction began in October 2016. It is not the intention of the MSP to

641 address deepening activities in the Grays Harbor navigation channel. However, the MSP may play a role
642 in any suggested changes to dredge disposal sites within the Study Area.

643 To accommodate the additional amount of dredged material from the 2 foot deepening of the Grays
644 Harbor channel, the Corps proposes a one-time 1,000 foot north-northwestern shift in the Point
645 Chehalis open-water disposal site. Dredged material from the initial deepening activities would be
646 placed within the shifted disposal site. This proposed one-time shift is intended to take advantage of
647 deeper water and more favorable hydrodynamics for the additional capacity needed during the channel
648 deepening construction year. About 1,972,000 additional dredged cubic yards is estimated for the initial
649 channel deepening, resulting in about 4,062,000 cubic yards of total dredged material for the
650 construction year. Dredge material from subsequent annual maintenance dredging would be placed in
651 the currently designated Point Chehalis DNR DMMP in-water site (U.S. Army Corps of Engineers, 2014b).

652 The DNR is also considering shifting the South Jetty disposal site slightly north in order to keep it
653 within the scour channel (C. Barton, personal communication, October 27, 2014).

654 Another potential small change in dredge disposal locations within the Grays Harbor area is related
655 to the actions to control erosion and reduced the risk of a breach at the east end of the South Jetty
656 between South Beach (Pacific Ocean) and Half Moon Bay. A breach first occurred during a winter storm
657 at this location in 1993. Since then, the Corps has maintained a land connection between the shoreline
658 and the South Jetty by placing sand on the dune between Half Moon Bay and South beach. This sand
659 placement is performed whenever certain threshold criteria are triggered. The Corps monitors this area,
660 and when it is determined that sand must be added to avoid a breach, the material is taken either from
661 the Point Chehalis revetment extension mitigation site (U.S. Army Corps of Engineers, 2012b) or sand is
662 purchased for the addition (U.S. Army Corps of Engineers, personal communication, September 29,
663 2014).

664 In 2012, the Corps proposed a long-term management plan to address the ongoing risk of a breach
665 at the South Jetty. This included building a modified diffraction structure at the eastern terminus to the
666 South Jetty and continuing to place sand on the dune area between Half Moon Bay and South Beach
667 similar to the current activities performed by the Corps. If this proposed alternative moves forward, the
668 location of dredge disposal will change slightly within the Half Moon Bay and South Beach location
669 relative to current activities (U.S. Army Corps of Engineers, 2012b). The proposed long-term
670 management strategy for the South Jetty is still under review.

671 *Mouth of Columbia River*

672 In the draft 2011 Regional Sediment Management Plan for the Mouth of the Columbia River, the
673 LCSG identified two nearshore beneficial use sites for dredge disposal that are within the Washington
674 MSP Study Area (Oregon Solutions et al., 2011). The first, Benson Beach, was used in 2010 as an onshore
675 demonstration project (Map 52) (see Summary of History and Current Uses: Mouth of Columbia River).
676 Benson Beach is currently permitted by Ecology for use by the Corps for dredge disposal, yet it has not
677 been used since the 2010 demonstration project. Onshore placement of dredge material requires
678 additional equipment, logistics, and time compared to traditional bottom-dump disposal methods.
679 These considerations increase the cost of disposal (Oregon Solutions et al., 2011). Safety concerns for
680 the dredge operators were also raised during the 2010 demonstration.

681 The Corps operates under a least cost alternative policy. Because of the increased cost associated
682 with onshore placement, an outside source must provide the incremental increased cost incurred for
683 using the Benson Beach site (U.S. Army Corps of Engineers, 2012a). The State of Washington provided
684 \$1.69 million in addition to the Corps \$1.8 million for the 2010 demonstration project (Oregon Solutions

685 et al., 2011). The future use of Benson Beach as an on-shore beneficial disposal site is dependent upon
686 additional funding (U.S. Army Corps of Engineers, 2012a).

687 The second site, named the North Head Nearshore Site, is a nearshore subtidal site located generally
688 north of the North Jetty and off of North Head in Cape Disappointment State Park. This 2011 RSM
689 identified this site for the potential to minimize erosion at Benson Beach and Peacock Spit and to
690 contribute to beach accretion (Oregon Solutions et al., 2011). The Dungeness crab fishery historically
691 avoided this area and initially identified it as a potentially acceptable beneficial dredge disposal site.
692 However, the crabbing fleet now uses the North Head nearshore area frequently. Therefore, concerns
693 on the effects to the Dungeness crab fishery and navigational safety from disposal material mounding
694 has led to strong opposition from some for the use of this site for dredge disposal (U.S. Army Corps of
695 Engineers, personal communication, September 25, 2014; R. Mraz, personal communication, September
696 10, 2014) (See Human use conflicts and Environmental impacts sections). Several studies are currently
697 being conducted in the North Head nearshore area.

698 In the event the Corps decides to pursue adding a North Head site to the sediment management
699 network of disposal sites at the MCR, the site would need to go through a designation and permitting
700 process. The site would be designated for use either by the Corps through their Section 404 authority, or
701 the EPA. As a part of the permitting process, the lead agency would conduct a NEPA process including
702 environmental studies and consultations with NOAA National Marine Fisheries Service. The Corps would
703 then apply for an Ecology 401 Water Quality Certification. After thorough review, Ecology may authorize
704 the use of this site by issuing a 401 certification and a Coastal Zone Management Act consistency
705 determination (L. Randall, personal communication, October 14, 2014).

706 *Small Ports*

707 Small ports are likely to continue to use a mix of flow lanes, small scale beneficial use sites, and DNR
708 authorized sites for dredge material disposal and no significant alterations are anticipated. Expanded
709 activities include the possible addition of a few flow lanes within Willapa Bay (R. Chaffee, personal
710 communication, October 1, 2014).

711 With regards to future trends in funding, it is difficult to predict what the future federal funding will
712 be for small ports within the Study Area. The 2014 Water Resources Reform and Development Act may
713 result in a certain portion of the Harbors Maintenance Trust Fund to be allocated toward small ports,
714 although it could be a few years before this is implemented (U.S. Army Corps of Engineers, personal
715 communication, September, 2014). It is very likely that small ports will continue to seek federal funds to
716 keep their ports open and accessible due to their economic and social importance to the coastal
717 communities of Washington.

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790

2.10.4 Marine Product Extraction

A potential new use of Washington's Pacific coast is the extraction of marine organisms for commercial industries¹ such as cosmetic, pharmaceutical, and biomedical research.

Summary of history and current use

Marine product extraction is the practice of harvesting marine plants and animals to develop non-food related goods. Examples of products derived from marine organisms around the world include anti-viral, anti-cancer, and anti-tumor agents used in medical treatments, an anti-inflammatory agent used in a cosmetic skin cream, chemicals used in biomedical and cell biology research, and fatty amino acids in nutritional supplements (Arrieta, Arnaud-Haond, & Duarte, 2010; Baerga-Ortiz, 2009; Bruckner, 2002; Pomponi, 1999).

Researchers, universities, government agencies, and private companies use marine bioprospecting to search for compounds that can be used for human health and well-being products (Bruckner, 2002). Marine bioprospecting methods for compound identification include SCUBA diving, manned submersible vehicles, remotely operated vehicles, and collection of organisms from intertidal areas (Arrieta et al., 2010; Pomponi, 1999).

Once a potential compound has been identified, it must go through a series of product testing and clinical trials before it can be released on the market. Identifying compounds, testing them, performing clinical trials, and selling products commercially requires various quantities of the target organism. Often compounds discovered within marine organisms are only available in small amounts per organism. Therefore, it may require harvesting vast amounts to get the required quantity for testing and market availability. Alternatives to mass wild harvesting are the use of aquaculture or the use of biotechnology to synthesize the newly discovered compounds in a lab (Arrieta et al., 2010; Pomponi, 1999).

For each newly discovered product, the potential intensity of harvest from natural populations in the ocean will depend upon the demand for the target product as well as the ability to replicate it in the lab or through aquaculture. In the case of DNA sequence discovery, a onetime extraction may be all that is needed, as DNR replication techniques can be used in the lab. For natural products, however, additional and perhaps extensive collections may be required (Arrieta et al., 2010). Methods for supplying natural products are influenced by the availability and reproductive biology of the host organism, the quantity of the target compound per biomass unit, the complexity of the biosynthetic pathway, and suitable environmental conditions for biochemical synthesis (Pomponi, 1999).

Several target products discovered in marine organisms have been successfully synthesized using biotechnology. However, many of these processes are quite complex and may not be cost effective for industrial scale production (Baerga-Ortiz, 2009; Pomponi, 1999). There is ongoing research to increase the understanding of biosynthetic pathways to sustainably and cost effectively supply marine extracted chemicals for pharmaceutical treatments (Baerga-Ortiz, 2009).

Land-based and in-the-sea aquaculture has also been used to grow host organisms. For example, the mangrove sea squirt, *Ecteinascidia turbinata*, from which an anti-tumor compound has been successfully isolated, has been cultured on a commercial scale (Arrieta et al., 2010; Pomponi, 1999). A deep-water sponge in New Zealand (*Lissodendoryx* sp.), identified for another anti-tumor compound, has been successfully cultured in shallow water while maintaining the anti-tumor compound. This indicates the

¹ Marine product extraction, as discussed here, does not include any extraction or harvest performed by the tribes.

41 potential for shallow-water culture of deep-water sponges. However, other target compounds from
42 deep-water host organisms may require the specific pressure, temperature, and other deep-water
43 conditions to form, so the use of aquaculture to supply target compounds from deep-water organisms
44 may be limited (Pomponi, 1999).

45 Wild harvest of marine organisms to meet the quantity demands for clinical testing and commercial
46 supply may not be sustainable for many organisms. Monitoring and evaluation of harvest impacts can
47 help determine the sustainability of wild collection, before large scale harvest commences. For example,
48 a feasibility survey found that the New Zealand deep-water sponge could only sustain small quantities of
49 harvest, despite rapid recovery from extraction by dredging (Arrieta et al., 2010). Sustainable harvest of
50 marine organisms for marine product extraction is, however, possible for some species. A Gorgonian
51 coral in the Bahamas harvested for an anti-inflammatory compound used in a cosmetic skin cream has
52 been harvested for over 15 years by utilizing a sustainable harvest management plan (Arrieta et al.,
53 2010; Bruckner, 2002). Sustainability remains a key issue for marine product extraction (Arrieta et al.,
54 2010; Bruckner, 2002; Pomponi, 1999).

55 Potential use compatibilities

56 Marine Protected Areas (MPAs) and marine product extraction have the potential to be compatible
57 uses. MPAs have been recognized as a way to protect marine genetic reserves and be sources for future
58 discoveries (Arrieta et al., 2010). The ecological impact from the initial phase of marine bioprospecting is
59 likely to be minimal, due to the limited amount of harvest required to identify a compound or perform
60 DNA sequencing. It is the potential for more intense harvest for clinical trials and commercial supply that
61 sparks concerns over the sustainability and habitat impacts of marine product extraction. Conservation
62 measures are recommended for the sustainability of marine product extraction (Arrieta et al., 2010;
63 Bruckner, 2002). Possible measures include harvesting feasibility studies (Pomponi, 1999), monitoring
64 (Bruckner, 2002), sustainable collection methods, and export regulations (Arrieta et al., 2010).

65 Potential use conflicts

66 No information was found on conflicting uses, with the exception of potential environmental
67 conflicts in cases of unsustainable or habitat altering harvest practices (Arrieta et al., 2010; Bruckner,
68 2002; Pomponi, 1999). Spatial conflicts with other uses are difficult to forecast because extraction may
69 be very temporary (initial bioprospecting) or a continued, large scale commercial harvest. Even in
70 circumstances where a sustained harvest were to occur, it is difficult to generalize the conflicts as it
71 would depend upon the organism harvested, the method, intensity, and frequency of harvest, and other
72 factors.

73 Permitting marine product extraction

74 The Washington Department of Fish and Wildlife (WDFW) has the permitting authority for scientific
75 exploration and harvesting of marine organisms, including plants and animals. State regulations require
76 a scientific collection permit for collection of organisms for research or education (WAC 220-20-045).
77 This permit would likely apply to researchers or universities engaging in bioprospecting (discovery and
78 sampling) of marine organisms.

79 The harvest of marine organisms for commercial activity (selling the organism) must also be
80 permitted through WDFW. Extracting marine organisms to sell to processors, research labs, etc, would
81 fall under a harvesting permit. If there is no established commercial fishery for the target organism, the
82 WDFW director could establish an emerging commercial fishery, which would include a permit process.
83 This would be either a trial fishery or an experimental fishery permit (M. Culver, personal

84 communication, November 10, 2014). Trial fisheries, by statute, cannot be limited; experimental
85 fisheries are limited and require WDFW to convene an advisory board with representatives from the
86 fishing industry to make recommendations to the WDFW director for fishery management (RCW
87 77.80.160). Within five years, the WDFW director would submit a report to the WA senate and house
88 with recommendations relating to the establishment of a permanent commercial fishery license, fee,
89 and/or limited harvest program (RCW 77.70.180).

90 WDFW has the authority to regulate harvest in both the state and federal waters off of WA's coast
91 and to permit the transport and/or sale of organisms harvested in state or federal waters into WA.
92 States have the authority to manage the harvest of marine organisms in federal waters in the absence of
93 a federal management plan for the target species (Magnuson-Stevens Act of 2006). If there was an
94 interest for marine product extraction in federal waters off the WA coast, WDFW would likely have a
95 role relative to permitting and management.

96 Under RCW 79.105 and WAC 332-30, the Washington State Department of Natural Resources (DNR)
97 has the authority to manage 2.6 million acres of state-owned aquatic lands as a public trust. The statute
98 requires DNR to manage these lands to promote uses and protect resources of statewide value. Any
99 person or organization interested in removing valuable materials from state-owned aquatic lands must
100 apply to the DNR for a use authorization, including the extraction of marine organisms for commercial
101 products.

102

103 Potential along Washington's Pacific coast

104 Globally, new discoveries of unique chemicals and DNA sequences from marine organisms are
105 occurring at a rapid pace. The rate of new natural products reported from marine organisms is growing
106 at a rate of 4% per year, which is faster than the rate of species discovery. About 18,000 natural
107 products have been described from marine organisms since the 1950s (Arrieta et al., 2010). Marine
108 organisms from which new products have been discovered include sponges, microalgae, coral, deep-sea
109 hydrothermal vent bacterium, bioluminescent jellyfish, red algae, a snail, and a sea hare (Bruckner,
110 2002; Pomponi, 1999). The potential for novel chemicals from marine organisms is estimated to be
111 about 300 to 500 times higher than discovery from terrestrial sources (Arrieta et al., 2010; Bruckner,
112 2002). Marine product extraction presents a considerable economic and business opportunity; the
113 marine biotechnology industry is currently a multibillion dollar industry and growing (Arrieta et al., 2010;
114 Bruckner, 2002).

115 It is impossible to know when and where a new compound may be discovered, but it is predicted
116 that high biodiversity habitats such as coral reefs and seamounts, and extreme habitats such as
117 hydrothermal vents and polar habitats have the greatest economic potential for new chemical discovery
118 (Arrieta et al., 2010). The potential for marine product extraction along the WA Pacific coast is unclear.
119 Based on the literature, it does not seem likely that the WA coast is a primary target for marine
120 bioprospecting. However, WA does have unique environments including hydrothermal vents,
121 seamounts, and deep sea corals. Therefore, as new marine species are discovered and technology
122 expands the depths of the ocean to be explored, it is entirely possible that novel chemicals and DNA
123 sequences could be discovered within Plan waters.

124

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1 2.10.5 Mining

2 A potential new use of Washington’s Pacific coast is mining within marine waters for sand and gravel
3 as well as gas hydrates. This chapter provides context for sand/gravel and gas hydrate mining
4 operations, environmental impacts, use conflicts, and future trends in Washington. Gold mining, which
5 is a current use within the MSP Study Area, is covered in Section 2.6 Recreation and Tourism.

6 Sand and gravel mining

7 Sand and gravel are mined more than any other material in the world, and worldwide demand is
8 increasing. Declining land-based sand and gravel resources has shifted mining for these resources into
9 marine waters. Globally, marine sand and gravel are used mainly for construction and land reclamation
10 (Peduzzi, 2014).

11 In the United States, marine sand mining is used to supply material for beach nourishment along the
12 Atlantic and Gulf of Mexico coasts. Several states mine marine sand for beach nourishment projects and
13 some have partnered with the Bureau of Ocean Energy Management (BOEM) to extract sand from
14 offshore sites in federal waters. State and local governments use this sand to renourish public beaches,
15 restore coastal habitats, and build nature-based infrastructure to protect against coastal storms and
16 erosion. In the United States, demand for marine sand is increasing due to coastal erosion, increasing
17 coastal storms, and sea level rise. BOEM continues to work with state and local partners and is updating
18 evaluations for sand resources within BOEM lease blocks (Bureau of Ocean Energy Management, 2014).

19 The majority of in-water sand and gravel mining in Washington is currently limited to rivers. Much of
20 the sand that is removed in rivers is for navigation or flood control, very little mining is currently
21 performed for the pure purpose of obtaining and selling sand (M. Rechner, personal communication,
22 November 20, 2014). A couple of sand mining companies mine sand on the WA side of the Columbia
23 River to sell for construction and other uses (L. Randall, personal communication, November 25, 2014).

24 The dune restoration project at Shoalwater Bay is a similar activity to sand mining activities on the
25 Atlantic and Gulf coasts for beach nourishment. The Army Corps of Engineers dredged (mined) sand
26 within Willapa Bay, and placed the material to reconstruct eroding dunes at Shoalwater Bay. For more
27 information, see Shoalwater Bay project in the Section 2.10.3 Dredging and Dredge Disposal Chapter.

28 A localized sand removal activity within the MSP Study Area is for maintenance of public beach
29 access and subsequent sand use by cranberry growers. The Washington State Parks and Recreation
30 Commission (Parks) maintains public beach access along ocean beaches within the Washington State
31 Seashore Conservation Area by occasionally removing accreted sand at access points. Parks is authorized
32 to sell permits to cranberry growers to use this sand within their bogs. This use of sand is allowed if
33 found by Parks to be reasonable, and not generally harmful or destructive to the character of the land
34 (RCW 79A.05.630). This activity is currently exercised by a handful of growers in the Long Beach area.
35 The cranberry growers use sand to improve productivity within their nearby cranberry bogs. The volume
36 of sand from the Seashore Conservation Area used for this purpose is relatively small, and growers often
37 find acquiring the sand from other sources to be an easier option. This use is not anticipated to expand
38 in the near future (L. Lantz, personal communication, December 11, 2014).

39 Marine sand and gravel mining equipment and infrastructure

40 The equipment and infrastructure for sand and gravel mining is very similar to navigation dredging
41 and disposal. Mining for sand and gravel in marine water is generally performed with a trailing suction
42 hopper dredge or a cutterhead dredge. When trailing suction hopper dredges are used to mine sand for

43 beach nourishment, the material is typically stored within hoppers on the ship and transported to a
44 pump-out station near the placement site. The dredge is then hooked up to a pipeline at a pump-out
45 station and material is pumped to shore via pipeline laid on the seabed. Occasionally for beach
46 renourishment projects, the material is placed at a nearshore temporary holding and rehandling site
47 near the nourishment project site which is then dredged again and transported by pipeline. Temporary
48 storage and nearshore rehandling areas are becoming more frequently used on the Gulf and East coast,
49 especially when using offshore sites long distances from the placement sites (Michel, Bejarano,
50 Peterson, & Voss, 2013).

51 Cutterhead dredges are typically used closer to shore, and the dredged material is transferred
52 directly from the dredge to the placement site via a pipeline. Cutterhead dredges often require barges,
53 multiple anchors, support boats, survey boats, and crew boats. Pump-out of the material through a
54 pipeline requires a long list of equipment, including but not limited to tugs, buoys, cranes, support crew
55 boats, and floating and submerged pipelines. Transport pipelines are assembled using barges with
56 cranes, and multiple tugs position the line before it is flooded into place on the seafloor. These pipelines
57 are temporary structures which can be repositioned and disassembled once the project is complete
58 (Michel et al., 2013).

59 Marine mining equipment also can have dump valves on the intake pipe. Sand and gravel mining
60 activities target a specific size of material; should the dredge encounter unsuitable material, the dump
61 valves are used to instantly dump the material overboard before it enters the hopper (Tomlinson et al.,
62 2007). The ships may also have sorting and screening equipment to release unwanted fine sediments
63 (Michel et al., 2013). Sand and gravel mining activities to sell for land-based purposes also require shore-
64 based facilities for storage, handling, and distributing the material.

65 *Potential use benefits and compatibilities*

66 Sand and gravel mining is a compatible use with beach renourishment and coastal protection
67 projects. Depending upon the location, amount and type of material needed for the coastal defense
68 project, mining may be the most practical and cost effective alternative to provide the needed material.
69 Sea level rise and climate change (including increased frequency of coastal storms) may increase the
70 need for beach and dune renourishment to protect recreational beaches and coastal infrastructure. The
71 dune reconstruction at Shoalwater Bay is a good example of a current sand mining project to protect
72 coastal infrastructure and intertidal habitat for tribal shellfish beds from coastal flooding and storms
73 (U.S. Army Corps of Engineers, 2009) (See Dredge Disposal Chapter).

74 No information was found in the literature on compatible ocean uses with sand and gravel mining
75 for upland purposes (construction, road maintenance, etc).

76 [This section still to be completed.]

77 *Environmental concerns*

78 No literature was found regarding sand and gravel mining (dredging) impacts for offshore areas in
79 Washington, as it is not a current use. The summary below describes the available literature for
80 observed and potential environmental impacts from offshore sand and gravel mining along the Atlantic
81 and Gulf coasts, as well as general environmental considerations from navigation dredging in Grays
82 Harbor.

83 *Benthic species and habitats*

84 Immobile and slow moving benthic species could be directly removed by sand and gravel mining
85 (dredging) through entrainment into the suction dredge. The amount of time for benthic species
86 recovery is variable. Studies on the Atlantic and Gulf coasts report that biomass and abundance recover
87 times range from 3 months to 2.5 years after offshore dredging. Species diversity recovery can take
88 more than 3-5 years after offshore dredging. Monitoring at U.S. sand mining sites has not been long
89 enough to determine times for complete community recovery (Michel et al., 2013). For navigation
90 dredging at estuarine sites in Washington, the Corps reports benthic invertebrate recovery of juvenile
91 salmon prey at sites at the Ports of Tacoma and Seattle within months of the dredging activity (U.S.
92 Army Corps of Engineers, 2014). Studies from the East coast report that recolonization of the dredged
93 areas is similar to successional colonization from other disturbances (Michel et al., 2013).

94 Benthic organisms may also be directly impacted by pipelines transmitting sand. Pipelines can
95 directly displace and crush benthic invertebrates, and this impact may be increased by movement of the
96 pipeline during storms if it is not securely positioned. Hard bottom habitats are expected to experience
97 the greatest impacts from pipelines, while soft-bottom habitats are expected to quickly recover after
98 pipeline removal (Michel et al., 2013).

99 Mining can create pits along the seafloor. Observations in South Carolina have shown that finer
100 material such as mud can accumulate in these pits, which can lead to changes in the benthic community
101 composition (Michel et al., 2013). Levels of oxygen could also be reduced within these pits.
102 Recommended mitigation measures to assist in rapid recovery of benthic habitats have included
103 rotational dredging, dredging areas expected to rapidly refill, avoid creating deep pits, and leaving some
104 areas undredged. These methods have yet to be tested. (Michel et al., 2013).

105 Deposition of sediments on the seafloor and turbidity may also affect benthic invertebrates.
106 Turbidity and deposition of finer materials (silt, mud) can be caused by the drill head, but also by fine
107 materials washed overboard. Studies from dredging on the outer continental shelf on the East coast
108 indicate that turbidity concerns are generally low when mining clean sands. In addition, dynamic,
109 offshore habitats are generally acclimated to natural sedimentation. Turbidity and sedimentation effects
110 are of greatest concern to coral reef and hard-bottom habitats and spawning areas (Michel et al., 2013).

111 It is unclear whether benthic community composition changes will be beneficial or detrimental to
112 predatory species such as fish and crabs. These effects will depend upon the specific predator-prey
113 relationship, species life histories, and timing of the dredging activities (Michel et al., 2013).

114 The impacts of noise on benthic invertebrates remain largely unknown (Michel et al., 2013).

115 **Fishes and other mobile species**

116 Sand and gravel mining (dredging) may directly or indirectly impact bottom and pelagic fishes and
117 other mobile species such as crabs. South Atlantic Fishery Management Council, researchers, and other
118 institutions have expressed concerns about the effects of offshore dredging to the ecological services of
119 sand shoals to fishery resources (Michel et al., 2013). Adult fish and mobile bottom dwelling fish species
120 are expected to be able to swim away from the dredging activities. However, higher risks to fishes may
121 be associated with the smothering of eggs on spawning grounds, or the entrainment of eggs, juveniles,
122 or benthic species by the suction dredge. It is also possible that pelagic eggs could be impacted by
123 turbidity. Possible indirect impacts include alteration of prey availability for bottom fish as well as loss of
124 habitat (Michel et al., 2013).

125 There are many concerns surrounding the impacts to fish and other mobile species from offshore
126 sand and gravel mining, yet several data gaps exist regarding this topic. Most of the entrainment rates
127 for fishes and mobile invertebrates have been assessed for shallow-water and estuarine dredging

128 activities. In a literature review summarized by Michel et al. (2013), Dungeness crab entrainment rates
129 by hopper suction dredges in estuarine and river settings were reported to range from 0.040 to 0.592
130 adult crabs per cubic yard of dredged material, with juvenile crabs entrained at 0.32 to 10.78 crabs per
131 cubic yard. Mortality was reported to increase with increasing crab size from 5% for smaller crabs (7-10
132 mm) to 86% for larger crabs (>75 mm) (Michel et al., 2013). In Grays Harbor, A Dredge Impact Model is
133 used by the Corps to estimate the number of Dungeness crab losses for navigational dredging (U.S. Army
134 Corps of Engineers, 2014). However, it is unknown what the entrainment and subsequent survival rates
135 for Dungeness crab or fish would be at an offshore sand borrow site. Existing information from other
136 locations suggest that eggs deposited on the seafloor and bottom-dwelling fish are the most sensitive to
137 entrainment. Entrainment rates and the subsequent impact on fishery resources remains a data gap
138 (Michel et al., 2013).

139 In Washington, dredging could entrain lingcod, flatfish, and possibly rockfish. However, the
140 likelihood and rates of entrainment will depend upon the mining location and life history of the fish
141 species (U.S. Army Corps of Engineers, 2014).

142 The redeposition of sediment from sand and gravel mining activities could pose a risk to smothering
143 eggs on bottom-dwelling fish spawning grounds and burial of crabs. While species with eggs attached to
144 the seafloor are considered to be sensitive to this potential impact, the specific quantitative effects are
145 unknown. Bottom-dwelling species are expected to have some tolerance to natural sedimentation
146 (Michel et al., 2013). Spawning could be disrupted if spawning periods overlap with dredging operations
147 (Tomlinson et al., 2007). Seasonal work windows have been recommended for mining in the United
148 Kingdom, but their effectiveness in reducing impacts has not been confirmed. Early life stages of fish
149 that use hard-bottom habitats also may potentially be impacted by sediment deposition over those
150 habitats. Site specific buffers around hard-bottom habitats are used for offshore sand mining along the
151 East coast to reduce impacts (Michel et al., 2013).

152 Water quality may decrease within deep dredge pits where water exchange is reduced and oxygen
153 levels are reduced. This may stress organisms unable to move to more oxygenated locations. Noise from
154 dredging operations may also have a temporary and limited impact to fish populations. Potential effects
155 from noise could include changes in behavior and physiological (loss of hearing) damage (Michel et al.,
156 2013). A study in the North Sea found that fish migrations to spawning areas were altered during dredge
157 activity (Tomlinson et al., 2007). Specific effects from noise will be species dependent, and more
158 research is needed to assess the hearing abilities of fishes at various life stages (Michel et al., 2013).

159 **Birds**

160 No direct information was found assessing impacts from East coast offshore sand mining activities.
161 Potential impacts predicted to have the largest effects include indirect impacts to foraging seabirds from
162 repeated dredging of sand shoals, flight path avoidance, and flock disturbance if dredging or associated
163 navigation occurs near areas with dense flocks. It is unknown to what extent any of these impacts would
164 have on seabirds (Michel et al., 2013). The Environmental Impact Statement for Grays Harbor navigation
165 dredging suggests that dredge vessels and turbidity may temporarily displace foraging seabirds and
166 waterfowl (U.S. Army Corps of Engineers, 2014). Offshore sand and gravel mining (dredging) effects on
167 seabirds represents a large data gap (Michel et al., 2013).

168 **Marine Mammals**

169 Marine mammals could potentially be impacted by sand and gravel mining operations (dredging)
170 through pressures such as vessel interactions (vessel strikes), noise, and water quality. Vessel strikes can
171 cause injury or mortality to whales, and therefore mining may pose some increased risk to whales.

172 However, dredging vessels are often slow moving, and East coast dredging operations have mitigation
173 measures to reduce risk to marine mammals. There have been no reports of marine mammal strikes
174 from dredging or support vessels during dredging operations (Michel et al., 2013).

175 Noise from dredging and vessel operations has the potential to alter marine mammal behavior.
176 Specific effects and severity will depend upon the actual noise generated by the dredge and the marine
177 mammal species. There are few studies which document the reactions of marine mammals to dredging.
178 Direct injury to marine mammals from the sound produced from offshore dredging operations is
179 estimated to be unlikely based on the NOAA noise threshold criteria, although behavior disturbance and
180 harassment are possible. Potential impacts to marine mammals are assessed for individual projects
181 through Section 7 consultations (Michel et al., 2013).

182 It is unknown if or how marine mammals are impacted through disturbance of bottom habitats,
183 turbidity, and deposition of fines onto the seafloor from dredging (Michel et al., 2013).

184 *Sea turtles*

185 The main concern for East coast offshore dredging is the entrainment and mortality of sea turtles.
186 Loggerheads, Kemp's ridley, and Green sea turtles are considered to have the highest risk of
187 entrainment due to their benthic foraging habitat preferences. Several mitigation measures have been
188 developed to reduce entrainment and mortality of sea turtles (Michel et al., 2013). There is little to no
189 information on other potential impacts, such as alteration of benthic habitat, noise, turbidity, vessel
190 strikes, and increased sediment deposition. A review of biological impacts from offshore dredging
191 indicated that most impacts will likely be specific to the sea turtle species life histories, prey and habitat
192 preferences, and behaviors (Michel et al., 2013).

193 *Ecosystem effects*

194 As mentioned above, sand and gravel mining directly impact bottom habitats and benthic species. It
195 remains uncertain, however, to what degree these impacts have on trophic systems and ecological
196 interactions. Ecosystem impacts are difficult to measure. Food web and other ecosystem models have
197 been used to try to examine direct and indirect impacts of sand mining in marine systems, yet there is
198 currently high uncertainty based on limited information (Michel et al., 2013).

199 Another area of uncertainty is the potential cumulative impacts from sand and gravel mining and
200 current and historical fishing activities, particularly the bottom-disturbing fisheries. The impacts from
201 bottom-disturbing fishing can serve as a proxy for examining the potential ecosystem impact from sand
202 and gravel mining, although a few key differences exist. These differences include intensity of the
203 activity (sand mining may have a greater direct disturbance to the bottom habitat as compared to
204 bottom disturbance fishing) and spatial extent of the activity (sand mining will likely be located at fewer
205 sites and smaller in scale than bottom disturbance fishing) (Michel et al., 2013).

206 Ecosystem and food chain effects from sand and gravel mining activities remain a data gap of high
207 interest to ecosystem based management, fishery commissions, and other interested groups (Michel et
208 al., 2013).

209 *Potential use conflicts*

210 Sand and gravel mining activities have the potential to conflict with current and potential new uses
211 in Washington's MSP Study Area. Conflicts with commercial and recreational fisheries have been studied
212 for sand and gravel mining activities along the East coast and the United Kingdom. Based on literature
213 reviews and case studies in Florida, common spatial conflicts between commercial and recreational

214 fisheries and sand and gravel mining include: loss of fishing gear (particularly crab pots), changes to
215 navigation routes, reduced access to fishing grounds, and increased boat traffic (Tomlinson et al., 2007).

216 The loss and damage of gear, particularly fixed gear such as crab pots, due to dredging operations is
217 a contentious issue voiced by fisherman in the U.S. Gear can be directly damaged, or buoys can be
218 severed, interfering with equipment retrieval. This may lead to economic impacts to the fishermen for
219 the cost of replacement gear and loss of catch (Tomlinson et al., 2007).

220 In some locations, fishermen have reported concerns about disruptions to their navigation routes.
221 Dredging activities and equipment may require fishermen to alter navigation routes to their traditional
222 fishing grounds, depending upon the material borrow and placement sites. This may increase time and
223 money for the fisherman, including increased fuel costs. Dredging operations may also directly restrict
224 access or displace fisherman from traditional fishing grounds. This conflict will depend upon the
225 location, season, and longevity of the dredging (Tomlinson et al., 2007).

226 Sand and gravel mining activities may also increase boat traffic, which can lead to increased risk of
227 collisions or increased inconveniences to fishermen avoiding large dredging vessels. Effective
228 communication and standard operating procedures regulated by the U.S. Coast Guard can mitigate
229 these risks. However, shrimp fishermen in Lee County, Florida have reported loss of catch due to
230 avoiding dredge vessels while towing their nets (Tomlinson et al., 2007).

231 Fishermen in Florida (sand mining) and the United Kingdom (gravel mining) have also expressed
232 concerns related to dredging impacts on fish and crab ecology and how it may influence the stock
233 availability and catch. There is an established history of conflict between the sole and brown crab
234 fisheries with the gravel mining operations at Hastings Shingle Bank. For example, the Hastings fleet in
235 the United Kingdom, which is a net fishery for sole, estimates that the sole stock has been reduced from
236 16,000 tons to 2,000 tons since gravel dredging was undertaken at the Hastings Shingle Bank. As of
237 2007, it is unclear as to the exact dredging impacting mechanism is for this stock reduction (Tomlinson
238 et al., 2007).

239 Case studies indicate that the severity of these spatial conflicts vary between project locations and
240 specific fisheries. For example, in Brevard County, Florida, concerns about dredging traffic interfering
241 with fishing navigation routes were expressed by the finfish industry but not by the shrimp industry
242 (Tomlinson et al., 2007). The location of the borrow sites, placement sites, and dredging traffic routes
243 with respect to specific fishing grounds and access routes will significantly influence the level of
244 potential conflict between sand/gravel mining and fisheries.

245 Poor communication can also increase conflict during dredging operations. Fishermen in Lee and
246 Collier Counties in Florida have reported increased gear loss and navigation issues due to poor
247 communication about dredge and support vessel traffic locations (Tomlinson et al., 2007).

248 Sand and gravel mining operations may also pose potential conflicts with other current and future
249 uses, particularly those with permanent or semi-permanent infrastructure. Sand and gravel mining is
250 generally not suitable in areas with offshore oil and gas infrastructure, including platforms and pipelines
251 (Michel et al., 2013), and therefore we can predict that other similar infrastructure, such as for marine
252 renewable energy or methane hydrate mining will also not be compatible. Dredging activities could also
253 result in the uncovering and transfer of unexploded and discarded munitions. Historical munitions
254 disposals sites are marked on nautical charts and the U.S. Army Corps of Engineers requires historical
255 record searching of sites to prevent this issue (Michel et al., 2013).

256 Dredging activities also directly conflict with prehistorical sites and shipwrecks. The dredge
257 equipment and ground tackle for moorings can directly damage these sites. In the U.S., shipwreck

258 remains have been damaged by dredging activities, and prehistorical artifacts have been pumped ashore
259 as a result of renourishment. Indirect impacts include the uncovering or burial of historical resources.
260 BOEM is required by the National Historic Preservation Act to protect historical resources. GIS and sonar
261 technology is used to survey potential borrow sites for historical resources. Buffers around U.S. historic
262 sites where no dredging or anchoring can occur have ranged from 98 feet (30 meters) to about 1811
263 feet (360 meters) (Michel et al., 2004).

264 Based on the nature of sand and gravel mining activities and conflicts listed in the literature above,
265 we can assume that dredging activities will also conflict with uses such as shipping, offshore
266 aquaculture, marine cables, and other marine infrastructure.

267 *Permitting sand and gravel mining*

268 [This section still to be completed.]

269 *Potential along Washington's Pacific coast/Future trends and factors*

270 [This section still to be completed.]

271 *Gas hydrate mining*

272 Gas hydrates are a mixture of gas and water which, under low temperature and high pressures,
273 forms a solid ice-like structure. The main type of gas in hydrates is methane (Bureau of Ocean Energy
274 Management, 2012a). In marine systems, methane gas is produced by organic decomposition deep
275 within the sediment. As the methane migrates up through the sediment column, it begins to cool (P.
276 Johnson, personal communication, December 3, 2014). Under these cooler conditions and high
277 pressures within the sediment, the methane combines with water to form a solid ice-like structure
278 which is called a hydrate (Bureau of Ocean Energy Management, 2012a).

279 The depth, temperature, and pressure range at which the hydrates form is termed the hydrate
280 stability zone (Consortium for Ocean Leadership, 2013). On the Washington margin, the hydrate stability
281 zone begins at about 500 meters (1650 feet) water depth. The hydrates can occur on the surface of the
282 seafloor and can be distributed within the sediment column down to 200 meters (656 feet) (P. Johnson,
283 personal communication, December 3, 2014.) At depths too shallow or too warm, the hydrate stability
284 zone ends, the gas hydrates will “dissociate” and the methane will dissolve into the surrounding water
285 (Hautala, Solomon, Johnson, Harris, & Miller, 2014). Methane hydrates of a sufficient size may be
286 brought up to the surface of the ocean, where they will continue to dissociate into gas and water. The
287 hydrates brought to the surface can be lit with a match and the methane emitting from the hydrate will
288 burn.

289 Methane is a natural gas and can be used as an energy source. Methane hydrate resources are
290 estimated by BOEM, Department of Energy, and other sources to be the one of the largest sources of
291 organic carbon on earth (Consortium for Ocean Leadership, 2013; Hautala et al., 2014). This has been a
292 primary driver in the interest of using gas hydrates for energy production. In the Methane Hydrate
293 Research and Development Act of 2000, congress projected a shortfall in natural gas supply by 2020.
294 The Act identified the potential for methane hydrates to help alleviate the projected shortfall, and
295 authorized federal funding for a methane hydrate research program. Since 2000, significant U.S. funding
296 has been invested in exploring gas hydrates for natural gas resources (Boswell, 2009).

297 While there is currently no commercial scale production of methane from gas hydrates, ongoing
298 research continues to advance understanding of the gas hydrate system and the potential for methane
299 recovery. Two exploration and production studies have been recently conducted in the U.S., one on the

300 continental slope of northern Alaska, and other in the Gulf of Mexico. Production testing in land-based
301 locations in Alaska and Canada, and offshore testing in Japan indicate that natural gas can be produced
302 from methane hydrates using existing oil and gas production technology (Consortium for Ocean
303 Leadership, 2013).

304 *Gas hydrate mining equipment and infrastructure*

305 Based on preliminary extraction tests, it appears that oil and gas infrastructure can be easily
306 adapted to gas hydrate extraction (Consortium for Ocean Leadership, 2013). The summary that follows
307 briefly describes the main tools currently used to explore for methane hydrates and some the main
308 components of offshore oil and gas equipment and supporting infrastructure to provide context to
309 potential gas hydrate exploration and production activities.

310 Tool that have been used to characterize gas hydrate resources include seismic and electromagnetic
311 surveying, shallow and deep coring, well logging, and logging while drilling (Consortium for Ocean
312 Leadership, 2013). Seismic surveys utilize shock waves sent through the water and sediment which then
313 refract back to a receiver either on a floating or submerged receiver. The most common technology
314 used for offshore oil and gas exploration utilizes airguns, which transmit acoustic energy through the
315 water column and into the subsurface. Seismic data is generally collect using multiple vessels (National
316 Oceanic and Atmospheric Administration, 2013).

317 Well logging and logging while drilling utilizes drilling and coring methods to take samples of the
318 material within the well. Exploratory wells for offshore oil and gas are often drilled utilizing a mobile
319 offshore drilling unit. These units can be fixed, semisubmersible, or a floating drill ship (Bureau of Ocean
320 Energy Management, 2012b). Floating vessels are held over a well by either a mooring system or
321 through a dynamic positioning system. Fixed platform structures are grounded on the seafloor, utilizing
322 lower support legs to stabilize the rig. Each of these structures often requires the use of several support
323 vessels and support aircraft (Bureau of Ocean Energy Management, 2012b; National Oceanic and
324 Atmospheric Administration, 2013).

325 Production and storage facilities are similar to exploration platforms. They come in multiple designs
326 capable of various water depths. Fixed structures, semi-submersible, and floating facilities are used
327 throughout the world. Floating platforms are moored with line systems and anchors, while fixed
328 structures have support legs attached to the seafloor. Facilities have been moored at over 7,000 feet
329 (Office of Ocean Exploration and Research, 2010). Offshore processing facilities may also occur on or
330 floating next to the platforms. Underwater pipelines and coastal support infrastructure, such as pipeline
331 landfalls, processing facilities, and pipe yards) (Bureau of Ocean Energy Management, 2012b) may also
332 accompany exploration and commercial production of methane hydrates.

333 *Potential use compatibilities*

334 [This section still to be completed.]

335 *Environmental impacts*

336 Environment impacts specific to gas hydrate mining are unknown. However, since the infrastructure
337 and production technology for gas hydrate extraction is anticipated to be similar to oil and gas
338 (Consortium for Ocean Leadership, 2013), environmental effects from offshore oil and gas production
339 can be extrapolated to gas hydrate mining. Offshore drilling consists of multiple stages of activities.
340 These include exploration, development, operation, and decommissioning. Each of these activity phases
341 will have different impacts depending upon the specific activity. Some activities may be temporary,

342 while others may occur throughout each phase, although at varying intensities (Bureau of Ocean Energy
343 Management, 2012b).

344 The following is a brief summary of the general environmental concerns and impacts related to the
345 physical presence and activities of offshore oil and gas production. This summary is primarily compiled
346 from information available in the Programmatic Environmental Impact Statement (PEIS) produced by
347 BOEM for the 2012-2017 offshore oil and gas lease block plans for Outer Continental Shelf (OCS) sites in
348 the Gulf of Mexico and Alaska (Bureau of Ocean Energy Management, 2012b). Information from other
349 sources is included when available. The specific effects to water quality, habitat, and species within
350 Washington OCS waters from any proposed gas hydrate mining will depend upon the specific activities
351 and intensities, and will be directly assessed in an EIS for any proposed lease block plans and individual
352 leases.

353 Water quality

354 Activities that can affect water quality include disturbance of bottom sediments, wastes and
355 disposals, vessel traffic, well drilling, and operational discharges. During offshore oil and gas drilling,
356 drilling muds are used for lubrication and cooling of the drill bit and pipe. Some water-based and
357 synthetic based muds are permitted for ocean discharge, while others are required to be disposed of
358 onshore. Offshore disposal of muds and drill cuttings can have localized environmental impacts and are
359 regulated by NPDES permits (Bureau of Ocean Energy Management, 2012b). While drill cuttings and
360 muds can cause some impacts to benthic species in the immediate vicinity of the discharges, it is unclear
361 whether this has a significant impact at the community-level scale (California Coastal Commission,
362 2013).

363 The largest discharge from oil and gas extraction is from produced water (water that is brought to
364 the surface from an oil-bearing formation). Produced waters can have elevated concentrations of
365 hydrocarbons, metals, and salts. Hydrocarbons in produced water discharges are a major environmental
366 concern. Produced water is generally treated and must meet NPDES standards before discharge. Water
367 and sediment quality may be degraded in the immediate area of discharge (Bureau of Ocean Energy
368 Management, 2012b). In California, studies have indicated that sublethal effects to invertebrates could
369 occur from produced water concentrations expected up to 100 meters from discharge locations. It is
370 unclear, however, if these sublethal effects translate to population effects (California Coastal
371 Commission, 2013).

372 The construction and placement of drilling units, wells, platforms, anchoring, and mooring may
373 result in bottom disturbance and temporary increases in turbidity. Pipeline trenching may also result in
374 bottom disturbance and increased turbidity. This is an unavoidable impact, but is expected to be
375 temporary (Bureau of Ocean Energy Management, 2012b).

376 Accidental spills and other discharge events can occur. With regards to methane, it is possible that
377 decreased oxygen levels could occur during a discharge event due to microbial activity. However,
378 evidence from the Deepwater Horizon spill event indicates that natural gas released from a well is
379 rapidly broken down by bacterial activity (Bureau of Ocean Energy Management, 2012b).

380 Air quality

381 Emissions from oil and gas drilling operations may affect air quality. Emissions are produced from a
382 variety of activities. Air quality effects from offshore oil and gas operations and accidental spills within
383 the Gulf of Mexico are expected to be minor to moderate with temporary effects. Catastrophic
384 discharge events may result in air emissions lasting for days or months, although levels would eventually
385 return to pre-event levels after the well is capped. Adverse effects on humans and wildlife may have

386 long-term consequences from the exposure (Bureau of Ocean Energy Management, 2012b). Air quality
387 effects from methane hydrate mining can be difficult to compare, since some of the emissions may be
388 different from conventional oil and gas; other emissions, such as from supporting vessels, engines, cargo
389 transport vessels, etc, may be similar.

390 Noise

391 Several routine operations for offshore oil and gas produce noise. These activities include
392 exploration, construction activities such as pile driving and trenching, operational noise from platforms,
393 ships, and aircraft, and demolition activities. A study from BOEM determined that seismic surveys may
394 have a potentially adverse effect on marine mammals, sea turtles, fishes, and commercial and
395 recreational fisheries while other survey activities were found to have negligible or no measurable noise
396 impacts. Construction noises may disturb fishes, sea turtles, marine mammals, and birds in the near
397 vicinity of the operation. Gas eruption from loss of well control may also be significant enough to harass
398 or injure marine mammals, depending upon their proximity to the well. Marine mammals, sea turtles
399 and fish could be affected by the noise and shock waves from explosives during demolition. Specific
400 effects from noise depend upon the species hearing capabilities and the type, frequency, and intensity
401 of noise generated (Bureau of Ocean Energy Management, 2012b).

402 Habitats

403 Benthic habitat can be disturbed through well drilling, anchors, bottom-fixed platform structures,
404 pipeline trenching, and seabed equipment. Movement of anchors and mooring lines from floating
405 platforms and support vessels may have a more chronic impact on the seafloor. In the Gulf of Mexico,
406 anchor scars were detected up to two miles from a well location. Sediment contamination from
407 discharges and temporary increases in turbidity may also impact seafloor habitat. Essential fish habitat
408 could be affected by these same activities (Bureau of Ocean Energy Management, 2012b).

409 Pelagic habitat can be affected by platform and pipeline placement, drilling activity, seismic surveys,
410 platform lighting, aircraft and vessel traffic, and discharges. Discharges can affect water quality,
411 although this impact is has been estimated to be minimal in the Gulf of Mexico and Alaska. Offshore
412 platforms can act as artificial reefs, and can be colonized by sessile organisms and attract mobile
413 organisms, which is a shift in the normal habitat of the open ocean. Overall, in the Gulf of Mexico and
414 Alaska pelagic habitat impacts are expected to be negligible to minor (Bureau of Ocean Energy
415 Management, 2012b).

416 Coastal and estuarine habitats could be impacted by the construction of coastal support
417 infrastructure, increased vessel traffic to offshore platforms, and possible installation of pipelines. The
418 specific degree and what habitat types affected will depend upon the specific activity, location, and
419 support infrastructure needs. Federal, state, and local permits will be required and are expected to
420 minimize impacts through mitigation and appropriate siting (Bureau of Ocean Energy Management,
421 2012b).

422 Mammals

423 Specific potential effects to marine mammals will depend upon the species and level of activities.
424 Some general potential effects listed in the 2012-2017 Programmatic Environmental Impact Statement
425 (Bureau of Ocean Energy Management, 2012b) include: collisions with support vessels, injury and
426 disruption of normal behavior from seismic exploration, behavior disruption from construction,
427 operation, and support vessels, physical disturbance or reduced habitat quality from onshore and
428 offshore construction, toxicity from produced water and drilling muds, ingestion or entanglement from

429 solid wastes and debris, toxicity from spills. Predicted impacts to marine mammals in the Gulf of Mexico
430 and Alaska lease block areas are expected to range from negligible to moderate (Bureau of Ocean
431 Energy Management, 2012b). Impacts to marine mammals specific to the Washington coast from any
432 offshore drilling activities will be assessed during an environmental impact statement as a part of the
433 permitting process.

434 Birds

435 Activities from offshore oil and gas that may negatively impact birds include offshore structure
436 placement and pipeline trenching, offshore structure removal, operational discharges and wastes, vessel
437 and aircraft traffic, onshore construction, and noise. These activities may impact birds by either affecting
438 their habitat, life stages, or behaviors. Collisions with vessels, platforms, and aircraft, exposure to
439 discharges, ingestion of trash or debris, loss or degradation of habitat, and behavioral disturbance are
440 potential impacts listed within the Programmatic EIS for 2012-2017 BOEM leasing program (Bureau of
441 Ocean Energy Management, 2012b). Collisions with platforms in the northern Gulf of Mexico are
442 estimated to be at least 50 birds per platform a year; this is likely an underestimate. While these
443 activities may impact individual birds, population effects from routine operations in the Gulf of Mexico
444 are not likely. Platforms in the Gulf of Mexico have been observed to be used by overwintering birds as a
445 rest point. Impacts to birds in the Gulf of Mexico and Alaska are estimated to be negligible to moderate
446 (Bureau of Ocean Energy Management, 2012b).

447 Fish

448 Offshore oil and gas routine operational activities that have the potential to impact fish species
449 include platform lighting, increased ship traffic, vessel discharge and miscellaneous discharges. BOEM
450 indicates that these impacts are expected to be minimal to fish populations. Exploration and site
451 development activities that could impact fish include noise from seismic surveys, drilling, platform
452 placement, and pipeline activities. Discharges of drilling muds and cuttings could impact fish by
453 contaminating food resources. Although these activities can directly impact bottom fish, it is expected to
454 be localized the immediate vicinity of the activity and BOEM has estimated no population-level impacts
455 to fish communities in the northern Gulf of Mexico and Alaska as a result of their 2012-2017 block
456 leasing plan (Bureau of Ocean Energy Management, 2012b).

457 Benthic invertebrates that prefer hard habitat could colonize the platforms and exposed pipelines.
458 Fish can also be attracted to oil and gas platforms to feed on colonizing organisms and other attracted
459 fish. This represents a change of community structure and behavior of fishes. The positive and negative
460 effects of these fish aggregations will depend upon the life history of the fish and fisheries management
461 in other areas (Bureau of Ocean Energy Management, 2012b).

462 Environmental impact statements for any proposed offshore methane mining activity in Washington
463 waters will address fish species specific to our region, including listed endangered and threatened
464 species.

465 Sea turtles

466 Sea turtles may potentially be impacted by offshore oil and gas noise, collisions with vessels, and
467 toxicity from discharges. Noise from seismic surveys, construction of platforms and pipelines, and
468 platform demolition by explosives can kill, injury, or disrupt behavior of turtles near the activity (Bureau
469 of Ocean Energy Management, 2012b). Disturbance effects to sea turtles from any proposed offshore
470 methane mining in Washington will be evaluated in an environmental impact statement.

471 Invertebrates

472 Activities that can impact invertebrates include vessel and other discharges, offshore lighting, noise
473 for seismic surveys and bottom disturbance activities, and release of drilling muds and cuttings.
474 Invertebrates can be killed, injured or displaced from drilling, platform construction, pipeline trenching,
475 and disturbance from anchors. Disturbed sediments may also resettle and bury or damage the gills of
476 some benthic invertebrates. Recolonization of these areas by invertebrates may be relatively rapid, but
477 the return of community composition to pre-disturbance levels may take longer (Bureau of Ocean
478 Energy Management, 2012b).

479 Drilling muds may contain chemicals toxic to marine invertebrates, but these effects may be species
480 dependent. This may chance the benthic community composition around the well. Toxic effects from
481 produced water discharges are not anticipated because of the NPDES permit requirements for discharge
482 of this material. (Bureau of Ocean Energy Management, 2012b).

483 As mentioned earlier, invertebrates which prefer hard-bottom substrates may colonize the platform
484 and pipeline structures. These structures may become habitat for native and introduced species (Bureau
485 of Ocean Energy Management, 2012b).

486 Safety hazards (instability from drilling)

487 Destabilization of the site could cause safety issues, a potential release of methane into the
488 sediments and water column and destabilization of the substrate. Industry is working to figure these
489 out, as it is safety hazard to their operations. Limited information was uncovered about what the
490 environmental effects would be. Different than oil and other gases, literature did not have much to say
491 about what the potential environmental effects of a catastrophic event for a methane mining activity.
492 About half of the methane releases from Deepwater Horizon spill were estimated to be consumed by
493 bacteria (University of Georgia, 2014).

494 Methane releases and climate change

495 Methane hydrates form within a stability zone dependent upon temperature and pressure. When
496 pressure decreases or temperature increases, the hydrates can dissociate and release methane into the
497 water column. Global climate change is influencing the temperature within some of the world's oceans,
498 and could lead to increased release of methane gas into the water column and possibly into the
499 atmosphere. Studies performed on the Washington coastal margin suggest a substantial volume of
500 methane gas has the potential to be released from hydrates due to contemporary climate change
501 (Hautala et al., 2014).

502 Methane seeps are a natural occurrence along the Washington coastal margin, and are currently a
503 focus of study (Hautala et al., 2014; Johnson, Solomon, Harris, Salmi, & Berg, 2014; Salmi, Johnson,
504 Leifer, & Keister, 2011). The estimated amount of methane emitted from these seeps is 0.1 metric tons
505 per year, which is approximately equivalent to the amount of gas emitted from the 2010 Deepwater
506 Horizon spill. Predicted changes to bottom water temperatures from climate change could shift the
507 hydrate stability zone, and could increase methane emission by a factor of four by 2100 (Hautala et al.,
508 2014).

509 Methane is a hydrocarbon and a greenhouse gas. Methane dissolved into the water column could
510 influence ocean acidification (Hautala et al., 2014), while methane released into air could contribute to
511 further global climate change (Consortium for Ocean Leadership, 2013; Ruppel & Noserale, 2012). While
512 these factors are important to understand, the natural methane seeps and potential zone for increased
513 methane dissociation from climate change are not the methane sources currently targeted for energy
514 mining. Methane hydrates currently targeted for mining are located deeper within the hydrate stability
515 zone.

516 *Potential use conflicts*

517 Methane hydrate mining is currently not a commercial use in any part of the world, yet there are
518 several potential use conflicts that could arise if the industry were to be proposed off of the Washington
519 coastal margin. The infrastructure and production technology for gas hydrate extraction is anticipated to
520 be similar to offshore oil and gas (Consortium for Ocean Leadership, 2013). To help inform the potential
521 use conflicts that may arise from gas hydrate mining, known and potential use conflicts from the BOEM
522 2012-2017 PEIS for offshore oil and gas lease block plans in the Gulf of Mexico and Alaska (Bureau of
523 Ocean Energy Management, 2012b) are summarized below. Specific use conflicts along the Washington
524 coast will depend upon the nature intensity of this potential new activity.

525 *Commercial and recreational fisheries*

526 Commercial fishermen may be affected by offshore oil and gas operations by causing changes in the
527 distribution or abundance of fishery resources, reducing the catchability of fish, precluding fishers from
528 accessing viable fishing areas, or causing losses of or damage to equipment or vessels. Impact will
529 depend upon the fishery, fishing method or year, and nature of particular structure. Navigation and
530 access to the fishing grounds may be disturbed. A safety zone for vessels longer than 100 feet may be
531 established up to 1,640 feet around each production platform, which would encompass up to
532 approximately 198 acres of surface area per platform. Decommissioning: all wellheads, casings, pilings,
533 and other obstructions will be removed to a depth of at least 15 feet below the mud line or other
534 approved depth. This would decrease a small area allowable for trawl fishing. Longlining not affected
535 after decommissioning. An offshore environmental cost model assumes 0.5 mile buffer around gas and
536 oil structures decreasing the area available for fishing. (pg 1206)

537 Recreational fisherman: specific effects mainly tied to any effects on the targeted species. The
538 platforms may have a positive effect on the availability of recreational fishing opportunities (pg 1206) In
539 the GOM up to 51% of party boat fishing trips were within 300 feet of an oil or gas structure because the
540 structures are known to aggregate pelagic fish.

541 It is difficult to extrapolate the effect of a spill or catastrophic event from an oil and gas platform to
542 methane hydrate mining, but it is possible that commercial and recreational fisheries would be
543 impacted by consumer perception of food safety and therefore reduce spending. Any closure of fishing
544 grounds would have impact on commercial and recreational fishermen.

545 In Alaska, there has been a history of conflicts between commercial fisheries and seismic exploration
546 vessels. Loss of gear, including crab pots and longlines. Some studies have found a temporary reduction
547 in fisheries catch during or following seismic surveys. (pg 1210)

548 Construction of pipelines can result in entanglement hazards for some types of fishing gear (bottom
549 trawl, crab pots). Recreational fisheries can experience disruptions to access fishing grounds, lost gear,
550 and reductions of catch following seismic surveys.

551 Commercial and recreational fishing could be affected if behavioral changes in target species (MMS
552 2007d) occur as a result of exposure to seismic surveys (see Section 4.4.11). The effect is expected to be
553 temporary. (Bureau of Ocean Energy Management, 2012b)

554 *Tourism and recreation*

555 [This section to be completed.]

556 *Archaeological and cultural resources*

557 [This section to be completed.]

558 *Permitting gas hydrate mining*

559 [This section to be completed.]

560 *Future trends and factors in WA/Potential along Washington's Pacific coast*

561 High gas hydrate concentrations in sand are currently the primary targets for exploration.
562 Conventional oil and gas technology favors methane extraction from sand dominated gas hydrate
563 reservoirs. In addition, gas hydrates can occur in various percentages within marine sediments. The Gulf
564 of Mexico, for example, has estimated gas hydrate saturation at 50-90% (Consortium for Ocean
565 Leadership, 2013). By comparison, the Washington coastal margin has an estimated 5% gas hydrate
566 saturation (Hautala et al., 2014). Based on resource assessments and the status of methane hydrate
567 research, the U.S. Department of Energy and the Consortium for Ocean Leadership identified the Gulf of
568 Mexico and the New Jersey coastal margin as top priorities for scientific methane hydrate drilling
569 (Consortium for Ocean Leadership, 2013).

570 Production of methane from gas hydrates is currently in the development stage; no commercial
571 operations exist. Field scale tests for methane production from gas hydrates have been limited to short
572 durations (less than one month). A six-day offshore field test in Japan established that methane gas
573 production is feasible. However, the methane produced was one to two magnitudes lower than a typical
574 commercial rate for gas accumulation. Initial production rates are expected to be low because it may
575 take years before a well reaches its maximum production rate. Longer tests are needed before
576 commercial viability of this resource can be established (Consortium for Ocean Leadership, 2013).

577 The United States federal government continues to provide significant investments and coordinated
578 research plans for assessing gas hydrates and developing production technologies (Consortium for
579 Ocean Leadership, 2013; National Energy Technology Laboratory, 2012). It is possible that commercial
580 scale production of methane from gas hydrates in Alaska and offshore Japan could begin within the next
581 10 to 20 years (Boswell, 2009; Consortium for Ocean Leadership, 2013). Since conventional oil and gas
582 equipment can be used to mine methane from gas hydrates, the roadblocks to commercial scale
583 production relate more to the economics of hydrate extraction (Consortium for Ocean Leadership,
584 2013).

585 Gas hydrate resources within the Washington coastal margin have been estimated by BOEM. These
586 are modeled estimates of in-place gas hydrates and do not assess technically recoverable resources
587 (Bureau of Ocean Energy Management, 2012a). Researchers at the University of Washington are
588 currently mapping a more detailed resource assessment of gas hydrates in the Washing margin (P.
589 Johnson, personal communication, December 3, 2014). Although gas hydrate volumes within the
590 Washington margin are estimated to be quite substantial, the average gas hydrate saturation is assumed
591 to be 5% (Hautala et al., 2014). Therefore, methane hydrate mining within Plan is likely not a primary
592 target compared to methane rich highly concentrated sands in the Gulf of Mexico and Atlantic margin.

593 *Other mining activities*

594 Preliminary research was conducted to understand the potential for uranium extraction and deep
595 seabed mineral resource mining activities with the MSP Study Area. Uranium extraction is the extraction
596 of uranium from seawater for energy purposes. Deep seabed mineral resource mining is the mining of
597 polymetallic nodules, ferromanganese crusts, and massive sulphides from the seafloor. Literature and
598 other resources indicated that uranium extraction and deep seabed mineral mining activities are

599 generally early in development and are not targeting Washington waters (“International Seabed
600 Authority,” 2014; G. Gill, personal communication, November 20th, 2014). Therefore, we assessed that
601 both of these potential activities are highly unlikely to occur in the MSP Study Area in the near future
602 and are therefore are not described further within the MSP.

603

DRAFT

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1 2.11 Climate Change

2 Introduction

3 Climate change is a global phenomenon that will impact the MSP Study Area in a variety of ways.
4 While the future effects can be projected based on the best available science, the precise magnitude,
5 duration, and frequency of the effects are not certain. In the MSP Study Area, the current uses and
6 potential uses, coastal populations, habitats, and wildlife are likely to experience changes. This section
7 provides information on the potential impacts of global climate change on the MSP Study Area.
8 Scientific research into the effects of climate change continues to provide improved information on
9 what can be expected, but the real-life impacts will depend on how significant the changes in conditions
10 are, the degree of vulnerability of resources and their responses to those changes, as well as any
11 cumulative impacts.

12 Climate change modeling provides projections based on varied scenarios that lead to a range of
13 results. These ranges of projected impacts can be used for planning purposes. This section provides a
14 review of potential impacts of climate change, with projections from climate change models, however
15 they may shift as our understanding of the issue becomes more refined. More detailed information and
16 in-depth analysis can be found in many scientific reports. Climate change has the potential to greatly
17 alter the physical, ecological, economic, and social environment of the MSP Study Area and should be
18 considered with any potential new uses of the area.

19 Summary of climate change

20 Climate change can be defined as any substantial change in a measure of climate, such as
21 temperature or precipitation, which lasts for decades or longer. During previous periods of time this
22 change has been due to natural factors, but the changes observed now are primarily caused by human
23 activities (U.S. Environmental Protection Agency, 2016). Shifting climate has the potential to drive
24 significant changes in the air, land, and sea that will in turn influence the lives of the human and
25 ecological communities that rely on them. This section includes an explanation of the forces driving
26 global climate changes, as well as the range of impacts that are projected to result in the MSP Study
27 Area.

28 Greenhouse gases

29 The primary driver of human-caused climate change is through the addition of significant amounts
30 of greenhouse gases into the atmosphere, such as the burning of fossil fuels for electricity generation
31 and transportation (U.S. Environmental Protection Agency, 2016). The major greenhouse gases are
32 carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and fluorinated gases¹ (U.S. Environmental
33 Protection Agency, 2016). They are called greenhouse gases because they trap heat in the lower part of
34 the atmosphere and as the volume of gases increases, so does the amount of heat trapped. With this
35 extra heat trapped in the atmosphere, it leads to higher air temperatures near the surface of the Earth,
36 higher water temperatures in the oceans, and altered weather patterns. Humans have added significant
37 quantities of greenhouse gases to the atmosphere by burning fossil fuels and clearing forests (U.S.
38 Environmental Protection Agency, 2016).

¹ Fluorinated gases are gases that contain fluorine including hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride (U.S. Environmental Protection Agency, 2016).

39 Many of the major greenhouse gases can remain in the atmosphere for tens to thousands of years
40 after being released, while some substances have shorter atmospheric lifetimes but still affect the
41 climate. Carbon dioxide is not destroyed over time, but rather moves between the atmosphere, ocean,
42 and land. Therefore, some CO₂ may remain in the atmosphere for thousands of years while some is
43 absorbed quickly into the ocean. The greenhouse gases all mix together in the lower part of the
44 atmosphere and are distributed globally so that the concentrations of the gases are similar across the
45 planet. The resulting climate change impacts from these greenhouse gases are also global. One
46 exception to this is in areas that are large sources or sinks of a specific gas where the concentration
47 varies from the global concentration (U.S. Environmental Protection Agency, 2016).

48 *Climate change impacts*

49 The increase in greenhouse gas emissions and resulting climate change have already impacted
50 atmospheric conditions and are projected to continue to do so. Some of the impacts are discussed
51 below including changes in air temperature, precipitation, and air circulation patterns.

52 *Air temperature*

53 The Pacific Northwest (PNW) has experienced warming of 1.3°F between 1895 and 2011. During
54 the same time period, the frost-free season also lengthened by 35 days (±6 days) (Snover, Mauger,
55 Whitely Binder, Krosby, & Tohver, 2013). Scientists project the temperature in the PNW to rise by 5.8°F
56 by the 2050s for a high greenhouse gas emissions scenario when compared to the average temperature
57 from 1950-1999. Extreme heat events are projected to become more frequent while extreme cold
58 events become less frequent (Snover et al., 2013).

59 *Precipitation*

60 There has been no long-term trend of wetter or drier conditions in Pacific Northwest precipitation
61 from 1895-2011 (Snover et al., 2013). In the PNW, annual precipitation is projected to have relatively
62 small changes, with models projecting a change of -4% to +14% during the 2050s as compared to the
63 average for 1950-1999 (Snover et al., 2013). The projections for seasonal changes are also mixed with
64 most models projecting drier summers and a majority of models projecting increases in precipitation for
65 the rest of the year. Scientists project an increase in the number of heavy rainfall events and less snow
66 accumulation (Snover et al., 2013).

67 *El Niño-Southern Oscillation and Pacific Decadal Oscillation*

68 Two important climate patterns that impact climate variability along the Pacific Coast of Washington
69 are the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). Although ENSO
70 and PDO are unique from the climate change discussed in this chapter, they affect similar components
71 of the climate system. Both ENSO and PDO alter regional surface winds, air temperatures, and
72 precipitation and are distinguished by warm and cold phases. In the northeast Pacific, the observable
73 responses to a warm phase of ENSO include warm upper ocean temperatures, winds that are favorable
74 to downwelling, reduced primary productivity, the appearance of southern marine species not normally
75 part of this range, and elevated average water level. During a cold phase, sometimes referred to as La
76 Niña, the opposite will occur (Miller, Shishido, Antrim, & Bowlby, 2013; Moore, Mantua, Hickey, &
77 Trainer, 2010).

78 The PDO and ENSO occur on different time scales, but positive phases of ENSO tend to be associated
79 with positive phases of the PDO. In the northeast Pacific, PDO positive phases cause warm
80 temperatures, positive sea level pressure, and higher sea level (Miller et al., 2013). A typical ENSO event

81 will last for 6-18 months and a typical PDO event will last for 20-30 years (Moore et al., 2010). It can be
82 challenging to distinguish between the long-term climate change trends and climate cycles like these
83 that occur on annual to decadal time scales. It is still unclear what impact climate change will have on
84 ENSO and PDO, or whether it will force changes in either frequency or intensity (Miller et al., 2013;
85 Vecchi & Wittenberg, 2010).

86 *Ocean and coastal impacts*

87 Climate change, due to human-caused increases in greenhouse gases, influences many components
88 of marine ecosystems. Increased CO₂ in the atmosphere directly causes increasing ocean temperatures
89 and increasing acidity. The increase in ocean temperatures drives additional changes including rising sea
90 level, increased ocean stratification, decreased sea-ice extent, and altered patterns of ocean circulation,
91 precipitation, and freshwater input (Doney et al., 2012). Ocean warming and changes in circulation also
92 lead to reduced subsurface oxygen (O₂) concentrations (Doney et al., 2012). Projected changes in ocean
93 temperature, dissolved oxygen, sea level rise, flooding, erosion, storms, ocean acidification, and harmful
94 algal blooms are briefly discussed in this section.

95 *Ocean temperature*

96 Ocean temperature can be broken down into both the sea surface temperature and ocean heat
97 content. Water has a higher heat capacity than air, therefore the ocean can absorb large amounts of
98 heat with only a slight increase in temperature. The oceans have not warmed as much as the
99 atmosphere, even though the oceans have absorbed a majority of the Earth's extra heat (U.S.
100 Environmental Protection Agency, 2016). The ocean has absorbed approximately 80% of the heat in the
101 climate system associated with greenhouse gas emissions during the last fifty years (P. W. Mote,
102 Petersen, Reeder, Shipman, & Whitely Binder, 2008). The upper layer of the ocean is generally expected
103 to absorb heat most rapidly and warm the fastest due to its proximity to the atmosphere. It will take
104 longer, likely centuries, for the deep ocean to warm as global circulation patterns mix the warmer
105 surface water with the deeper colder water (Miller et al., 2013).

106 Sea surface temperature has increased at an average rate of 0.13°F per decade between 1901 and
107 2015 (U.S. Environmental Protection Agency, 2016). Mote and Salathe (2010), projected increases in
108 sea surface temperature of about 2.2°F to the 2030-2059 future annual cycle from the 1970-1999
109 average.

110 A warming ocean has consequences for sea level because water expands slightly as it gets warmer.
111 The heat in ocean surface waters also provides energy for storms, influences weather patterns, and can
112 change ocean currents (U.S. Environmental Protection Agency, 2016). Increases in sea surface
113 temperature and the resulting changes in ocean circulation patterns can affect which species are
114 present in marine ecosystems, alter migration and breeding patterns, threaten corals, and change the
115 frequency and intensity of harmful algal blooms (U.S. Environmental Protection Agency, 2016).
116 Increasing sea surface temperatures could weaken the circulation patterns responsible for the upwelling
117 of water and nutrients from the deep sea to surface waters, which could contribute to declines in fish
118 populations and the human impacts related to decreased food supply and job impacts in the fishing
119 industry (U.S. Environmental Protection Agency, 2016).

120 *Hypoxia and anoxia*

121 As climate changes, it is expected to impact the concentration of dissolved oxygen in the ocean.
122 Hypoxia is the state of low dissolved oxygen concentrations that causes stress to aquatic animals and
123 anoxia is the state of no dissolved oxygen in water. Hypoxia is associated with large scale ocean

124 circulation and productivity as well as local upwelling. In the MSP Study Area, upwelling of water that is
125 low in dissolved oxygen and high in nutrients promotes increased primary productivity. Large
126 phytoplankton blooms in turn support the food web leading to increased waste products. As waste
127 products sink through the water they are broken down by bacteria that respire and use dissolved oxygen
128 in the process, further decreasing the available dissolved oxygen (Miller et al., 2013).

129 The coast of Washington regularly experiences a seasonal cycle of dissolved oxygen concentrations.
130 In the winter, waters at depth have relatively high dissolved oxygen concentrations due to decreased
131 biological productivity and frequent storms producing winds that are favorable to downwelling. In the
132 summer, waters at depth have decreasing dissolved oxygen levels that often reach hypoxic levels. This
133 is due to prevailing winds that are favorable to upwelling as well as high biological productivity.
134 Increases in the severity and frequency of hypoxia are projected to reduce species diversity, decrease
135 organism size, and decrease the efficiency of energy transfer between trophic levels (Miller et al., 2013).

136 Global climate models project that dissolved oxygen concentrations in the ocean will decline. As
137 ocean temperatures increase, the solubility of oxygen will decrease. The stratification of the ocean will
138 increase as a result of the surface water experiencing increasing temperature and decreasing salinity
139 (due to increasing freshwater input). The combination of these factors will reduce dissolved oxygen
140 concentrations as the denser water is not able to mix with surface waters and experiences longer
141 periods of respiration at depth (Miller et al., 2013).

142 [Sea level rise and flooding](#)

143 The temperature of the Earth and sea level are connected in multiple ways. As discussed above,
144 when water warms it expands slightly. This becomes significant when measured over the entire depth of
145 the oceans. Additionally, the volume of the water in the oceans can change based on changes in the
146 volume of water and ice on land. As glaciers and ice sheets melt due to increasing temperatures, this
147 will increase the volume of water in the oceans. Sea level rise is a threat to coastal communities
148 through shoreline erosion, contributions to coastal flooding, and inundation of low-lying land. Higher
149 sea level can also threaten coastal infrastructure as higher storm surges increase the likelihood of
150 flooding (U.S. Environmental Protection Agency, 2016).

151 Since 1993, average sea level has risen at a rate of 0.11 to 0.14 inches per year (U.S. Environmental
152 Protection Agency, 2016). Global sea level rise is projected to increase by 11 to 38 inches by 2100 as
153 compared to 1985 to 2005 levels (Snover et al., 2013).

154 Although global sea levels are rising and predicted to continue to do so, there are local and regional
155 factors that influence the amount of sea level rise that is predicted for the MSP Study Area. This
156 variability in sea level rise is greatly influenced by the fact that the Northwest is a geologically active
157 area with an active subduction zone. The subduction of the Juan de Fuca plate beneath the North
158 America plate forces vertical land motion that can either increase or decrease the overall rate of
159 regional sea level rise (Dalton, Mote, & Snover, 2013; Miller et al., 2013). On the Olympic Peninsula, the
160 coast has experienced vertical uplift at the same rate as sea level rise and there is the potential for a net
161 decrease in local observed sea level.² In other locations, subsidence of land may contribute to higher
162 sea level rise (Dalton et al., 2013).

² For the NW Olympic Peninsula coast, projected sea level rise ranges from -5" to 14" by 2050 and -9" to 35" by 2100. For the central and southern coast, projected sea level rise ranges from 1" to 18" by 2050 and 2" to 43" by 2100 (P. W. Mote, Petersen, Reeder, Shipman, & Whitely Binder, 2008)

163 Changing wind stress patterns may also impact sea level rise along the coast.³ Since approximately
164 1980, the North Pacific has been under PDO warm phase conditions. The associated predominant wind
165 stress patterns have regionally moderated sea level rise trends that were otherwise seen globally. If
166 there is a shift to PDO cold phase conditions, there may be higher rates of sea level rise along the West
167 Coast (Dalton et al., 2013).

168 A number of coastal impacts can result from sea level rise and affect the MSP Study Area. Some
169 low-lying areas will become permanently inundated depending on the shoreline characteristics and the
170 rate of sea level rise. Coastal rivers may also see increased flooding, both in the extent and depth of
171 flood waters, as it will be harder for rivers to drain into the ocean. High river flows are also expected to
172 increase in size and frequency as a result of climate change. Similarly, high tide and storm surge events
173 will be amplified as sea level increases. This in turn will expose more areas to erosion and potentially
174 threaten coastal infrastructure (Snover et al., 2013).

175 Storms and erosion

176 Scientists project storms to increase in both intensity and frequency on a global scale as a result of
177 climate change. Storms can directly impact the coast of the MSP Study Area, but even storms that are
178 further offshore can still impact the area by increasing wave heights and causing changes in wave
179 direction. These can cause erosion or redistribute sediment which alters shallow marine and intertidal
180 habitats (Miller et al., 2013). Global climate models project that storm tracks in the PNW will be driving
181 northward over time and there will be an increase in the intensity of the precipitation associated with
182 the storms. Other associated impacts are likely to include increasing wave heights and the potential for
183 large storm surges which could increase coastal erosion (Miller et al., 2013).

184 Overall, the erosion along the beaches in southwest Washington is influenced by reduced sediment
185 supply, gradual sea level rise, and a northward shift in Pacific winter storm tracks. The sandy ocean
186 beaches and dunes are shaped by a high-energy system with waves that shift seasonally in both energy
187 and direction. Beach erosion occurs when large waves meet the beach at a steeper angle from the
188 south. This is enhanced during El Niño conditions when the sea level is higher in the winter. As climate
189 change continues to shift conditions, it is likely that these erosion events will continue or increase due to
190 increasing sea level rise and winter storms. The Washington Coast has several areas of high erosion,
191 including Washaway Beach which has the fastest erosion on the Pacific coast. On average, Washaway
192 Beach has been losing 65 ft. of beach annually since the 1880s. (Climate Impacts Group, 2009).

193 Ocean acidification

194 Ocean acidification is a reduction in the pH of the ocean for an extended period of time that is
195 primarily caused by the uptake of carbon dioxide (CO₂) from the atmosphere. The ocean absorbs
196 approximately one-third of atmospheric CO₂ generated through human activities (Chan et al., 2016;
197 Marshall et al., 2017). Additional sources driving acidification in Washington include local input of
198 nutrients, nitrogen oxides and sulfur oxide gases, upwelling, and hypoxia. Since the mid-1700s, open
199 ocean surface waters have become approximately 30% more acidic (Chan et al., 2016; Feely, Klinger,
200 Newton, & Chadsey, 2012). Washington's coastal waters are projected to increase in acidity by 38% to
201 109% by 2100 when compared to levels from 1986-2005 (Snover et al., 2013). This correlates to an
202 increase of roughly 150% to 200% when compared to pre-industrial levels (Snover et al., 2013).

203 As ocean water becomes more acidic, the concentration of carbonate ion (CO₃²⁻) decreases.
204 Carbonate ion is required by many marine animals and some plants to build shells, skeletons, and other

³ Changes in atmospheric circulation can result in changes to wind stress.

205 hard parts by forming calcium carbonate. Calcium carbonate, usually in the form of calcite or aragonite,
206 is also susceptible to acidification as the water becomes more chemically corrosive. Aragonite is about
207 twice as susceptible to dissolution as calcite (Washington State Blue Ribbon Panel on Ocean
208 Acidification, 2012). Pteropods, corals, and most larval bivalves use aragonite to build their shells,
209 making them vulnerable to negative impacts from ocean acidification. In the northeast Pacific Ocean,
210 aragonite-corrosive conditions are expanding much more rapidly than calcite-corrosive conditions
211 (Washington State Blue Ribbon Panel on Ocean Acidification, 2012). Scientists predict ocean
212 acidification will have a significant impact on shellfish populations. By 2100, ocean acidification is
213 projected to reduce the rate at which mollusks form shells by 40% globally. It is also projected to cause
214 a 17% decline in growth and a 34% decline in survival (Snover et al., 2013).

215 Organisms that are not impacted by reduced calcification are still experiencing other negative
216 consequences from ocean acidification. Some species experience decreased growth, reproductive
217 issues, and increased mortality. These negative impacts are felt throughout the ecosystem as the
218 organisms normally provide habitat, shelter, and food for other organisms (Chan et al., 2016;
219 Washington State Blue Ribbon Panel on Ocean Acidification, 2012). One example is the food web
220 effects that may result from impacts to pteropods, which in some locations are showing signs of shell
221 dissolution in more than 50% of the population. Many West Coast fisheries species like herring,
222 mackerel, and salmon rely on pteropods as an important food source and are therefore vulnerable
223 indirectly to ocean acidification (Chan et al., 2016).

224 While ocean acidification due to absorption of CO₂ from the atmosphere is a global phenomenon,
225 there are local factors that increase the occurrence of regional acidification. Upwelling, nutrient and
226 organic carbon input from land, and absorption of other acidifying gases from the atmosphere all
227 contribute to ocean acidification on Washington's Pacific coast (Washington State Blue Ribbon Panel on
228 Ocean Acidification, 2012). Acidified waters are most prominent in the Northwest during the spring
229 through late summer, due to upwelling of corrosive waters from seasonally shifting winds. The acidified
230 waters are transported up to the continental shelf, reaching surface waters in some places, and entering
231 the estuaries. When acidified waters enter the estuaries, they can combine with inputs of nutrients and
232 organic matter creating conditions that are even more corrosive than the waters off the coast. This
233 acidification of coastal waters, especially within the estuaries, is a threat to the shellfish aquaculture in
234 the region (Dalton et al., 2013).

235 Harmful algal blooms

236 Harmful algal blooms (HABs) are blooms of algae that can produce natural toxins that cause illness
237 or death in humans and other animals. The algae can become concentrated in the flesh of filter feeding
238 shellfish and fish. Human and animal exposure may occur through consumption of contaminated fish
239 and shellfish, inhalation, or skin contact with contaminated water. Two of the main HABs in Washington
240 are paralytic shellfish poisoning (PSP) caused by dinoflagellates in the genus *Alexandrium* and amnesiac
241 shellfish poisoning caused by domoic acid created by diatoms *Pseudo-nitzschia* (Climate Impacts Group,
242 2009; Washington State Department of Fish and Wildlife, 2015).

243 HABs on the coast are considered a natural event. However, HAB magnitude, frequency, and
244 duration are influenced by climate change through sea surface temperature and upwelling. In general,
245 phytoplankton growth is determined by temperature, light, and the availability of nutrients. However,
246 all HAB species will not respond in the same way to shifts in climate change factors. Marine HAB
247 dinoflagellates are expected to have an advantage as climate changes, because they are able to swim
248 and therefore reach nutrients in the deeper parts of the water column that other phytoplankton cannot
249 reach (Climate Impacts Group, 2009).

250 Over the last 30 years, the frequency and distribution of HABs has increased. There has also been a
251 resulting increase in human illness due to algal sources. The rising air and sea surface temperatures that
252 are predicted with climate change may promote earlier and longer lasting HABs. In addition to
253 increasing temperatures, HABs may be influenced by wind-driven upwelling and nutrients supplied by
254 land runoff. Runoff into coastal estuaries may shift due to changes in the timing of snowmelt and
255 freshwater inputs (Climate Impacts Group, 2009).

256 *Ecological impacts*

257 While it is challenging to project the responses of different species to the effects of climate change,
258 certain types of responses are expected to occur. The physical and chemical changes in the ocean that
259 result from climate change have a strong impact on the physiology and behavior of marine organisms.
260 These effects are both direct and indirect and can also drive population and community level changes
261 that alter how an ecosystem is structured and functions (Doney et al., 2012). Changes in the
262 environment due to climate change could alter the structure and relationships between predators, prey,
263 parasites, and competitors in a community and, therefore, impact the productivity of the community
264 (Miller et al., 2013).

265 Another result of changes to the physical environment may be shifts in certain phases of the life
266 cycles of organisms. These shifts in life cycles will not only impact the organisms themselves, but may
267 alter predator and prey relationships and lead to larger changes on the ecosystem scale. Scientists have
268 already document shifts in timing of phytoplankton blooms, which can impact organisms up the food
269 chain. Organisms at higher trophic levels are highly dependent on phytoplankton blooms and often rely
270 on them during a short time period in their life cycle (Miller et al., 2013).

271 Species shift the areas where they live, also referred to as their range, as climate changes and local
272 conditions change. If new conditions become too extreme, some species will be able to shift to
273 locations with more favorable conditions. Studies have documented shifts in species ranges as a result
274 of changes in temperature. Fish species have been documented to respond to warming ocean
275 temperatures by moving north to cooler waters or by moving to deeper waters (Miller et al., 2013). As a
276 result of shifting ranges, some non-native species may move into new territories as they respond to
277 changing conditions. These non-native species have the potential to cause significant impacts through
278 ecological impacts to the food web (Miller et al., 2013).

279 While the same basic climate forces will be changing everywhere in the MSP Study Area and
280 adjacent areas, each region will respond differently. The substrate, slope, and surrounding conditions
281 will influence the impacts of climate change. The changes in climate will be experienced in different
282 ways on the coast north of Point Grenville with steep rocky shores, the coast south of Point Grenville
283 with sandy beaches with shallow slopes and high energy waves, and the estuaries with shallow water
284 and protected bays and mudflats (Climate Impacts Group, 2009; Dalton et al., 2013). Some specific
285 ecological impacts related to the various habitats of the MSP Study Area are discussed below.⁴

286 *Pelagic*

287 Pelagic habitats and the organisms that occupy them are expected to experience changes due to
288 climate change factors including acidification, reduced oxygen events, shifts in metabolism due to ocean
289 temperature changes, and changes in patterns of storminess or waves (Miller et al., 2013). Increasing
290 surface water temperatures may increase stratification in the water column and, therefore, decrease

⁴ More information on the habitats discussed here are available in Section 2.1 Ecology of Washington's Pacific Coast.

291 primary productivity by reducing mixing with nutrient-rich waters. However, increases in upwelling
292 winds could increase mixing and counteract the stratification. Shifts in primary productivity related to
293 changes in upwelling can impact the entire food web. Some plankton, like larval oysters and pteropods,
294 that need calcium carbonate to build their shells will experience negative impacts from ocean
295 acidification while other plankton like euphasiids may benefit from increasing water temperatures
296 (Miller et al., 2013).

297 Pelagic fishes will likely be impacted by any changes in the zooplankton communities discussed
298 above. However, the specific impacts are unclear since pelagic fish species rely on different varieties of
299 zooplankton. It is unknown how changes in the prey availability will impact them as some fish may
300 benefit from the changes while others may suffer from a decrease in their food source. Most pelagic
301 fishes do experience reductions in population due to reduced oxygen in the California Current. The
302 cumulative impacts of potential reductions in prey and oxygen could have serious consequences for
303 pelagic fishes (Miller et al., 2013).

304 *Seafloor*

305 The seafloor and deep water habitats are likely to be impacted by the changes in ocean
306 temperature, ocean acidification, hypoxia, and surface productivity that are associated with climate
307 change. The deep sea corals that are found in the MSP Study Area are especially impacted by changes in
308 the water temperature and acidification as they use aragonite to form their skeletons. Any resulting loss
309 of corals would have an impact on the many species of fish and invertebrates that rely on them for
310 habitat (Miller et al., 2013; Skewgar & Pearson, 2011).

311 Deepwater fishes may suffer loss of suitable habitat and decreased populations if the hypoxic or
312 anoxic zones expand, or if the frequency of events increases. While benthic fish populations may
313 decrease as a result of changes in primary productivity, species ranges, zooplankton community
314 structure, acidification, and hypoxia, other organisms may experience population increases. Ecological
315 models of food webs predict increases in biomass of benthic and pelagic invertebrates as the biomass of
316 benthic fish decreases (Miller et al., 2013).

317 *Kelp forest*

318 Kelp forests are an important biogenic habitat in the MSP Study Area and support a variety of
319 organisms. Increasing ocean temperatures are likely to impact kelp physiology, growth, reproduction,
320 and competitive interactions. The exact impacts depend on the timing and duration of temperature
321 changes. Some non-native species may be able to move north into MSP Study Area waters as a result of
322 increasing temperatures. All marine algae species may experience benefits due to ocean acidification as
323 an increase in available CO₂ could benefit their productivity. However, it is unclear if the benefits of
324 increasing CO₂ would exceed any of the consequences caused by increasing ocean temperature.
325 Increasing storm intensity has the potential to impact kelp forest habitats by shifting the availability of
326 large hard substrates needed for attachment and damaging seagrasses through wave action (Miller et
327 al., 2013).

328 *Rocky shores*

329 Climate change is likely to cause stress to intertidal organisms that have limited vertical ranges due
330 to the stress of heat and exposure above and from predators below. These organisms may be forced
331 lower into the intertidal zone to adjust to increased air temperatures. However, their predators may be
332 able to move higher into the intertidal due to sea level rise increasing the potential for predation.
333 Intertidal organisms will also be threatened by increasing storms and wave energy, erosion, and

334 increased sediment delivery from rivers. Ocean acidification also threatens many intertidal organisms
335 that may have declining survival rates based on inability to form shells. This could lead to a shift in the
336 intertidal community structure as other organisms, like algae, can thrive with increasing CO₂ in the
337 water (Miller et al., 2013).

338 *Sandy beaches*

339 As discussed above, sandy beaches are likely to experience many physical impacts from climate
340 change. Sandy beaches offer habitat that supports prey for foraging birds, spawning habitat for forage
341 fish, and haul-out areas for marine mammals, but this may be lost if erosion causes beach areas to
342 coarsen and steepen due to increasing erosion and storm intensity and frequency (Miller et al., 2013).

343 *Large coastal estuaries*

344 Many of the key factors that drive the functioning of estuaries are affected by climate change.
345 Changes in the annual precipitation, sea level, winds, and seasonal runoff will all impact estuaries.
346 Flooding, erosion, coastal inundation, and saltwater intrusion into freshwater aquifers are predicted to
347 occur as climate changes (Skewgar & Pearson, 2011). A reduction in estuarine habitats like tidal flats,
348 estuarine, and outer coast beaches will impact associated animals like forage fish and shorebirds (Dalton
349 et al., 2013).

350 Some of the impacts on the plant and animal life dependent on estuaries include wild and farmed
351 shellfish harmed by acidifying waters and eelgrass and kelp suffering from changes in benthic nutrient
352 cycling (Skewgar & Pearson, 2011). Increases in the occurrence of hypoxic or anoxic conditions in the
353 estuaries would impact the distribution, abundance, and community composition of zooplankton. As
354 sea level rise causes inundation, estuaries will likely experience habitat changes such as migration, loss,
355 or expansion of certain habitats, thus impacting the overall composition of habitats within estuaries.
356 For example, loss of intertidal habitat due to sea level rise would impact Dungeness crab populations.
357 Dungeness crab rely on estuaries as nursery areas for juveniles and foraging grounds for subadults and
358 are also susceptible to changes from ocean acidification, and hypoxia (Miller et al., 2013).

359 *Existing uses*

360 The impacts of climate change on the environment and ecological resources of the MSP Study Area
361 are likely to affect current uses like fisheries, recreation and tourism, aquaculture, transportation, and
362 tribal uses. The section below highlights some of the possible effects, however projections are still
363 limited due to uncertainty about the degree of climate change expected and degree of vulnerability, as
364 well as adaptability. For more information about these current uses please see Sections 2.4-2.7.

365 *Commercial, recreational, and tribal fisheries*

366 Climate change and the associated changes in the oceanic conditions are potential threats to
367 commercial, recreational, and tribal fishing in the MSP Study Area. Ocean acidification is particularly
368 concerning for shellfish populations, such as Dungeness crab and shrimp. As the ocean chemistry
369 changes, shellfish experience slower growth rates, thinner shells, and higher mortality rates
370 (Washington State Blue Ribbon Panel on Ocean Acidification, 2012). Shellfish have also been found to
371 be more vulnerable when they are young. For example, in lab experiments juvenile crab experience
372 drastically increasing mortality under increasing ocean acidification (Welch, 2013). Fisheries that rely on
373 crab, oysters, and other shellfish could potentially experience great consequences as a result of ocean
374 acidification (Industrial Economics Inc., 2014a). Ocean acidification does not just impact fisheries that
375 rely on organisms that are directly affected, but also other organisms that are indirectly affected

376 through the food web. For example, juvenile salmon rely on pteropods as an important source of food,
377 and pteropods experience reduced shell-building and growth rates due to ocean acidification (Industrial
378 Economics Inc., 2014a; Washington State Blue Ribbon Panel on Ocean Acidification, 2012). A decrease
379 in an important food source could reduce salmon populations and, in turn, impact the salmon fisheries.

380 Finfish fisheries are likely to experience varied seasons as ocean conditions shift, although the
381 specific impacts are unclear at this time. As the ocean temperature rises, it will impact the distribution
382 and availability of commercial fish species. Fish populations may shift their range as a result of changing
383 temperatures and availability of prey species. Shifting population numbers and ranges can have a
384 significant impact on the fisheries that rely on them (Taylor, Baker, Waters, Wegge, & Wellman, 2015).

385 Recreation and tourism

386 Recreation and tourism in the MSP Study Area also has the potential to be impacted by some
387 aspects of climate change. Increasing storms and erosion are concerns for coastal locations, particularly
388 along the southern coast. Increased erosion can damage or destroy recreational facilities and areas.
389 State parks and other recreational beaches and facilities in southwest Washington are already
390 experiencing erosion and loss of facilities (Industrial Economics Inc., 2014b).

391 Another potential issue for the recreation and tourism industry could result from an increase in
392 HABs due to climate change. The recreational shellfish fishery has great economic benefits for coastal
393 communities and the state (Taylor et al., 2015). Occurrences of HABs are projected to shift in frequency,
394 intensity, and duration as a result of rising temperatures and changes in upwelling (Climate Impacts
395 Group, 2009). An increase in HABs could lead to more closures of recreational shellfish harvesting to
396 protect human health and result in negative economic consequences (Dyson & Huppert, 2010).

397 Aquaculture

398 Shellfish aquaculture is vulnerable to the effects of climate change in a variety of ways. Increased
399 sea surface temperature has the potential to negatively impact shellfish growth, reproduction,
400 distribution, and health (Climate Impacts Group, 2009). Ocean acidification is already impacting the
401 aquaculture industry and is projected to continue to worsen. Commercial shellfish species suffer under
402 conditions that are corrosive and decrease their ability to form, build, and maintain their shells.
403 Shellfish farmers are already experiencing increased costs to deal with acidifying coastal waters and the
404 increase in larval oyster mortality (Washington State Blue Ribbon Panel on Ocean Acidification, 2012).

405 Sea level rise may also negatively affect shellfish aquaculture by shifting habitat types and increasing
406 water coverage of growing areas. This is a concern for shellfish growers, especially those that operate
407 directly on intertidal substrate, as it may result in reduced access to shellfish beds, unless the beds move
408 landward. If the shellfish beds remain in the same location, increased water coverage would reduce the
409 time available for harvest as the beds would be submerged for a greater part of the day. If sea level rise
410 causes beach profiles to shift landward, there is no guarantee that a grower will have access to the
411 property with the preferred beach profile as it may shift off their property or leased area. This will
412 become a property rights issue to be addressed as sea level rise occurs and intertidal areas shift (Climate
413 Impacts Group, 2009).

414 The impact of climate change on the occurrence of HABs and the relationship to shellfish is
415 discussed above. If HAB outbreaks increase as predicted due to climate change, there is the potential
416 that commercial shellfish operations will experience more closures or restrictions to prevent human
417 health impacts (Climate Impacts Group, 2009).

418 Transportation, navigation, and infrastructure

419 Ports and marinas will likely experience impacts to their infrastructure and operations due to sea
420 level rise associated with climate change. Ports and marinas may need to adjust or reconstruct piers
421 and structures to address sea level rise. Land-based port facilities may also be impacted by sea level rise
422 and erosion and require adaptation to maintain full functioning of the facilities. The transportation
423 systems that surround and support ports may also have negative consequences to their infrastructure
424 that impact the port operations (Climate Impacts Group, 2009). Sediment loading from upstream
425 erosion has the potential to affect ports and marinas by restricting boat access to and from the ocean.
426 This may be overcome with increased dredging at additional effort and expense to the port (Industrial
427 Economics Inc., 2014b).

428 Tribal uses

429 Tribal economies, traditions and treaties are heavily reliant on place-based natural resources. This
430 makes them disproportionately susceptible to the negative consequences of climate change (P. Mote,
431 2015). In a study conducted through interviews with members of three Northwest tribes, Mote (2015)
432 found that climate change may cause a shift in cultural traditions. Some aspects of tribal culture
433 including songs, stories, prayers, and dances include natural resources that may be affected by climate
434 changes. Additionally, the study found that seasonal changes due to climate change are impacting
435 traditional activities as most are tied to an environmental cue rather than a specific date. This issue has
436 become problematic and makes it challenging to rely on traditionally held information about cultural
437 activities. However, all the tribes that participated in the study were continuing with their traditional
438 cultural ways but had adapted with changes or alterations when necessary (P. Mote, 2015).

439 Economic impacts

440 The various uses of the MSP Study Area are likely to experience a range of economic impacts due to
441 climate change. As discussed throughout this plan, the areas adjacent to the MSP Study Area receive
442 great economic benefits from marine resources and the associated uses and industries. The combined
443 effects of sea level rise, ocean acidification, and an increased likelihood of extreme weather events are
444 likely to have very costly consequences for coastal systems and communities. Communities that are
445 highly dependent on marine resources, like those adjacent to the MSP Study Area, are going to be
446 challenged to adapt to a changing climate (Dalton et al., 2013). It is complex to consider quantifying the
447 economic impacts of climate change in and adjacent to the MSP Study Area. A few examples of
448 potential economic impacts are included in this section.

449 Coastal uses that rely on shellfish populations are especially vulnerable to climate change and
450 particularly the impacts of ocean acidification. Washington is the country's leading producer of farmed
451 oysters, clams, and mussels with total annual farmed shellfish sales of over \$107 million. Shellfish
452 growers in Washington directly or indirectly employ more than 3,200 people (Washington State Blue
453 Ribbon Panel on Ocean Acidification, 2012). In addition to the aquaculture industry, ocean acidification
454 threatens recreational shellfish harvesting and the economic benefits that brings to coastal
455 communities. Recreational clam and oyster harvests account for \$27 million in annual impacts to
456 coastal economies as well as \$3 million in state revenue from licensing (Washington State Blue Ribbon
457 Panel on Ocean Acidification, 2012). One grower has moved hatchery operations to Hawaii to avoid the
458 impacts of ocean acidification on the oyster larvae. The associated costs are obviously great and not all
459 growers will have the means to relocate hatcheries. For growers that do not own a hatchery, but
460 purchase oyster spat, they will still likely face increased costs passed down from hatchery owners
461 (Taylor et al., 2015). Shellfish growers may also experience economic impacts as a result of sea level
462 rise. As discussed above, additional water coverage of growing areas will decrease harvest time
463 available and reduce workdays for growers (Taylor et al., 2015).

464 Increasing HABs will likely lead to an increase in recreational and commercial shellfish fishery
465 closures. This would reduce or eliminate related visitor spending during the closures. Dyson and
466 Huppert (2010), conducted a study to measure the changes in the local economy of Pacific and Grays
467 Harbor counties due to reduced visitor expenditures during HAB closures of recreational shellfish
468 fisheries. They found that a single beach closure for an average opening (typically 2-5 days) of all
469 beaches to be an expenditure reduction of \$4 million dollars (2008 dollars) and for a whole season
470 closure (October through April) to be an expenditure reduction of \$20.4 million dollars (2008 dollars)
471 (Dyson & Huppert, 2010). Although the impacts of a HAB closure may be more complex than this as
472 tourists may shift their vacation to a different coastal community or alter their spending in some other
473 way, it does indicate that HABs could have a significant economic impact on coastal communities (Dyson
474 & Huppert, 2010).

475 Commercial and recreational fisheries are also predicted to experience economic consequences of
476 climate change. The specific effects are challenging to assess though, as different species will vary in
477 their responses to climate change with changes in distribution, abundance, and productivity. This will in
478 turn impact the level, composition, and value of landings (Dalton et al., 2013). Dungeness crab and pink
479 shrimp are both expected to be affected by ocean acidification. Dungeness crab is one of the main
480 commercial fisheries in Washington, providing the highest ex-vessel value per weight landed, so the
481 economic impacts could be severe. Salmon fisheries could also be impacted as water temperatures
482 increase and become inhospitable to species that prefer cooler water (Taylor et al., 2015).

483 *Summary*

484 Climate change and the resulting shifts in oceanic and atmospheric conditions are likely to have
485 widespread impacts on the MSP Study Area. Scientists predict that climate change will bring changes in
486 air temperature, precipitation, water temperature, sea level, ocean pH, storminess, harmful algal
487 blooms, and hypoxia. However, it becomes more challenging to accurately predict the magnitude of the
488 impacts as it depends on the interplay of many different factors. The economy of the coastal areas
489 adjacent to the MSP Study Area is highly influenced by the ocean economy and likely to experience
490 impacts due to climate change.

491 As climate change continues and the impacts are felt throughout the MSP Study Area and beyond,
492 this may influence the demand for new ocean uses addressed in this MSP. New uses may be seen as a
493 way to offset the impacts of climate change. Offshore renewable energy could be one method of
494 meeting increasing energy demands while decreasing emissions of greenhouse gases. Offshore
495 aquaculture may be used to address climate change impacts on shore-based aquaculture. Dredge
496 disposal and sand and gravel mining may be used to address erosion issues along the shoreline through
497 beach restoration. The effects of climate change on the ecological and human communities and existing
498 uses of the MSP Study Area will need to be considered and addressed as any new uses for the area are
499 considered.

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Marine Spatial Plan for Washington's Pacific Coast

Section 3: Spatial Analyses

- 3.1. Seabird and Marine Mammal Modeling
- 3.2. Ecologically Important Areas Analysis
- 3.3. Use Analysis

1 Chapter 3: Introduction

2 As part of the Marine Spatial Planning process, the interagency team commissioned several analyses
3 to provide additional information relevant to present and potential future conditions in the study area.
4 Analyses were selected fill known data gaps, and to fulfill several of the requirements outlined in RCW
5 43.372.040(6)(c). Results of these analyses include data products, previously not available through
6 empirical datasets alone, that inform and support many of the spatial and management
7 recommendations outlined in the plan.

8 This chapter will not provide specific recommendations, which are described in detail in the
9 management framework presented in Chapter 4. Rather, it briefly describes the data, tools and methods
10 used to perform analyses that have contributed to the development of these recommendations and the
11 planning process as a whole. In addition, each section also provides a brief overview of important
12 results, and highlights some of the products from three projects completed to support the Marine
13 Spatial Planning process in Washington:

- 14 1) Ecological modeling of seabird and marine mammal distribution by NOAA
- 15 2) Ecologically Important Areas (EIA) modeling by WDFW
- 16 3) A use analysis comparing the location and intensity of existing uses with technical suitability for
17 offshore renewable energy

18 19 3.1: Seabird and Marine Mammal Modeling

20 The National Centers for Coastal and Ocean Science (NCCOS) at NOAA conducted several analyses
21 for the state planning process, including developing ecological models of predicted seabird and marine
22 mammal distribution within the study area. It is important to note that this process did not predict
23 abundance but rather relative density. The resulting maps show where in the study area one would
24 expect to find the highest density of each species, rather than predicting the number of animals actually
25 present in the planning area or comparing abundance numbers across species.

26 NCCOS produced ecological models for eight species of birds and six species of marine mammals.
27 Species were selected for analysis by the Washington Department of Fish and Wildlife (WDFW) because
28 they are either of management concern (such as threatened or endangered species), or are
29 representative of groups of species with important life history strategies or ecological functions. Seabird
30 species included the Marbled Murrelet (*Brachyramphus marmoratus*), Tufted Puffin (*Fratercula*
31 *cirrhata*), Common Murre (*Uria aalge*), Black-footed Albatross (*Phoebastria nigripes*), Northern Fulmar
32 (*Fulmarus glacialis*), Pink-footed Shearwater (*Puffinus creatopus*), Sooty Shearwater (*Puffinus griseus*),
33 and Rhinoceros Auklet (*Cerorhinca monocerata*). An analysis for Short-tailed Albatross, also a listed
34 species, could not be completed because of insufficient data.

35 Maps of marine mammals included two species of pinniped, the Steller Sea Lion (*Eumetopias*
36 *jubatus*) and Harbor Seal (*Phoca vitulina*), and four species of cetaceans: the Humpback Whale
37 (*Megaptera novaeangliae*), Gray Whale (*Eschrichtius robustus*), Harbor Porpoise (*Phocoena phocoena*)
38 and Dall's Porpoise (*Phocoenoides dalli*). Insufficient observations were available to produce models for
39 the Sei Whale (*Balaenoptera borealis*), Blue Whale (*Balaenoptera musculus*), Fin Whale (*Balaenoptera*
40 *physalus*), Southern Resident Killer Whale (*Orcinus orca*) or Sperm Whale (*Physeter macrocephalus*).

1 This section summarizes the data and general methods used to create the relative density maps, and
 2 highlights some key results. Reports from NCCOS covering additional technical details and maps for all
 3 species are available (Menza et al. 2016).

4 *Data Sources*

5 NCCOS staff and other contributors synthesized information from eleven existing monitoring
 6 programs that have collected data on sightings of species within the planning area (Table 3.1). While all
 7 of these programs overlap with the study area, they vary in geographic extent and years of operation.
 8 For this study, data collected between 2000 and 2013 within or just beyond the study area boundary
 9 was used. All observations were made at sea from ships or aircraft, typically along transects ranging in
 10 length from 25 kilometers to several hundred kilometers.

11

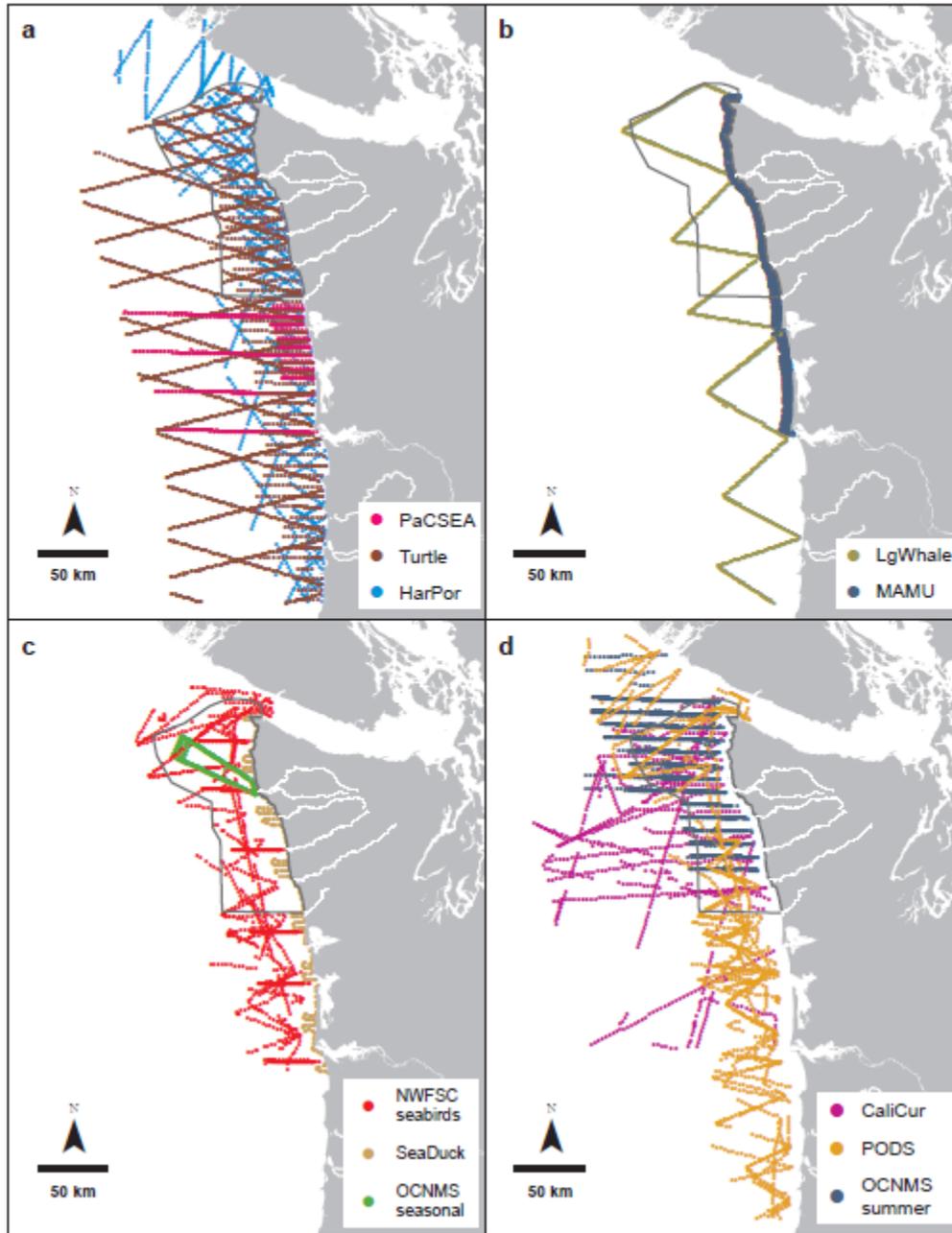
12 **Table 3.1: Summary of seabird and mammal survey data compiled by NCCOS for the distribution analysis.**

Survey Name	Data Collectors	Data Category
Harbor porpoise surveys	Cascadia Research Collective, NOAA Alaska Fisheries Science Center	Mammals
Leatherback turtle aerial survey	NOAA Southwest Fisheries Science Center	Mammals
Pacific Continental Shelf Environmental Assessment (PaCSEA)	USGS Western Ecological Research Center, Bureau of Ocean Energy Management	Birds and Mammals
California Current Ecosystem Surveys (includes ORCAWALE and CSCAPE surveys)	NOAA Southwest Fisheries Science Center	Birds and Mammals
Northwest Fisheries Science Center Northern California Current Seabird Surveys	NOAA Northwest Fisheries Science Center	Birds
Olympic Coast National Marine Sanctuary Seabird and Marine Mammal Surveys	Cascadia Research Collective, Olympic Coast National Marine Sanctuary, NOAA Southwest Fisheries Science Center	Birds and Mammals
Pacific Coast Winter Sea Duck Survey	Sea Duck Joint Venture, Washington Dept of Fish and Wildlife	Birds
Pacific Orcinus Distribution Survey (PODS)	NOAA Northwest Fisheries Science Center	Mammals
Large whale surveys off Washington and Oregon	Cascadia Research Collective, Washington Dept of Fish and Wildlife, Oregon Dept of Fish and Wildlife	Mammals
Northwest Forest Plan Marbled Murrelet Effectiveness Monitoring Program	US Forest Service, US Fish and Wildlife Service, Washington Dept of Fish and Wildlife	Birds and Mammals
Seasonal Olympic Coast National Marine Sanctuary seabird surveys	NOAA Olympic Coast National Marine Sanctuary	Birds

13

14 Figure 3.1 provides an overview of the spatial coverage of bird, cetacean, and pinniped surveys used
 15 in modeling. Through additional analysis of the location and timing of transects, NCCOS also identified
 16 seasonal patterns in survey effort for the study period. Effort per square kilometer was more
 17 concentrated in the northern section of the study area for birds and mammals during the summer,
 18 whereas winter bird survey effort was more evenly distributed from north to south.

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Figure 3.1: Spatial distribution of surveys from 11 programs used in bird and mammal models. The gray line in each frame indicates the boundaries of the Olympic Coast National Marine Sanctuary. Additional details on this figure and its source data provided in the final NCCOS report (Menza et al 2016).

Numerous datasets describing environmental and temporal parameters were used as predictor variables in the modeling process. Environmental predictors examined included geographic, topographic, oceanographic, and biological information, either collected as part of survey data or acquired by NCCOS from other sources. Table 3.2 summarizes the full list of predictor variables assessed. For analysis, all spatial datasets were averaged or extrapolated to a resolution of 3km. Additional details about data sources, data selection, and processing steps for individual predictor variables are provided in the final report (Menza et al. 2016).

1 **Table 3.2: Summary of ecological predictor variables incorporated into distribution models.**

Geographic variables	Topographic Variables	Temporal Variables	Oceanographic Variables	Survey Variables
<ul style="list-style-type: none"> • Coordinates (X,Y) • Distance to key habitats like colonies or haul-outs for: <ul style="list-style-type: none"> - Tufted Puffin - Common Murre - Marbled Murrelet - Steller sea lion - Harbor seal 	<ul style="list-style-type: none"> • Depth • Bathymetric position indices • Profile curvature • Planform curvature • Slope 	<ul style="list-style-type: none"> • Julian Day • Year • Upwelling index • Indices for: <ul style="list-style-type: none"> - El Niño-Southern Oscillation - North Pacific Gyre Oscillation - Pacific Decadal Oscillation 	<ul style="list-style-type: none"> • Probability of cyclonic and anticyclonic eddy rings • Sea surface salinity • Sea surface temperature • Probability of sea surface temperature front • Surface chlorophyll <i>a</i> • Frequency of chlorophyll peaks index 	<ul style="list-style-type: none"> • Survey platform • Beaufort Sea State (marine mammals only) • Survey ID • Transect ID

2

3 *Methods*

4 In order to standardize and synthesize information from programs with diverse procedures for
 5 recording and collecting observations, datasets were first processed using a series of steps outlined in
 6 detail in the final project report (Menza et al. 2016) Data was sorted into summer (April to October) or
 7 winter (November to March) seasons based on the assumption that distribution patterns are affected by
 8 seasonal differences in environmental conditions or animal behavior. Statistical modeling was used to
 9 identify the ecological variables from Table 3.2 that best predict density for each species and season
 10 combination. To account for variations in observations due to survey methods and timing, the models
 11 also incorporated variables related to survey methods and conditions, such as weather and whether a
 12 survey was done from a boat or from aircraft. For most species, sufficient data was not available to
 13 conduct analysis for the winter period. Models and maps were produced for the Common Murre,
 14 Rhinoceros Auklet, and Black-footed Albatross for both seasons, and for summer only for all other bird
 15 and mammal species.

16 NCCOS produced multiple models for each species and season, and then used various diagnostic
 17 tools to assess and compare model performance before making a final selection. After identifying the
 18 best available model, further diagnostic steps included identifying limitations and caveats applicable to
 19 the results for each species.

20 After selecting a final model for each season and species combination, the outputs of each model
 21 were mapped to illustrate the areas of highest and lowest long-term relative predicted density. NCCOS
 22 also generated maps showing where in the planning area the coefficient of variation is highest for each
 23 species based on data inputs and model evaluations. These maps provide a mathematical and spatial
 24 representation of uncertainty. Areas with higher coefficients had a greater amount of variability in
 25 results, and therefore have a higher amount of uncertainty associated with how well model predictions
 26 align with the actual distribution of species. For detailed performance results and uncertainty
 27 information for each model, please refer to Appendix C of the final report (Menza et al. 2016).

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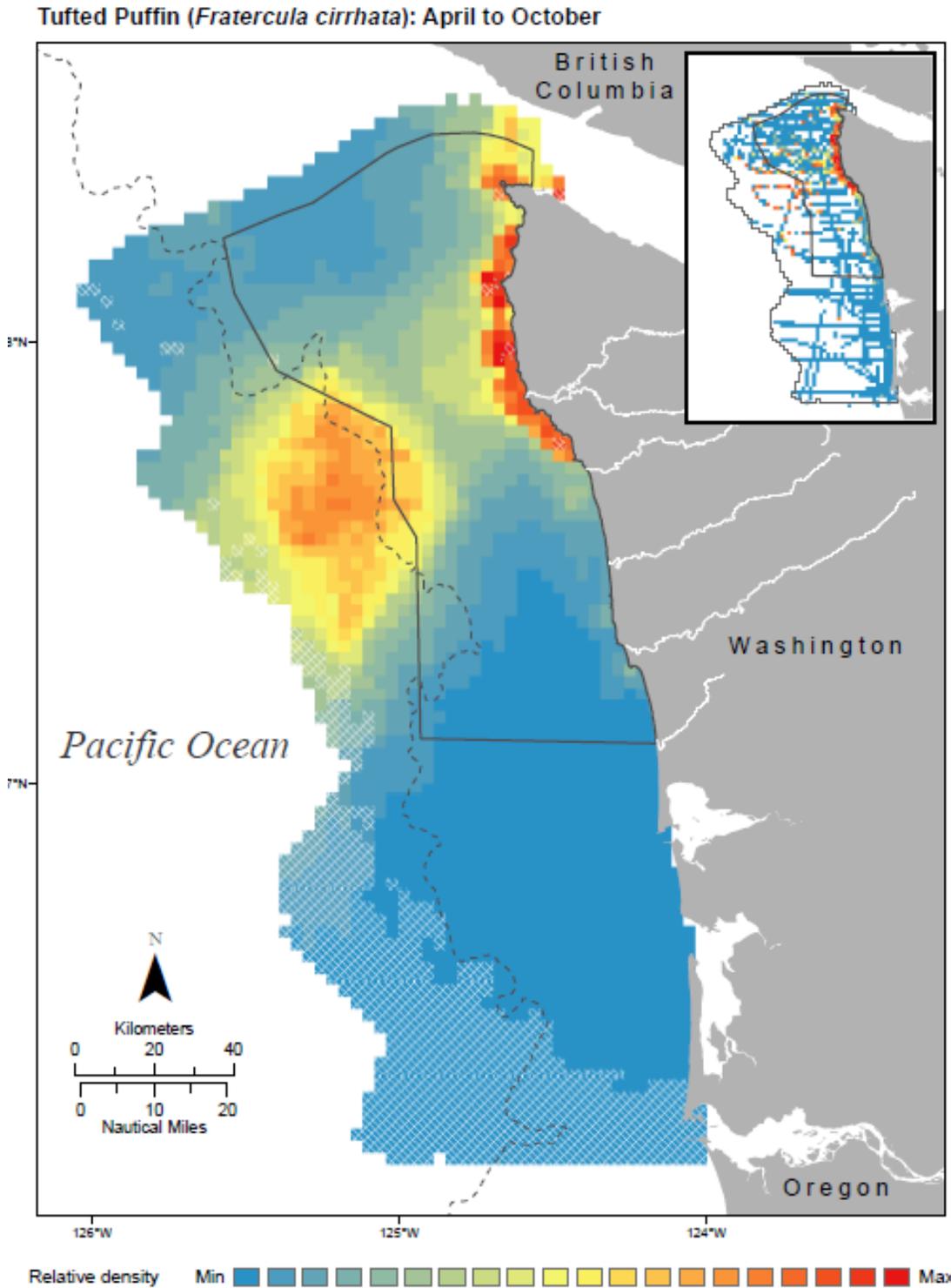
1 *Results*

2 The output maps from NCCOS provide general predictions for areas of highest and lowest density of
3 the selected species at a broad scale using extensively evaluated models. However, all models have
4 inherent uncertainties and limitations. While each model was assessed to ensure that it provides the
5 best possible representation of relative density at the planning scale based on available data, all maps
6 should be considered in the context of uncertainty and other available data and expertise.

7 Figures 3.2 and 3.3 provide examples of maps produced for each species and season combination.
8 The species presented in this chapter are of particular interest because of their conservation status, or
9 because they represent datasets that are particularly robust or can be representative of patterns seen in
10 other species. Figure 3.2 illustrates the best long-term density prediction for Tufted Puffin, a nearshore
11 species, in summer. This best prediction model represents the median of predicted values, and is shown
12 with an overlay depicting uncertainty and an inset showing survey coverage and species density for
13 actual field observations. Uncertainty varied greatly by species, and any interpretation of distribution
14 information from a specific model should include careful consideration of areas with high coefficients of
15 variation, particularly if assessing a specific site.

16 In addition to the best prediction median map (a), Figure 3.3 presents a spatial representation of
17 uncertainty based on the coefficient of variation (b), and two quantile maps (c and d). The quantile maps
18 show two additional potential distributions based on different levels of statistical confidence, which
19 could be of interest in cases where a more or less conservative approach to predictions is desired.
20 NCCOS produced each of these images for all models.

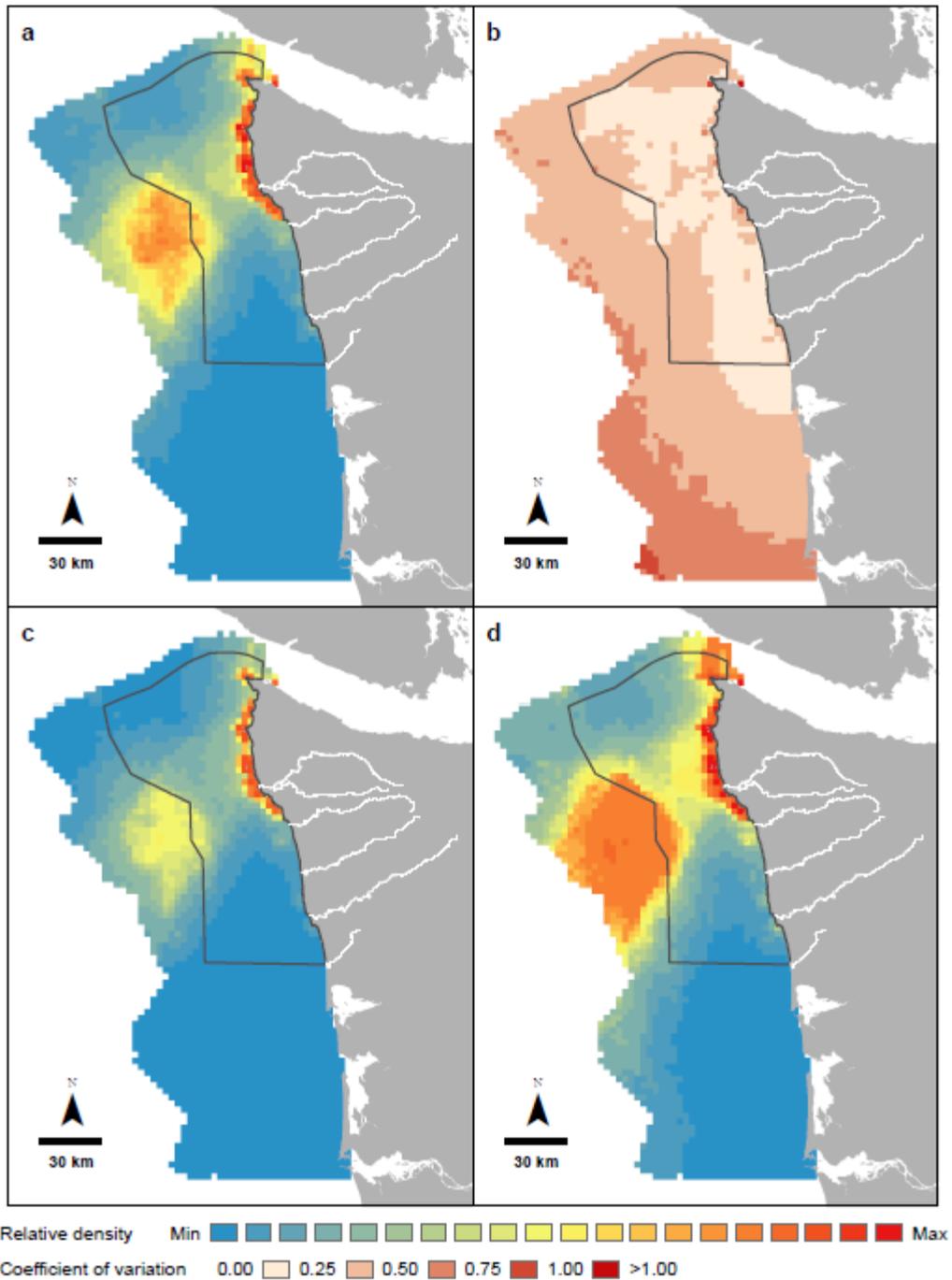
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Figure 3.2: Long-term predicted relative density for Tufted Puffin, summer. White cross-hatching indicates areas where the model has a coefficient of variation greater than 0.5 (relatively higher uncertainty). Gray line indicates the boundaries of the Olympic Coast National Marine Sanctuary, and inset shows observed density from surveys. Original figure and additional detail provided in the NCCOS final report (Menza et al 2016).

Tufted Puffin (*Fratercula cirrhata*): April to October



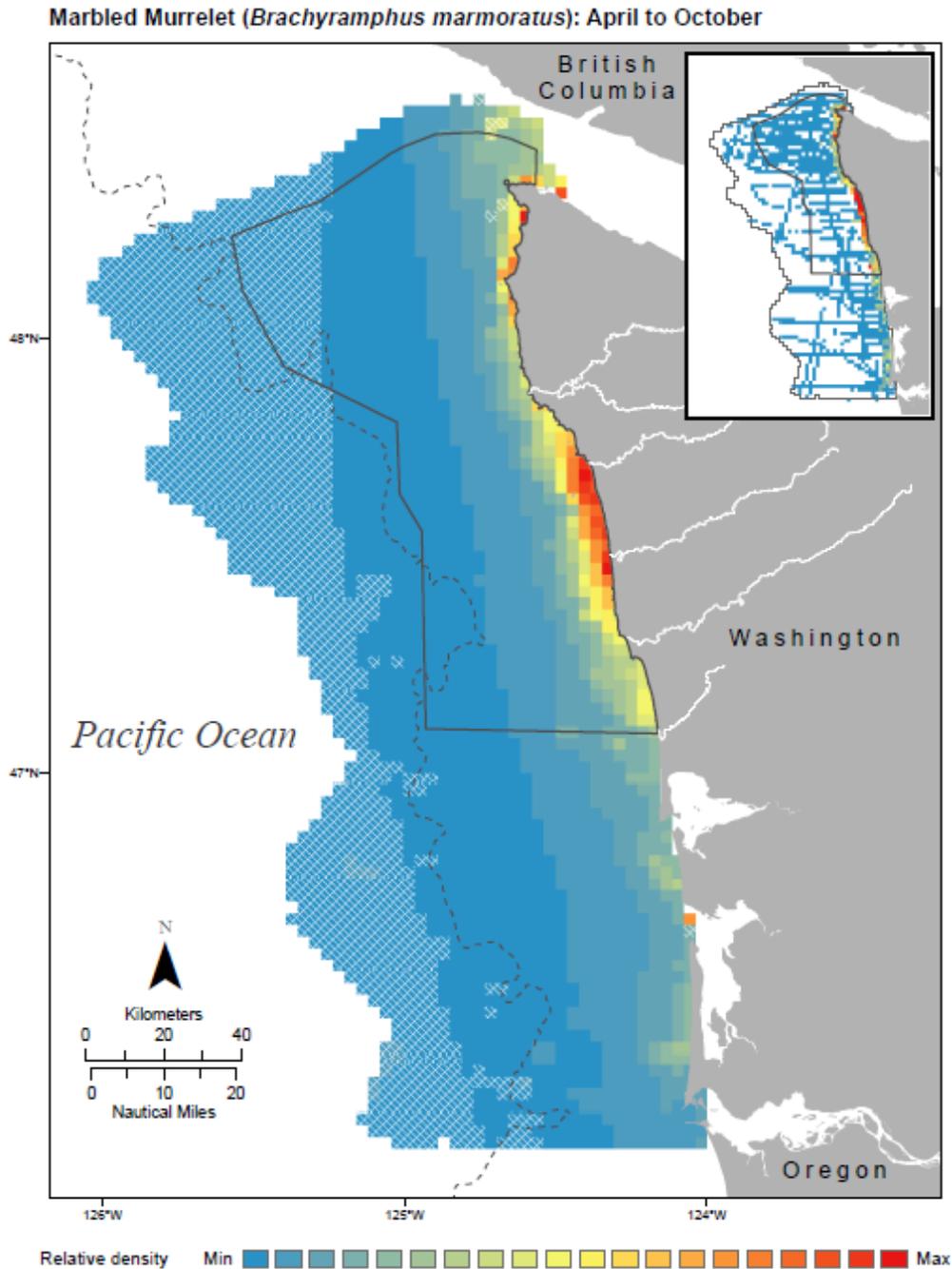
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Figure 3.3: Predicted long-term relative density for Tufted Puffin, summer, based on a) the median of predictions, c) a 5% quantile, and d) a 95% quantile. b) a spatial illustration of coefficients of variation for the model (a measure of uncertainty). Original figure and additional explanation of quantiles provided in the NCCOS final report (Menza et al 2016).

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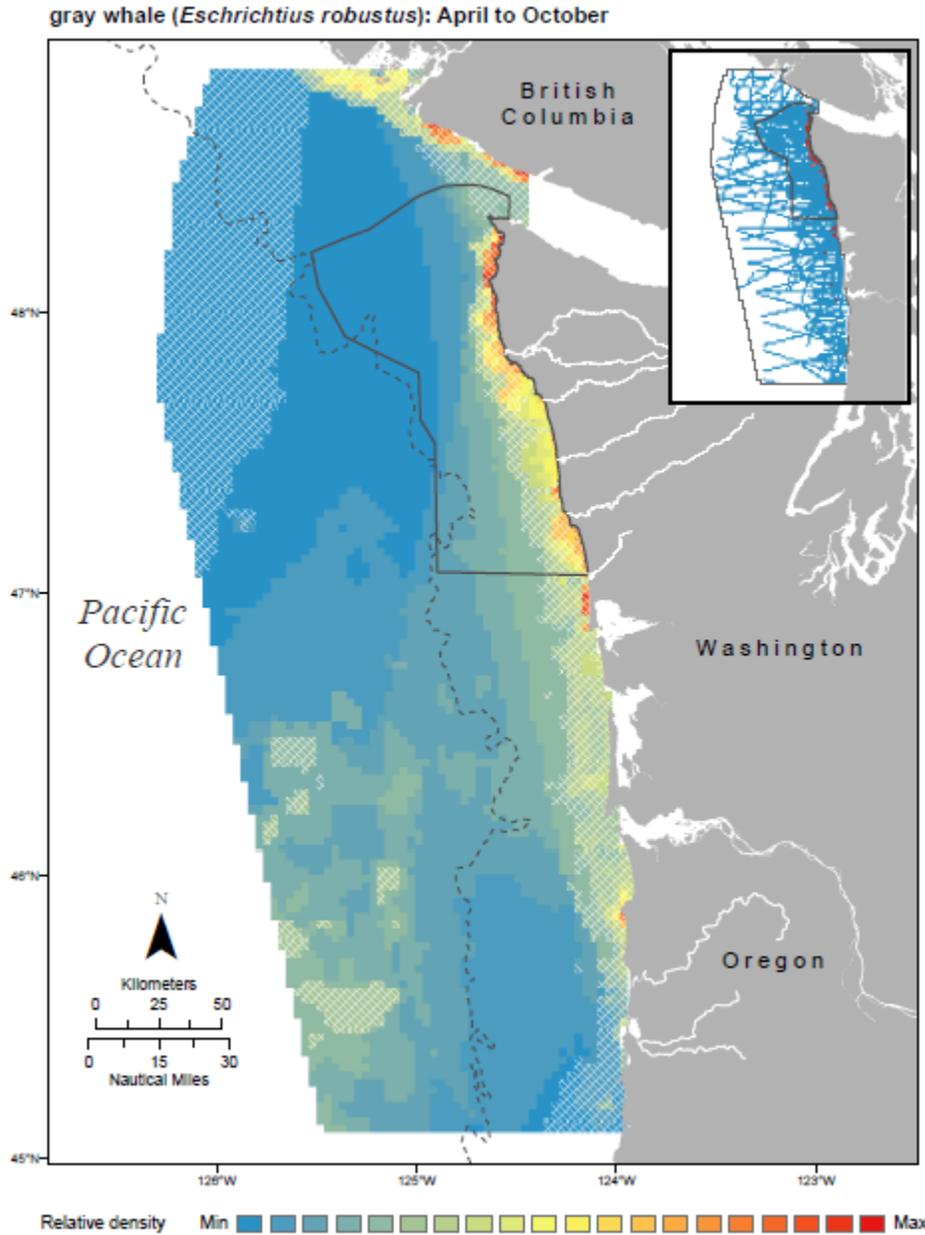
The predicted relative density of pelagic species was generally highest in the northern part of the study area; nearshore species such as the Tufted Puffin and Marbled Murrelet (Figures 3.2 - 3.4) were generally predicted to be concentrated within 10 to 15km from shore during summer, but with greater variation in north to south distribution. Patterns for pelagic species tended to be associated with the

1 continental shelf or other geological features such as submarine canyons. Models for some species, such
2 as the Gray Whale (Figure 3.5), may have been affected by the relationship between survey timing and
3 migration patterns. Possible anomalies of note for several specific species are discussed in the full
4 NCCOS report (Menza et al. 2016).



5
6 **Figure 3.4: Predicted long-term relative density for Marbled Murrelet, summer. White cross-hatching indicates areas**
7 **where the model has a coefficient of variation greater than 0.5 (relatively higher uncertainty). Gray line indicates**
8 **the boundaries of the Olympic Coast National Marine Sanctuary, and inset shows observed density from surveys.**
9 **Original figure and additional detail provided in the NCCOS final report (Menza et al 2016).**

10



1

2 **Figure 3.5: Predicted long-term relative density for Gray Whale, summer. White cross-hatching indicates areas where the**
3 **model has a coefficient of variation greater than 0.5 (relatively higher uncertainty). Gray line indicates the**
4 **boundaries of the Olympic Coast National Marine Sanctuary, and inset shows observed density from surveys.**
5 **Original figure and additional detail provided in the NCCOS final report (Menza et al 2016).**

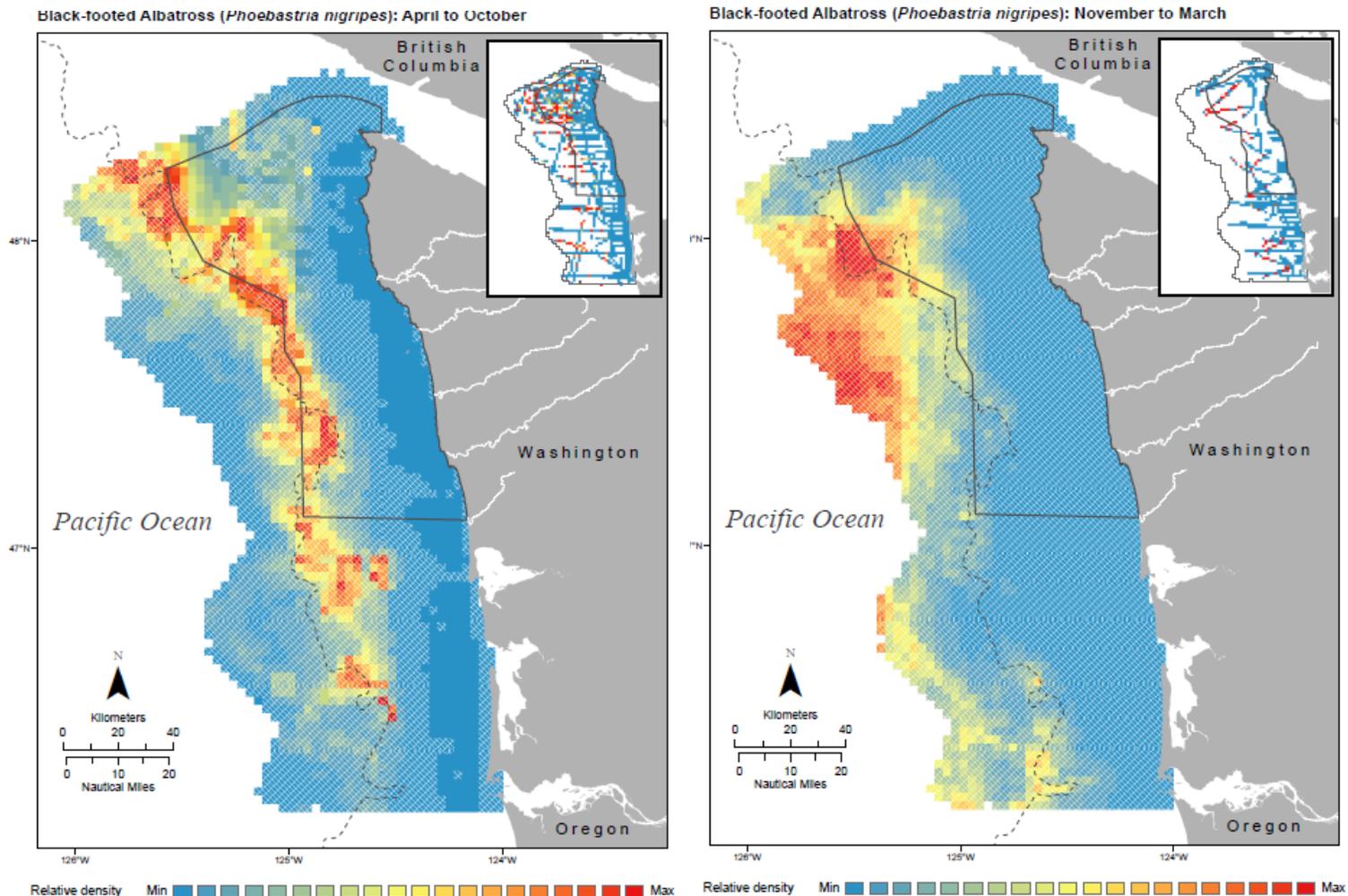
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7 Areas of high predicted density are often associated with known patterns of upwelling and high
8 productivity, or located near breeding colonies or haul-outs. The Marine Spatial Plan provides additional
9 detail on productivity patterns and the location of bird colonies and mammal haul-outs in the study area
10 in Section 2.1.

11 For species with sufficient data available to model both summer and winter, areas of greatest
12 density were further offshore in winter than in the summer. Figure 3.6 provides an example of this
13 pattern as seen in the results for the pelagic Black-footed Albatross. While insufficient data was

- 1 available to model predictions for Short-tailed Albatross in the planning area, the maps for Black-footed
- 2 Albatross can provide an indication of likely areas for greatest Short-tailed density due to similarities in
- 3 the ranges and life history traits of these two species.

4



25 **Figure 3.6: Predicted long-term relative density for Black-footed Albatross, summer (left) and winter (right). White cross-**
26 **hatching indicates areas where the model has a coefficient of variation greater than 0.5 (relatively higher**
27 **uncertainty). Gray line indicates the boundaries of the Olympic Coast National Marine Sanctuary, and insets show**
28 **observed density from surveys. Original figure and additional detail provided in the NCCOS final report (Menza et**
29 **al 2016).**

30

31 The full research report by NCCOS also provides detailed results from evaluations of each final
32 species model. This includes an in-depth statistical analysis of model performance and visual
33 representations of fit and potential bias using marginal and residual plots. A comparison of variable
34 importance between models shows that some predictors, such as depth and surface chlorophyll *a*
35 concentration, were relatively more important in final models for many species. Full discussion of model
36 fit and performance is available in Appendix E of the report (Menza et al. 2016). In cases where the
37 highest relative importance was assigned to random variables, such as Transect ID number, models may

1 benefit from the inclusion of additional ecological predictor variables which more strongly correlate with
2 that species' distribution.

3 Overall, performance was strong for all models, though variable across species and seasons. While
4 the strength of a model represents how well it fits the input data, it does not necessarily describe the
5 quality of the original data, fully assess accuracy of results, or give a clear indication of how well the
6 model predicts density in areas far from all input data points. As shown in Figure 3.1, there are also
7 known gaps in survey coverage for modeled species, particularly in offshore areas. This may have a
8 particular effect on the results for pelagic species which frequent these areas (Menza et al. 2016).

9 It is also important to note that because of data limitations, NCCOS could not analyze the full list of
10 species identified by WDFW as priorities for ecological modeling. In some cases the models discussed
11 here highlight areas that may also contain a higher density of species that were not modeled, by
12 illustrating general patterns common to many birds, cetaceans, or pinnipeds. However, a lack of
13 available data for a species does not imply that it plays a less important ecological role in the study area.
14 The species with insufficient sighting data are all listed at the state or federal level. They may be of
15 interest when prioritizing future monitoring and modeling projects, and despite not being included in
16 these results are important to consider in any finer-scale assessments of current conditions of a specific
17 site within the planning area.

18 Output layers from the NCCOS marine mammal and bird distribution analyses were used in
19 combination with other ecological datasets to support the Ecologically Important Areas assessment
20 described in Section 3.2.

21

22 3.2: Ecologically Important Areas

23 The Washington Department of Fish and Wildlife's (WDFW) Ecologically Important Areas (EIA)
24 project was completed to contribute to the series of maps required by RCW 43.372.040(6)(c). The
25 statute requires the series of maps to among other things, "summarize available data on:

26 The key ecological aspects of the marine ecosystem, including on its biological characteristics and
27 on areas that are environmentally sensitive or contain unique or sensitive species or biological
28 communities that must be conserved and warrant protective measures."

29 The EIA analysis contributes to the summary of key ecological aspects in two main ways. First, the
30 project analyzed and produced 39 maps of the ecological distribution of various species, species groups,
31 and habitat features. These individual maps, a.k.a. "layers", provide a substantial summary of how
32 biological communities are distributed throughout the Study Area. The state interagency team
33 considered these maps when developing various components of the plan, such as the designation of
34 Important, Sensitive, and Unique (ISU) areas, discussed in the management framework (Section 4.3).

35 The project's second main contribution involved combining the individual maps (or "overlying" the
36 maps) to explore broader ecological patterns in the study area. Due to data limitations, the individual
37 EIA maps can only cover a subset of the biological communities in the study area. Therefore, one goal of
38 the analysis was to use the patterns seen in their combined distribution to differentiate some regions of
39 the study area as being more ecologically important than others.

40 This section provides an overview of the individual maps that were produced in the EIA analysis and
41 the methods used to overlay them. Further discussion of how various combinations of EIA layers were
42 incorporated into the use analysis is provided in Section 3.3, and full details on the individual map layers
43 and the project will be available in a separate report (WDFW 2017a).

1 *Data Sources: Individual Map Layers*

2 WDFW used a variety of data sources and methods to produce the individual EIA maps, such as the
 3 NCCOS models described in Section 3.1, survey data, and fisheries logbooks. Many maps, particularly
 4 those for wildlife species, were based on surveys conducted by WDFW. Others were based on data
 5 provided by outside groups. Table 3.3 lists all of the individual layers or layer groups for which maps
 6 were completed. This table described the species within each layer, the data source or methodology
 7 used to collect or synthesize the data, the data timespan, and the CMECs zones that the layer can be
 8 found in (further description of the CMECs zones can be found in (WDFW 2017a)). For some layer
 9 groups, individual maps were produced for all species in the group (e.g. groundfish), while other layers
 10 may include multiple species (e.g. seabird colonies) in one map.

11 **Table 3.3: EIA Layers**

Layer Title or Group	Species Included	Methods	Timespan	Zone/ Strata
Snowy plover	Snowy plover	Transects and nest searches	2006-2013	Beach
Streaked horned lark	Streaked horned lark	Transects and nest searches	2006-2013	Beach
Seabird Colonies	<ul style="list-style-type: none"> - Ancient Murrelet - Arctic Tern - Black Oystercatcher - Caspian Tern - Cassin's Auklet - Common Murre - Cormorants - Gulls - Storm-petrels - Pigeon Guillemot - Rhinoceros Auklet - Tufted Puffin 	Colony counts	1970s -2013	Beach, Nearshore
Seal/Sea Lion haulouts	<ul style="list-style-type: none"> - Harbor Seal - California Sea Lion - Steller Sea Lion - Northern Elephant Seal 	Aerial observations	1998-2013	Beach, Nearshore
Nearshore seabirds and marine mammals	<ul style="list-style-type: none"> - Cassin's Auklet - Ancient Murrelet - Rhinoceros Auklet - Brandt's Cormorant - Double-Crested Cormorant - Pelagic Cormorant - Pigeon Guillemot - Harbor Seal - Harbor Porpoise. 	Boat-based line transects	2009-2013	Nearshore
Sea otter	Sea otter	Aerial observations	2012-2013	Nearshore
Seabird Abundance	<ul style="list-style-type: none"> - Black-footed Albatross (winter/summer) - Northern Fulmar (summer) - Sooty Shearwater (summer) - Common Murre (winter/summer) - Tufted Puffin (summer) - Marbled Murrelet (summer) 	Modelled abundance surface using environmental variables and results from boat and aerial surveys	1996-2013	Nearshore, Offshore, Oceanic

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Layer Title or Group	Species Included	Methods	Timespan	Zone/ Strata
Marine Mammal Abundance	<ul style="list-style-type: none"> - Steller Sea Lion - Harbor Seal - Humpback Whale - Gray Whale - Harbor Porpoise - Dall's porpoise 	Modelled abundance using a compilation of at-sea observations from multiple survey programs. Each program collected spatially-explicit observations of pinnipeds, and/or cetaceans within a sampling domain which overlapped, and in some cases extended well beyond the study area.	Data time series ranged from 11-22 years; 1995 to 2014	All zones and strata
Razor Clams	Razor Clams	Beach survey locations	1997-2014	Beach, Nearshore
Dungeness Crab	Dungeness Crab	Fishery logbooks	2009/10 - 2012/13	Nearshore, Oceanic, Offshore
Groundfish	<ul style="list-style-type: none"> - Darkblotched Rockfish - Dover Sole - Greenspotted Rockfish - Longspine Thornyhead - Pacific Ocean Perch - Petrale Sole - Sablefish - Shortspine Thornyhead - Yelloweye Rockfish 	Modeled abundance or probability of occurrence using bottom trawl survey information with covariates.	2003-2012	Offshore, Oceanic
Pacific Whiting	Pacific Whiting	Fishery logbooks and observer records	2001-2014	Oceanic, Offshore
Pink Shrimp	Pink Shrimp	Fishery logbooks	2003-2012	Oceanic, Offshore
Intertidal spawning forage fish spawning sites	<ul style="list-style-type: none"> - Surf Smelt - Night Smelt - Pacific Sand Lance 	Locations of beach spawning surveys	2003-2012	Oceanic, Offshore
Deep Sea Coral	Any species in the taxonomic orders Antipatharia or Scleractinia or the suborders Alcyoniina, Calcaxonina, Filifera, Holaxonia, Scleraxonia, Stolonifera.	Maxent species distribution model	Several	Oceanic, Offshore
Rocky Reefs/Hard benthic substrate types	Rocky reefs/hard benthic substrate types	Various	Several	Nearshore, Oceanic, Offshore
Kelp	<ul style="list-style-type: none"> - Bull Kelp - Giant Kelp 	Polygons representing floating kelp beds derived from annual aerial photos.	1989-2012	Nearshore

1 *Methods*

2 The source data for the EIA maps was measured in a variety of different ways, including counts of
 3 animals present, the probability of occurrence as estimated by a model, or total commercial fisheries
 4 catch in weight as reported in logbooks. To facilitate comparison and create the map overlays, WDFW
 5 analysts converted the original measurement units for each map to a relative ranking using a quantile
 6 method. Within each layer, ranking scores were assigned on a scale of 1 to 5, with 1 representing the
 7 areas of greatest relative ecological importance and 5 the lowest. Table 3.4 shows the quantile values
 8 that correspond to each ranking.

9 **Table 3.4: EIA scoring metrics**

EIA score	1 (Highest Importance)	2	3	4	5 (Lowest Importance)
Quantile	> 0.90	0.75-0.90	0.25-0.75	0.10-0.25	< 0.10

10 As one example of how this quantile method was applied, consider the Blackfooted Albatross EIA
 11 layer, which was based on modelled abundance values from the NCCOS model described previously. For
 12 this particular layer, each hexagon was associated with a modelled abundance value. To calculate a
 13 score, this value was compared to that of all other hexagons in the map and assigned a relative ranking.
 14 For example, a hexagon with a modelled abundance value greater than 80% of the values in the entire
 15 map would be called the 0.80 quantile, and would be assigned a rank of 2 based on Table 3.4. More
 16 detail about this process is available in WDFW’s final report (2017a).

17 In addition to being based on different units of measurement, EIA source data was also provided in
 18 various spatial resolutions and formats. Some datasets were created using grids of varying cell sizes (e.g.
 19 500 square meters), while others used precise point coordinates. To attain a common spatial resolution,
 20 the EIA analysis used a grid in which each cell (“hexagon”) is 1 square mile in area. For each individual
 21 map, an EIA score was assigned to all relevant hexagons. If the original spatial resolution of a map layer
 22 was finer than that of the EIA grid, it was possible to have multiple scores per hexagon. In such cases,
 23 the general approach was to score the hexagon based on the score closest to 1.

24 Not every map layer could be scored using the quantile approach. Some map layers, such as those
 25 for kelp and rocky areas, simply describe whether a feature is present or absent from an area. For those
 26 maps, the available data was not adequate to rank the relative quality of one area against another, as
 27 would be needed for the quantile approach. In these cases, the EIA scores were assigned based on other
 28 considerations, such as general knowledge that the areas have high ecological importance. While the
 29 scores of 1 assigned in this manner are not equivalent in meaning to those assigned using the quantile
 30 method, they are comparable for the purposes of the project.

31 In general, care should be taken when interpreting the EIA scores. The scores are not precise,
 32 quantitative measures of ecological quality. They are instead intended more as qualitative measures,
 33 and while they are easy to tabulate, must be interpreted in context. The scoring system would be no
 34 different if text labels were used instead of a 1 to 5 ranking. To best interpret the significance of the EIA,
 35 individual scores should be interpreted by closely assessing the source data and methods for each map,
 36 as well as other relevant information.

37 Furthermore, the EIA scoring approach has the same issue as many “binning” approaches where
 38 hard lines need to be drawn. For example, the difference between a score of 2 and 3 is the difference
 39 between information being included in the hotspot map described below or not. For an individual

1 species map, the difference between a 2 and a 3 could be as minor as the difference between the 74.9th
2 percentile and the 75th percentile. The latter would be a 2 and the former a 3, yet on the original
3 measurement scale the difference between the two could be very small and not ecologically meaningful.
4 This issue is not a major one in the context of the EIA project's aim to explore broad patterns in the
5 study area, but could be a flaw if used for a different purpose.

6 The EIA analysis team also produced relative uncertainty scores for many of the individual maps on a
7 scale from 1 to 3, with 3 being the highest uncertainty. The meaning of these uncertainty scores differs
8 for each map and is meant to qualitatively show the relative confidence in the EIA score. For instance,
9 the WDFW analysts have more confidence that a hexagon with an EIA score is 1 if the uncertainty score
10 is a 1 than if it is a 2 or a 3. More detail is given in the final analysis report (WDFW 2017a).

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12 *Results*

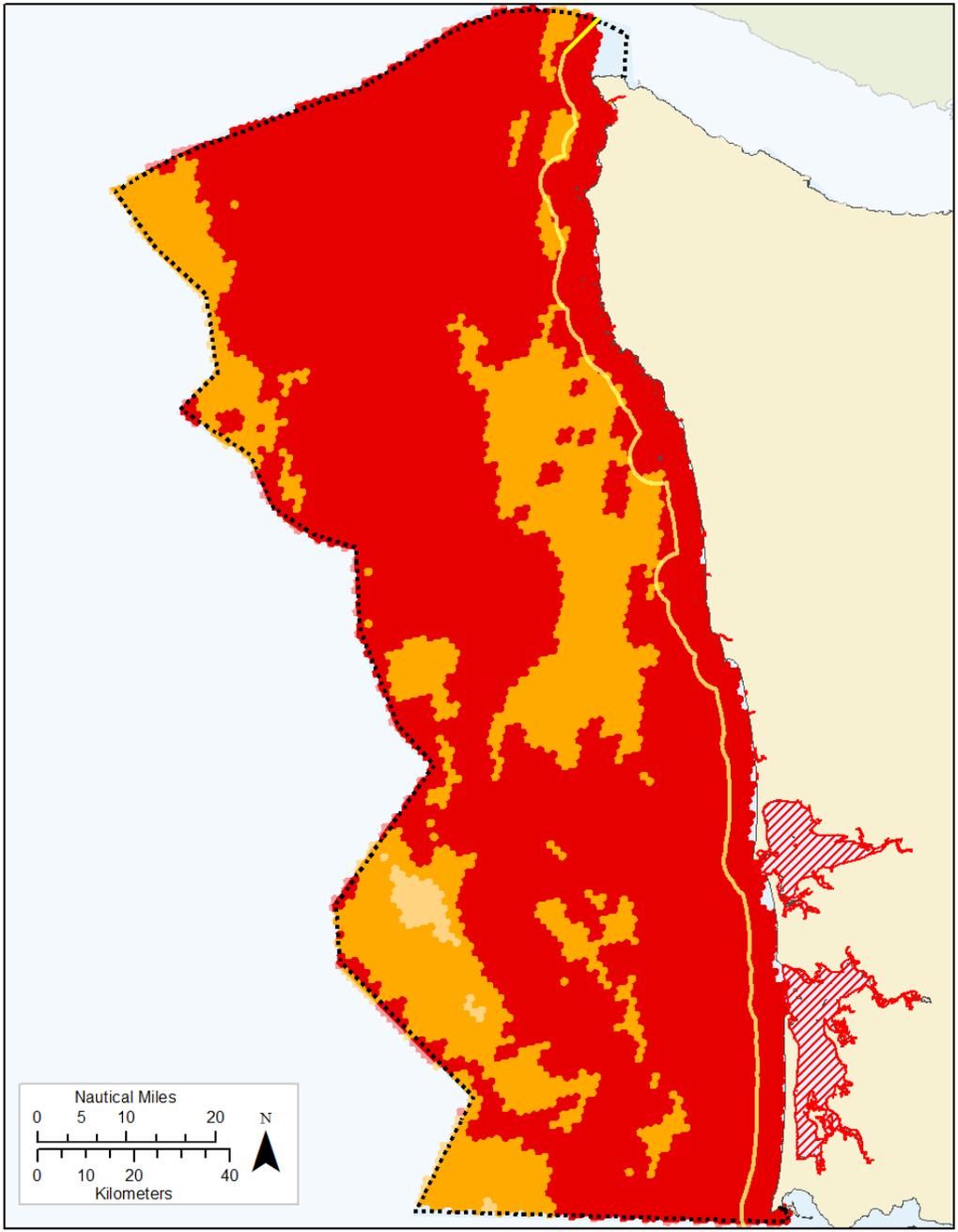
13 Again, the overall goal of the EIA was analyze the ecological distribution of individual species and
14 habitats and to evaluate the combined "overlay" patterns throughout the study area. There are several
15 different ways to combine layers, and no one result can provide a single "best" view of ecological
16 importance. This section provides examples of some of the main maps considered and interpretations.
17 Other examples and interpretations are further described in the full report (WDFW 2017a).

18 As described in the previous section, the EIA scores provide a unit of measure that can be compared
19 across all individual layers. For each map, an EIA score of 1 conveys the highest importance or an
20 important feature (e.g. rocky areas), and a score of 2 indicates lower, but still above average,
21 importance. One of the first overlays highlighted in the EIA analysis is shown in Figure 3.7. This map
22 evaluates which parts of the Study Area show up as important to at least one of the individual EIA maps.
23 In other words, this map shows the score from each hexagon that was closest to 1 (the greatest
24 importance ranking); this score could be from one or multiple layers. The result shows little contrast
25 within the Study Area, as all but a small percentage of the hexagons have a score of 1 or 2. None of the
26 hexagons in the Study Area are shown as a 4 or 5 in this map, because all cells had at least one layer
27 ranked 1, 2, or 3. Based on this result and the fact that the EIA maps only cover a small subset of species
28 in the marine ecosystem, it would appear that every part of the Study Area could be considered
29 important to at least one species.

30 After considering several overlays, the interagency team chose two for inclusion in the Use Analysis
31 (see Section 3.3) The "hotspot map" shows the number of 1s and 2s that appear in each hexagon (Figure
32 3.8). Hexagons that are important across multiple individual EIA maps may indicate higher ecological
33 activity than those that are important to just a few. Consistent with marine ecology literature, the
34 hotspot map shows the highest scores along the continental shelf break and at the heads of submarine
35 canyons, particularly in the Juan de Fuca Canyon area off northern Washington. Further interpretations
36 of the patterns seen in the hotspot map are given in WDFW (2017a). The hotspot map incorporated into
37 the use analysis (see Section 3.3) differs slightly from Figure 3.8. Instead of using a count of importance
38 scores across all 39 layers, the hotspot map included in the use analysis combined scores from several
39 subsectors covering key layers or groups of layers. This was done to account for the fact that the
40 amount of layers in the EIA outweighed the other existing use data. However, the overall patterns of
41 ecologically important hotspots are very similar.

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Ecologically Important Areas
Minimum Ecological Importance Score

1	2	3	4	5

..... Washington MSP Study Area¹
— WA State Boundary²
 Estuaries

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Figure 3.7: Score closest to 1 (indicating the greatest relative importance) for each hexagon in the planning area.

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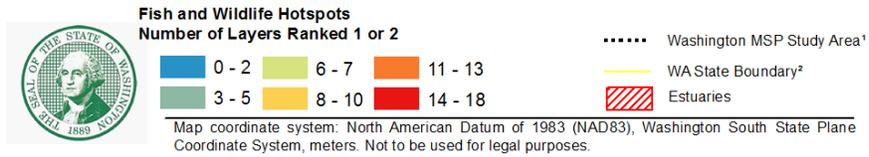
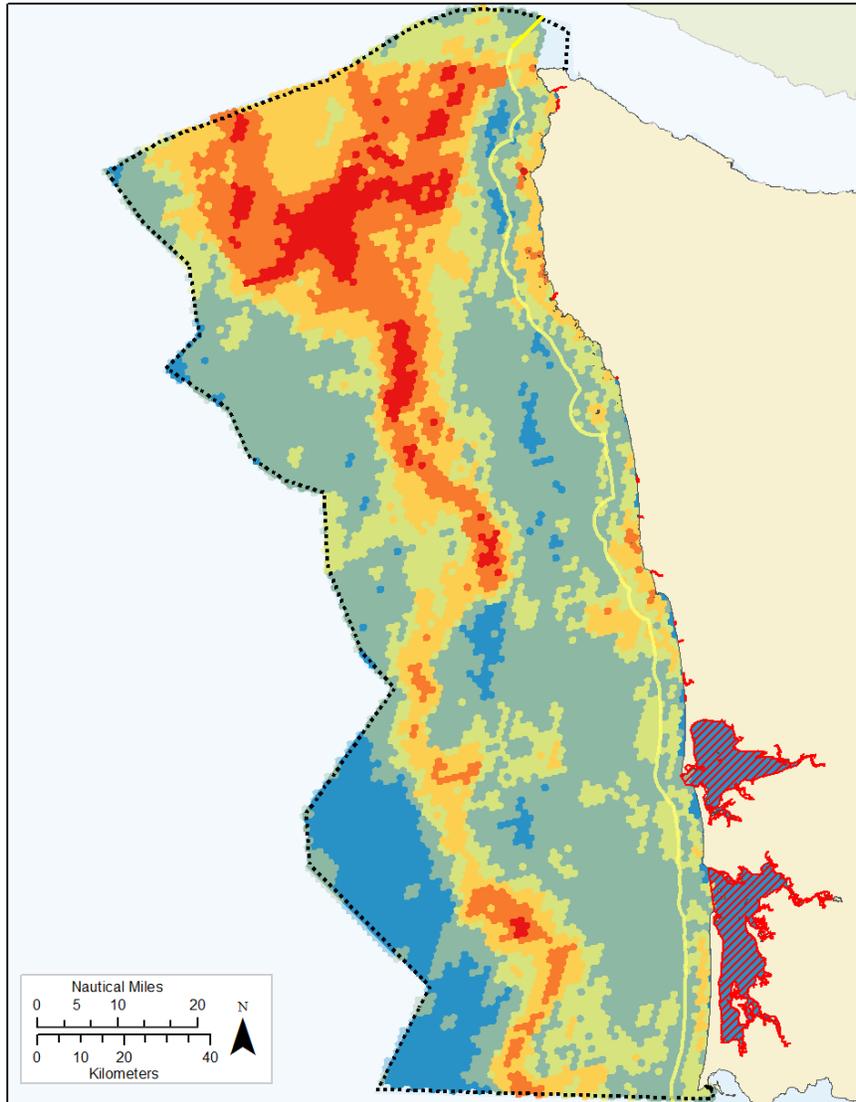
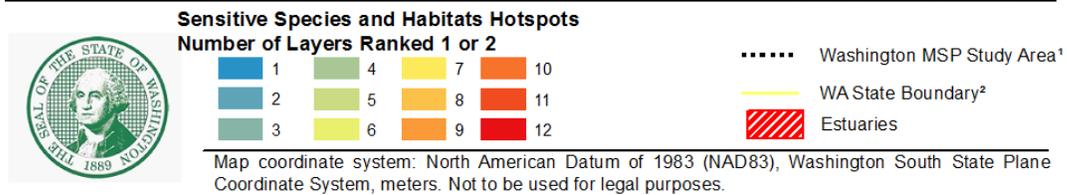
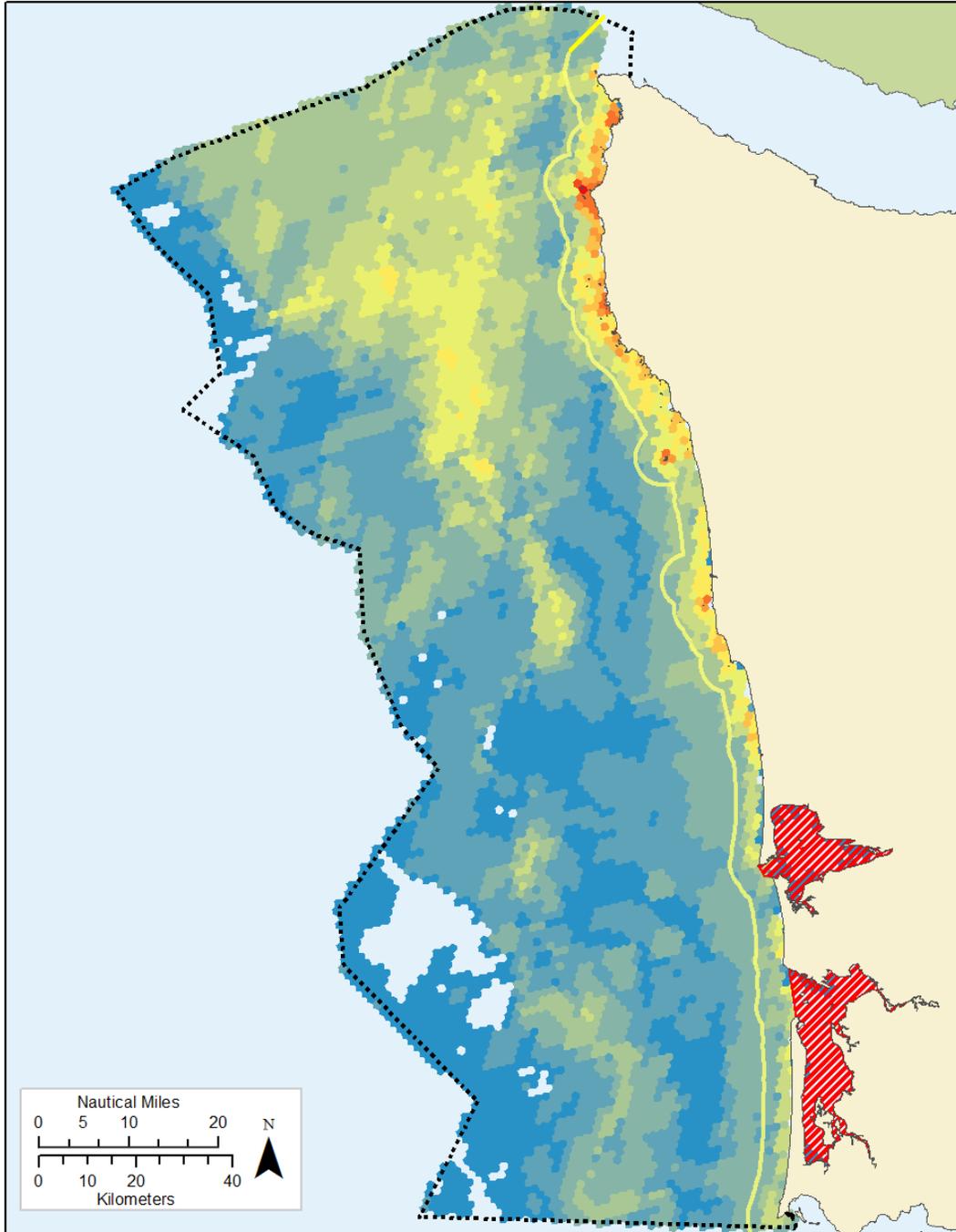


Figure 3.8: Hotspots for all combined EIA layers. Each hexagon’s value is the number of layers with an importance score of 1 or 2 in that location (the scores indicating greatest ecological importance).

22 The second map incorporated into the Use Analysis is similar to the hotspot map but only
23 includes species of high conservation concern (e.g. threatened or endangered species), or layers that
24 have a presumed sensitivity to the physical displacement that might accompany renewable energy
25 development (Figure 3.9). Sensitive species and habitats include kelp and rock areas, Snowy Plover
26 nesting areas, Marbled Murrelet, and all large whales, among others.



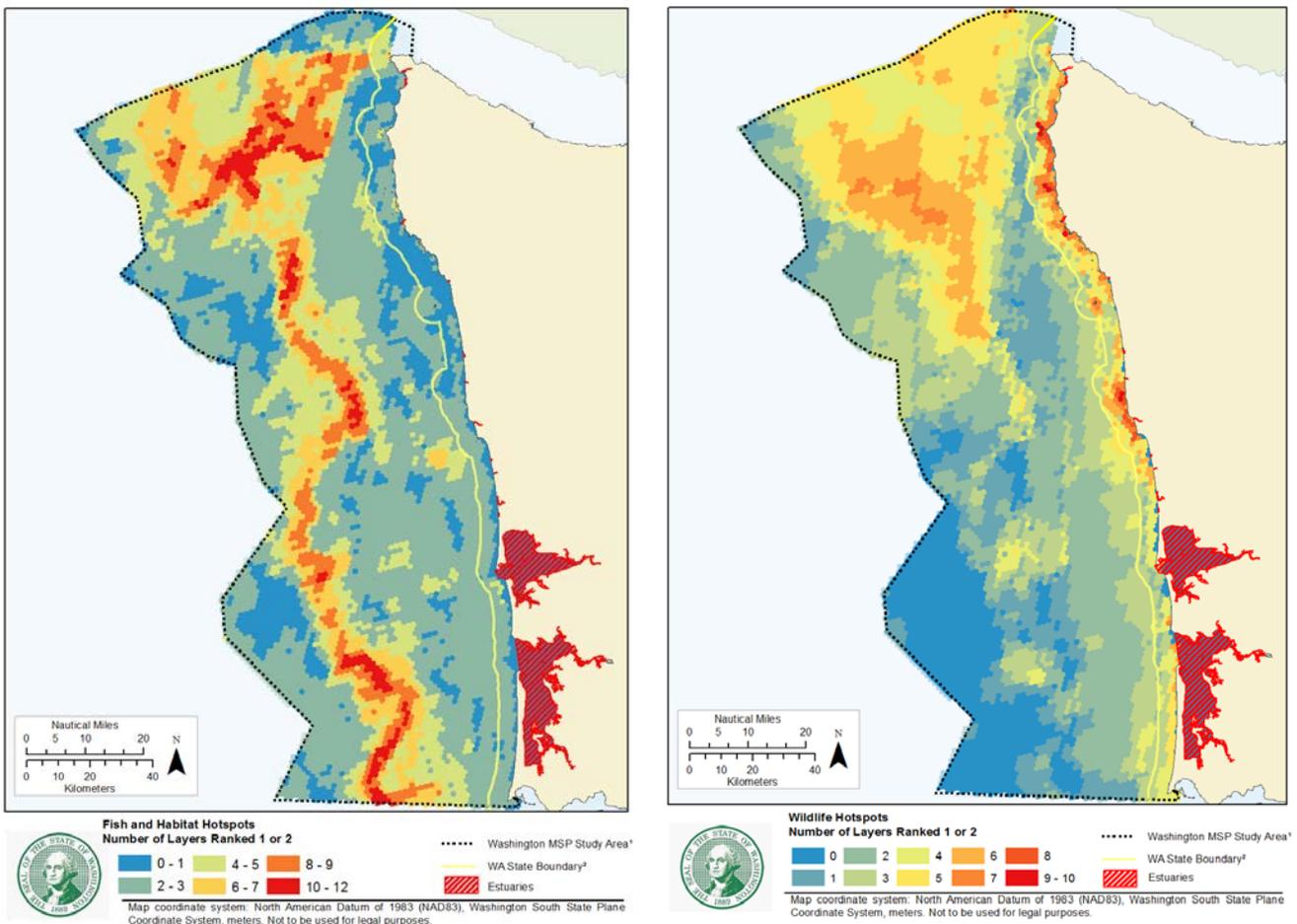
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Figure 3.9: Hotspots for sensitive species and habitats. Each hexagon’s value is the number of layers with an importance score of 1 or 2 in that location (the scores indicating greatest ecological importance).

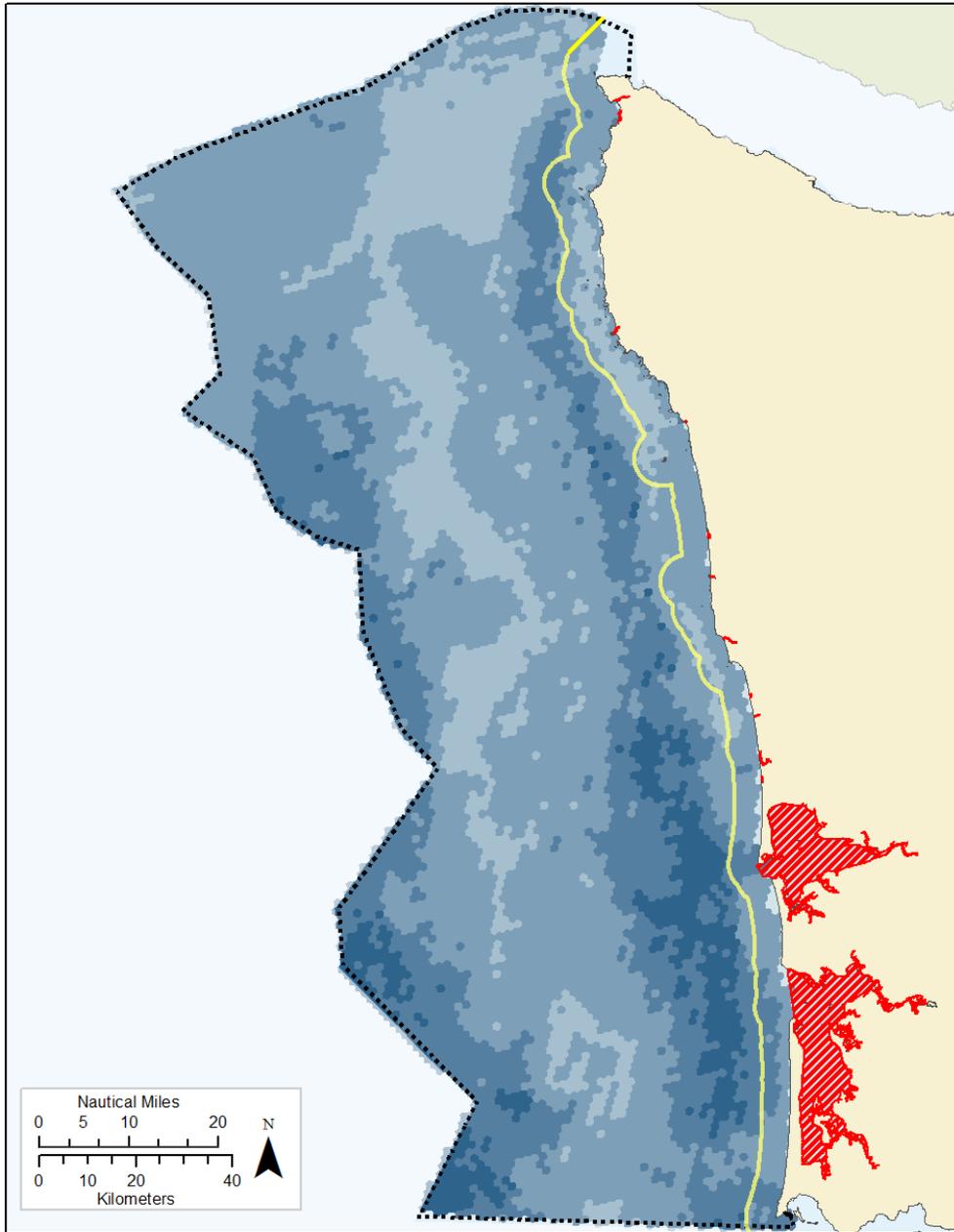
1 While the subsector hotspot and sensitive species maps were chosen for the Use Analysis, this does
2 not mean that they are the only outputs worth investigating. For example, Figures 3.10 and 3.11 show
3 hotspots for fish and wildlife, respectively. While the fish hotspot map shows the highest scores
4 clustered along the shelf break and the Juan de Fuca Canyon area (similar to the overall hotspot map),
5 the wildlife hotspots tend to be found in the northern part of the study area, including in the nearshore.

6 Alternatively, the “coldspot” map shows the number of 4s and 5s (below average importance
7 scores) that are found within a hexagon (Figure 3.12). While these areas may have a large proportion of
8 layers that are ranked lower in importance, the underlying individual layers may contain certain species
9 or habitats with scores of 1 or areas of great importance. For example, the southeast portion of the
10 planning area contains a large amount of “coldspots”, but is ranked as highly important habitat for
11 Dungeness Crab, one of the most important commercial fisheries in Washington.

12 Many other analysis outputs are discussed in the final report (WDFW 2017a). Again, the intent of the
13 overlay maps is to explore high-level patterns of ecological importance in the study area. Further
14 interpretation requires looking to the individual maps and the data that supports them in the context of
15 the question being evaluated.



17 **Figures 3.10 (hotspots for all fish and habitat layers) and 3.11 (hotspots for all wildlife layers). Each hexagon’s value is the**
18 **number of layers with an importance score of 1 or 2 in that location (the scores indicating greatest ecological importance).**
19 **Note that the color scales are not identical for the two figures, because each map incorporated a different number of layers.**



**Fish and Wildlife Coldspots
Number of Layers Ranked 4 or 5**



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

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Figure 3.12: Fish and wildlife coldspots. Each hexagon’s value is the number of layers with an importance score of 4 or 5 in that location (the scores indicating least relative ecological importance).

1 *Limitations, Data Gaps, and the Treatment of Estuaries*

2 As discussed in the EIA introduction, the primary purpose of the EIA was to summarize available
3 data on key biological aspects of the marine ecosystem using maps. However, while the EIA analysis
4 makes a strong contribution toward this goal, summarizing available data is a long way from definitively
5 mapping the ecology of the Study Area.

6 The perfect EIA analysis would involve knowing the full “time budget” of, at a minimum, a set of key
7 species that are representative of greater ecological activity. This “time budget” would describe which
8 parts of the Study Area each species uses and how often. To be comprehensive, it would need to
9 account for the changes that happen over seasonal, annual, and long-term time scales in the highly
10 dynamic California Current marine ecosystem.

11 Such perfection is of course not possible. Survey work in the Study Area’s coastal and marine
12 environment is logistically difficult and expensive. In addition, resources for ecological surveys are
13 limited. As an example, most of the surveys in the Study Area happen during the spring and summer
14 when conditions such as visibility and wave height are more conducive to research. Because of this,
15 there are many unknowns about how the species included in the EIA use the Study Area in the winter. In
16 general, limited survey resources mean that the EIA maps are biased towards the species of highest
17 conservation and management interest to the mandates of WDFW and partner agencies. Therefore,
18 many species that live in the Study Area are not surveyed regularly at all.

19 Even for the species included in the EIA project, the maps should be recognized as uncertain. Many
20 of the surveys conducted in the Study Area are used to monitor population abundance. Monitoring
21 abundance is a different objective than monitoring for the “time budget” of a species. The abundance of
22 a species can be reliably estimated by only partially sampling the area that the species occupies.
23 Statistical techniques, such as the ones described in Section 3.1, can be used to extrapolate survey
24 observations to un-surveyed areas, yet these methods are inherently limited in the certainty they can
25 provide. More on the caveats involved with each map are given in WDFW (2017a), including discussion
26 of using commercial fisheries data as a proxy for ecological distribution of fish species.

27 The quality of data needed to estimate the spatial patterns is so high that even relatively well
28 studied species lack sufficient data to make statistical estimates of their use the Study Area. This
29 includes species of high conservation interest like Chinook Salmon, Guadalupe and Northern Fur Seals,
30 Green Sturgeon and Leatherback Sea Turtles, among others. The latter two species even have Critical
31 Habitat designated under the Endangered Species Act located in the Study Area. For Leatherback Sea
32 Turtles, the Critical Habitat covers the entire Study Area, yet there is just insufficient information to call
33 out areas that are of lesser and greater importance.

34 Another limitation is that the focus of the EIA analysis primarily describes where animals use the
35 Study Area. The idea is that ecological importance in one sense is proportional to where these animals
36 spend their time. However, the word “ecological” can have much broader meaning and can
37 encompass many interacting physical, chemical, and biological features. The marine ecosystem of the
38 Study Area is a product of all these interacting features, some of which happen over broad areas and
39 may even happen far from the Study Area. Therefore, the EIA project’s view of the key ecological
40 aspects of this area should be considered in conjunction with information on these key features.

41 Lastly, one major data gap in the EIA project involves the estuaries, especially the two large
42 estuaries in the Study Area: Willapa Bay and Grays Harbor. While some individual EIA maps cover
43 features inside the estuaries (e.g. marine mammal haulouts), there is not enough data to perform the
44 same EIA overlay method used in the marine areas of the Study Area. Despite being unable to produce

1 EIA overlay maps for the estuaries, the EIA recognized the high ecological importance of estuaries. As
2 with kelp and rocky areas, the scientific evidence well establishes the importance of these areas. For
3 instance, it is well-known that estuaries provide important habitat to juvenile Pacific salmon, Dungeness
4 Crab, Green Sturgeon, migrating shorebirds and waterfowl, and many other species. However,
5 analogous to the Leatherback Sea Turtle example, the available spatial data is just not available to
6 differentiate which areas within the estuaries are relatively more important than others. An EIA-type
7 project for the estuaries would likely require using a finer-scale spatial scale (i.e. a grid using cells of less
8 than one square mile in area) as well as new survey and mapping efforts to complete. Additional
9 discussion of how estuaries are considered in the Marine Spatial Plan is provided in Section 4.3.3 of the
10 management framework.

11

12 SECTION 3.3: Use Analysis

13 The state agencies performed a use analysis designed to compare the extent and intensity of existing
14 uses and ecologically important areas within the planning area to the potential for renewable energy
15 production in the region. Coordinated by the interagency team and implemented by the Department of
16 Fish and Wildlife, the Use Analysis was structured to illustrate outputs for renewable energy at various
17 scales and for different energy types and technologies. Specifically, the outputs sought to illustrate areas
18 that had higher energy production, but contained fewer uses or less heavily used areas.

19 In particular, the use analysis:

- 20 • Provides an objective tool to use best available scientific, spatial data to develop a series of
21 maps that meet the requirement of RCW 43.372.040(6)(c)¹.
- 22 • Uses spatial extent and intensity data (where available) for existing uses to identify the spatial
23 overlaps between existing uses and potential new uses. Specifically, the analysis can:
 - 24 ○ Identify areas that have the most or more existing uses, including areas that are used
25 more frequently than other areas, versus areas that have fewer existing uses, including
26 areas that are relatively less frequently used.
 - 27 ○ Explore complex spatial relationships between existing use and ecological data and
28 information on renewable energy potential through map scenarios.
 - 29 ○ Provide a method to visualize complex data and relationships.
 - 30 ○ Use a series of maps to inform discussions regarding spatial recommendations for the
31 MSP.

32 The Use Analysis relied on several important assumptions that are critical to interpreting the outputs:

- 33 • No one map scenario can be used on its own to make a decision about a particular use.
- 34 • All uses have equal potential for conflict.
- 35 • Specific scenarios can explore particular spatial relationships or overlaps, but not tradeoffs.
- 36 • Existing use data and analysis cannot assess the degree of impact from a new use. This type of
37 assessment would be project-specific.
- 38 • Areas of fewer existing uses do not indicate no or low impact, or a lack of conflict.

¹ RCW 43.372.040(6)(c) requires that the plan provide maps including those showing "... appropriate locations with high potential for renewable energy production with minimal potential for conflicts with other existing uses or sensitive environments."

- 1 • Existing use data does not represent the value of areas, but rather potentially where and how
- 2 heavily they are used.
- 3 • The confidence in model outputs is dependent on the amount and quality of data.

4 The results of the use analysis were used to inform many of the recommendations outlined in Part 4 of
 5 the Marine Spatial Plan.

6 *Data Sources*

7 Two major categories of data were used as inputs in the Use Analysis: 1) existing uses in the
 8 planning area, including ecologically important areas, and 2) technical suitability models for future
 9 development of renewable energy.

10 Spatial models describing renewable energy suitability in the planning area were provided by the
 11 Department of Energy’s Pacific Northwest National Laboratory (PNNL). In a 2013 study, PNNL produced
 12 models of expected technical suitability off the Washington coast using three categories of information:
 13 site quality, grid connection, and shore-side support. These categories incorporated data relating to
 14 depth, energy resource potential, benthic substrate, and distance to relevant infrastructure. PNNL
 15 completed analyses for three types of offshore wind technology, four types of wave technology, and one
 16 type of tidal energy technology. Please see Maps 42 - 49 in the Maps Section for examples of the final
 17 outputs from these analyses. More detail on methods and data for the modeling process will be
 18 provided in a Data Appendix, or is available in the final report from PNNL (Van Cleve et al. 2013).

19 Current uses in the planning area were represented by a variety of data layers falling into five
 20 categories: cultural and archaeological uses, shipping, fisheries (non-tribal), recreation, and ecological
 21 uses (fish, wildlife, and habitat). Table 3.4 lists all of the data layers in used in each of these categories,
 22 though every layer was not used in all analysis scenarios.

23

24 **Table 3.4: Data layers used to represent existing uses and Ecologically Important Areas. For more information about**
 25 **individual uses or data layers, please refer to the referenced plan chapter and maps, or information in the data summary**
 26 **appendix [not available for preliminary draft].**

DATA CATEGORY	LAYERS	DATA SOURCE
Cultural and Archaeological Uses <i>Section 2.2</i>	Cultural risk model	Washington Department of Archaeology and Historic Preservation
Shipping <i>Section 2.6</i> <i>Maps 35 - 38</i>	Density of shipping activity: <ul style="list-style-type: none"> • Cargo Vessels • Passenger Vessels • Tanker Vessels • Tug and Tow Vessels Location of tug and tow lanes	Olympic Coast National Marine Sanctuary (NOAA) Washington Sea Grant (tow lanes)

<p>Non-Tribal Fisheries</p> <p><i>Section 2.4</i></p> <p><i>Maps 17 - 28</i></p>	<p>Commercial fishing intensity:</p> <ul style="list-style-type: none"> • Albacore tuna • Dungeness crab • Sablefish (fixed gear) • Groundfish (bottom trawl) • Pacific whiting • Pink shrimp • Salmon • Pacific Sardine <p>Recreational fishing intensity:</p> <ul style="list-style-type: none"> • Albacore tuna • Bottomfish and lingcod • Pacific halibut • Salmon 	<p>Washington Department of Fish and Wildlife</p>
<p>Fish and Wildlife / Ecological Uses</p> <p><i>Sections 2.1 (Ecology) and 3.2 (Ecologically Important Areas Analysis)</i></p> <p><i>Maps 5, 8, 9, 12, and Section 3.2</i></p>	<p>Ecologically Important Areas analysis</p> <ul style="list-style-type: none"> • Overall ecological hotspots, showing combined high use information from various “subsectors” (groups of layers), including: <ul style="list-style-type: none"> • Marine mammals • Pinniped haulouts • Habitats • Shorebird areas • Seabird abundance • Seabird colonies • Invertebrates • Fish Abundance • Hotspots for selected sensitive species and habitats 	<p>Washington Department of Fish and Wildlife</p>
<p>Recreation</p> <p><i>Section 2.6</i></p> <p><i>Maps 32 - 34</i></p>	<p>Participatory recreation data for:</p> <ul style="list-style-type: none"> • Diving Activities • Shore-Based Activities • Surface Water Activities • Wildlife Viewing & Sightseeing 	<p>Surfrider Foundation</p>

1

2 Some additional data layers discussed elsewhere in the Marine Spatial Plan were considered or used
 3 to illustrate some specific scenarios, but ultimately not included in the later stages of use analysis. For
 4 example, aquaculture occurs primarily within estuaries (which were not included in the use analysis) and
 5 is associated with other data limitations. Military use was not included because available data indicates
 6 that the entire planning area is a low-intensity use area for military operations, which would not provide
 7 any contrast within the use analysis process. The boundary of the Olympic Coast National Marine
 8 Sanctuary was also used in some phases of analysis to assess how its inclusion would affect results, but
 9 is not represented in the outputs provided in this chapter.

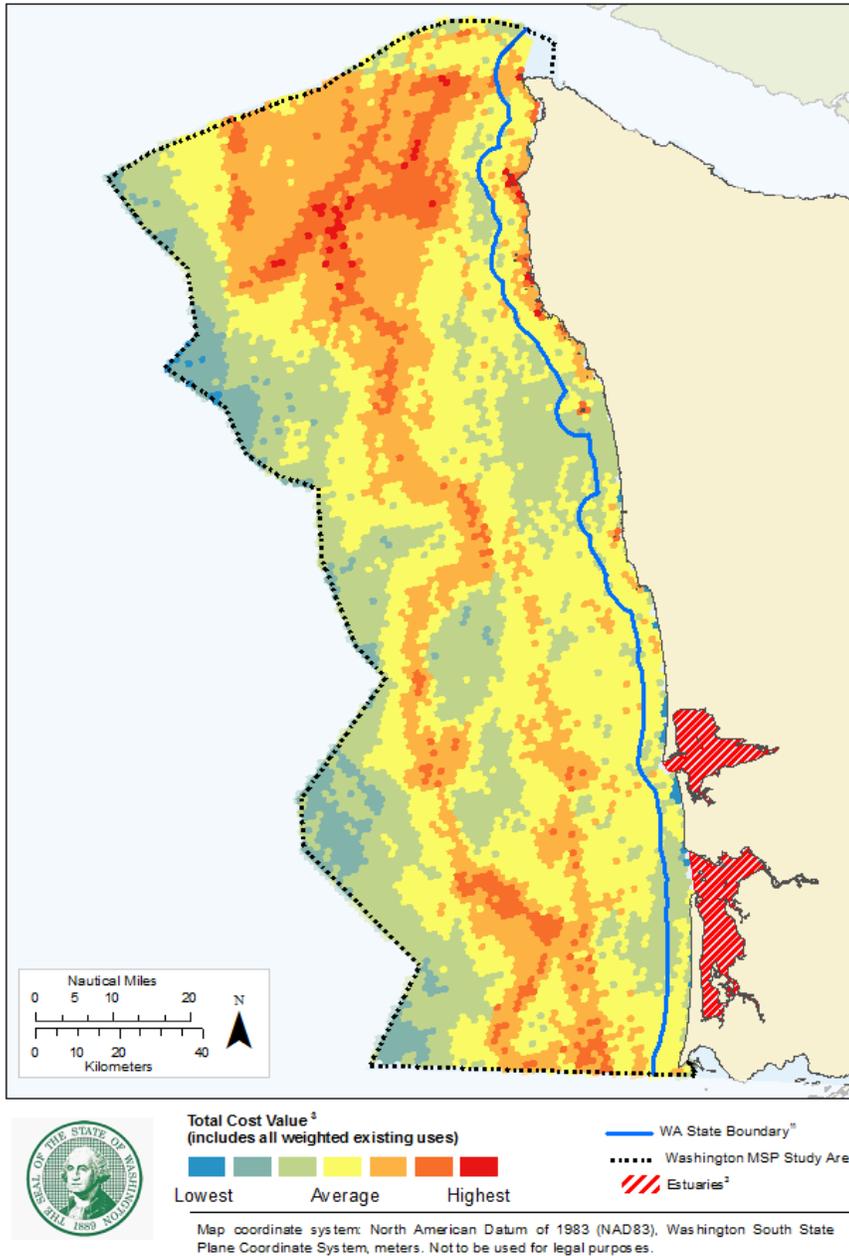
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1 *Methods*

2 The interagency team focused primarily on wind energy in these analyses rather than on tidal or
3 wave energy technologies. PNNL did provide technical suitability maps for tidal and wave energy, but
4 wind is a more established industry. Therefore, more information is available about the technical
5 requirements and viability of offshore wind development, and the interagency team expected wind to
6 be the most likely proposed use of the three in the near term. There is also significant overlap in areas
7 that were shown to be suitable for all three types of energy based on PNNL's analysis, due in part to
8 correlation between the availability of these resources in marine environments. Assessment of the
9 potential for wave or tidal energy production must be done on a case-by-case basis, but these maps can
10 provide a general understanding of energy resource patterns.

11 To complete the Use Analysis, WDFW used Marxan, a decision-support tool designed for marine
12 planning applications. This tool allows the user to set a series of targets and limitations, and generates
13 potential spatial solutions which optimize each scenario's goals within a given set of parameters. For this
14 project, the interagency team explored several different scenarios illustrating the relationship between
15 renewable energy suitability (as represented by PNNL's technical suitability analysis), and the number
16 and frequency of existing uses (Table 3.4). Each scenario provided a look at how analysis results might
17 change if certain existing uses or energy targets were prioritized.

18 Various data layers from Table 3.4 were combined into maps called cost surfaces, which represent
19 the multiple uses occurring in each 1-square mile hexagon of the planning area. To create these cost
20 surfaces, each individual dataset was weighted based on factors including the goal of that particular
21 scenario, the relative intensity of a given use, the number of layers being incorporated for that category
22 of use, stakeholder input, and review by experts familiar with each sector. Throughout the Use Analysis
23 process, WDFW produced cost surfaces for many different scenarios, which were refined through an
24 iterative process that included several workshops with the Washington Coast Marine Advisory Council
25 and other stakeholders. In the outputs for each scenario, Marxan attempts to minimize "cost," or
26 number and intensity of existing uses, based on the quantity assigned to each hexagon from weighted
27 input data. Note that this only accounts for the amount of use occurring in an area, not use value or
28 potential for conflict with new uses. An example is shown in Figure 3.13, which presents a cost surface
29 incorporating all of the uses described in Table 3.4.



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Figure 3.13: Combined map of existing uses incorporated into Use Analysis.

To illustrate how different weighting choices would affect the outcome of the use analysis, many other scenarios were assessed in which certain categories of uses were weighted more heavily. These included (but were not limited to) prioritizing avoiding:

- Areas with species, habitats, and cultural resources known to be particularly vulnerable to disturbance, such as endangered and threatened species (as discussed in Section 3.2)
- Important Dungeness Crab areas, including fishing grounds and habitats
- The boundaries of regions with special concerns including the Olympic Coast National Marine Sanctuary, tug and tow lanes, and Special Management Areas for fisheries

1 For some scenarios, WDFW performed analyses based on a “cost threshold.” That is, Marxan was
2 directed not to select any areas that exceeded a certain level of existing uses, based on the cost surface.
3 For others, the analysis focused on renewable energy targets (measured in MW) that minimized overlap
4 with existing uses, without setting a specific cost limit. Parameters for renewable energy potential were
5 also determined using an iterative process resulting in multiple variations of scenarios. Marxan allows
6 the user to set goals for how much of a particular resource is included in analysis outputs, and optimizes
7 those outputs based on goals and cost (i.e. existing use) limitations. In this case, renewable energy goals
8 were set based on the footprint that would be required for industrial- or community-scale wind projects,
9 measured by the number of 1 square mile hexagons these projects would need to cover to produce a
10 certain amount of energy. These footprint sizes were calculated based on knowledge of renewable
11 energy technology at the time of the analysis, parameters of comparable renewable energy projects
12 proposed or constructed in other states, and consultation with industry and agency experts. Analyses
13 were done for two types of renewable energy footprints: unclumped and clumped. Unclumped outputs
14 identify areas that meet total energy production goals without concern for whether they are all adjacent
15 to each other. Clumped outputs prioritized identifying areas where the total amount of desired energy
16 could be achieved in a single site composed of multiple connected hexagons.

17 As discussed in Section 3.2, estuaries were not included in these analysis scenarios because of
18 challenges associated with the scale of available data and density of existing uses in these areas.
19 Estuaries are known to be highly important areas for many human and ecological uses, and are
20 addressed more fully in Section 4.3.3 of the Management Framework.

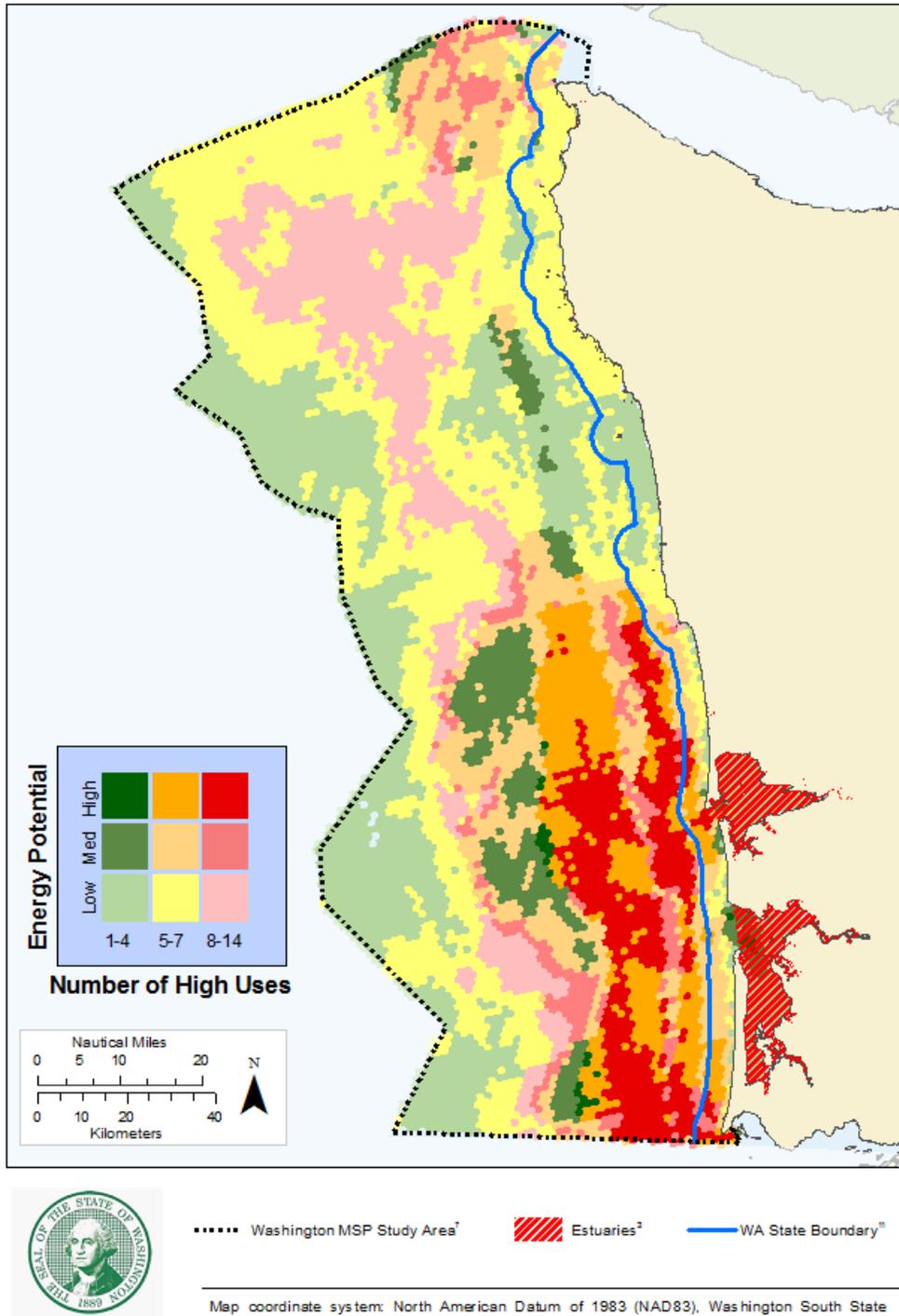
21 *Results*

22 Overall, the results of the Use Analysis provide a spatial illustration of the great number and
23 intensity of existing uses occurring in the study area, and shows how these relate to areas of possible
24 renewable energy potential. There is no single final solution in this type of analysis, as each scenario
25 prioritizes different factors and produces different outputs. The interagency team considered many
26 different outputs and results from the use analysis when developing the recommendations and
27 guidelines presented in the Management Framework, which also defines the distinction between
28 industrial- and community-scale projects for the purposes of the Marine Spatial Plan (Section 4.3.4).

29 As discussed in the project assumptions, it is important to highlight that while the following maps
30 offer a way to visualize existing uses and potential future uses, this type of analysis does not assess
31 potential conflict or impacts that could occur from the introduction of new uses such as renewable
32 energy production. The input layers give a measure of the current number of existing uses in a given
33 area and the intensity of those uses relative to other areas based on recent data. However, this does not
34 imply that fewer or less frequent existing uses would equate to less conflict in an area, or mean that any
35 area is less valuable than another. In addition, changes in the environment or regulations may lead to
36 changes in existing use patterns. Any evaluation of conflict or value would need to be done on a case-
37 by-case basis for any potential projects.

38 What the outputs of the use analysis can provide are several different types of spatial comparisons
39 between existing and potential new uses. Figure 3.14 demonstrates one approach. This output shows a
40 simple count of the existing number of uses categorized as “high uses” and how this overlaps with the
41 overall wind energy potential throughout the planning area. So, for example, the darkest green
42 hexagons show areas identified as having the fewest number of high intensity uses, and the greatest

1 amount of wind energy potential. While there is potential for conflict even in the case of one existing
 2 use, the red hexagons show areas that may present particular planning or permitting challenges due to a
 3 greater number of existing uses that would need to be addressed for a proposed project.



4
 5 **Figure 3.14: Comparison of renewable energy potential and the number of high intensity uses in each hexagon of the**
 6 **planning area.**

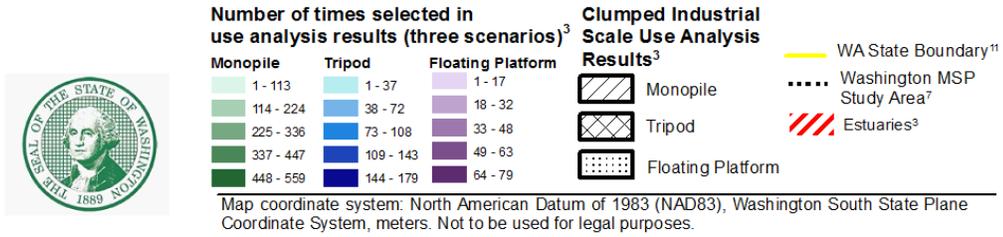
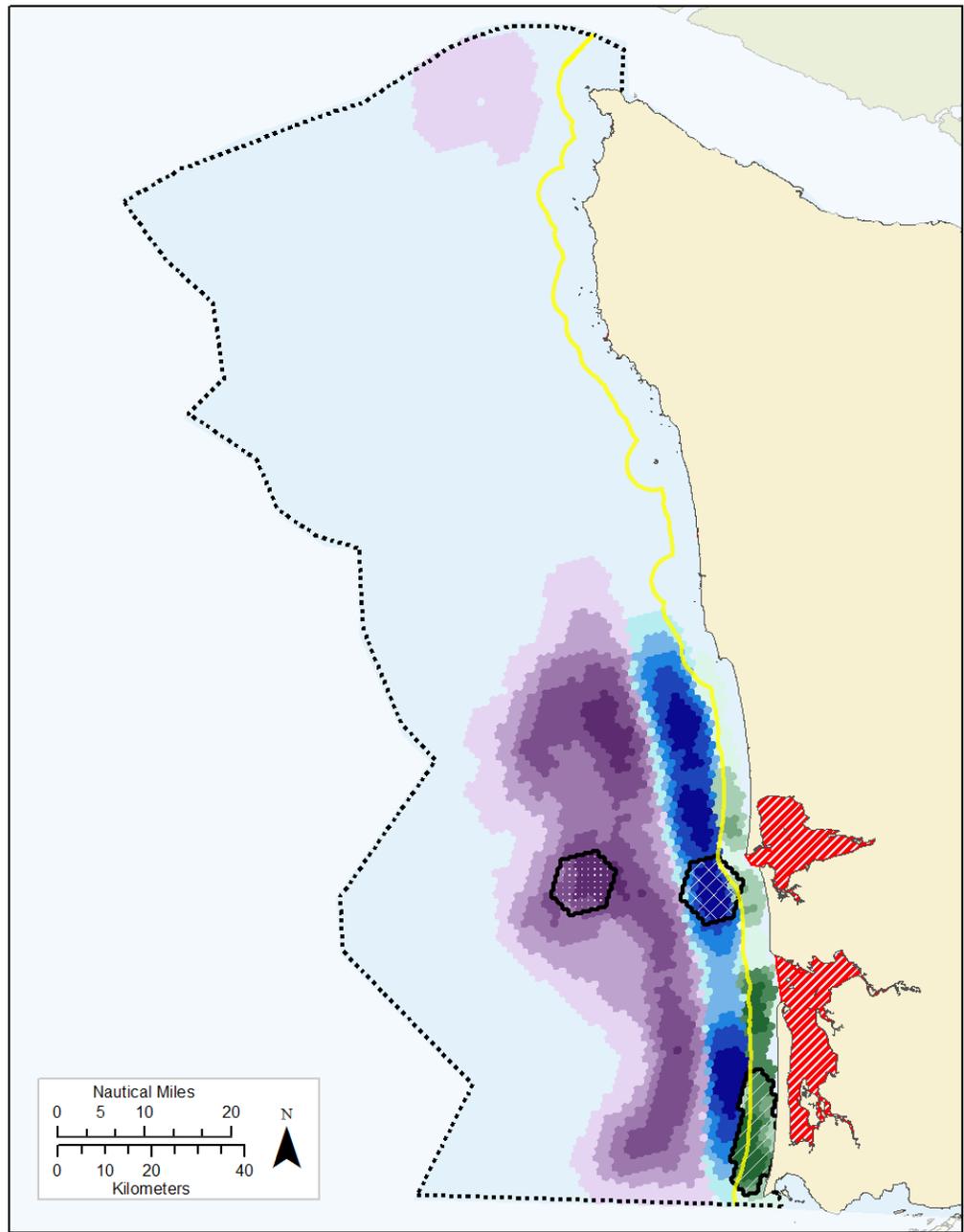
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1 Figure 3.15 shows another type of output. The results of this scenario identify clumped groups of
2 hexagons that would fulfill the expected energy requirements of three different types of industrial-scale
3 wind operations: monopole, tripod, and floating platform turbines (see Section 2.10.1 for more
4 information on the differences between these technologies). Clumped outputs are presented because
5 these results prioritized a single larger site over several smaller, scattered ones. While unclumped sites
6 may provide more flexibility in avoiding areas with the most existing uses, based on industry input the
7 interagency team expects the clumped approach to best reflect what developers might be looking for
8 when assessing potential sites for offshore renewable energy in Washington.

9 The gradients shown for each type of wind technology represent how frequently Marxan selected
10 each hexagon as part of a possible solution for the given scenario. During each analysis, the software
11 performs hundreds of runs, creating many possible solutions. The regions outlined in Figure 3.15 are the
12 areas identified by Marxan as the most frequently selected cells out of all the runs for that scenario
13 given the settings used for energy requirements, clumping, and avoidance of existing uses.

14 It is important to note that these outputs are not meant to be recommendations for areas where
15 renewable energy projects should be sited. The outputs are simply the product of the knowledge of
16 existing uses, our understanding of current renewable wind technology, and the data limitations that
17 are present with both. Additionally, the technical suitability analysis conducted by PNNL and the use
18 analysis outputs do not address any of the broader market or energy policy factors that may impact the
19 feasibility or desirability of the study area for renewable energy development, and there are many
20 measures of potential impact that would need to be considered for any proposed projects. Advances in
21 technology or other changes in the industry would Instead, these results provide quantitative and
22 visual representations of the overlap with existing uses that any offshore renewable energy
23 development in the study area would encounter, based on current knowledge. The outputs displayed in
24 this chapter and many other iterations and scenarios examined by the interagency team throughout the
25 use analysis process guided the development of the recommendations in Section 4.3.4.

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Figure 3.15: Use Analysis outputs for clumped, industrial-scale wind energy (three types).

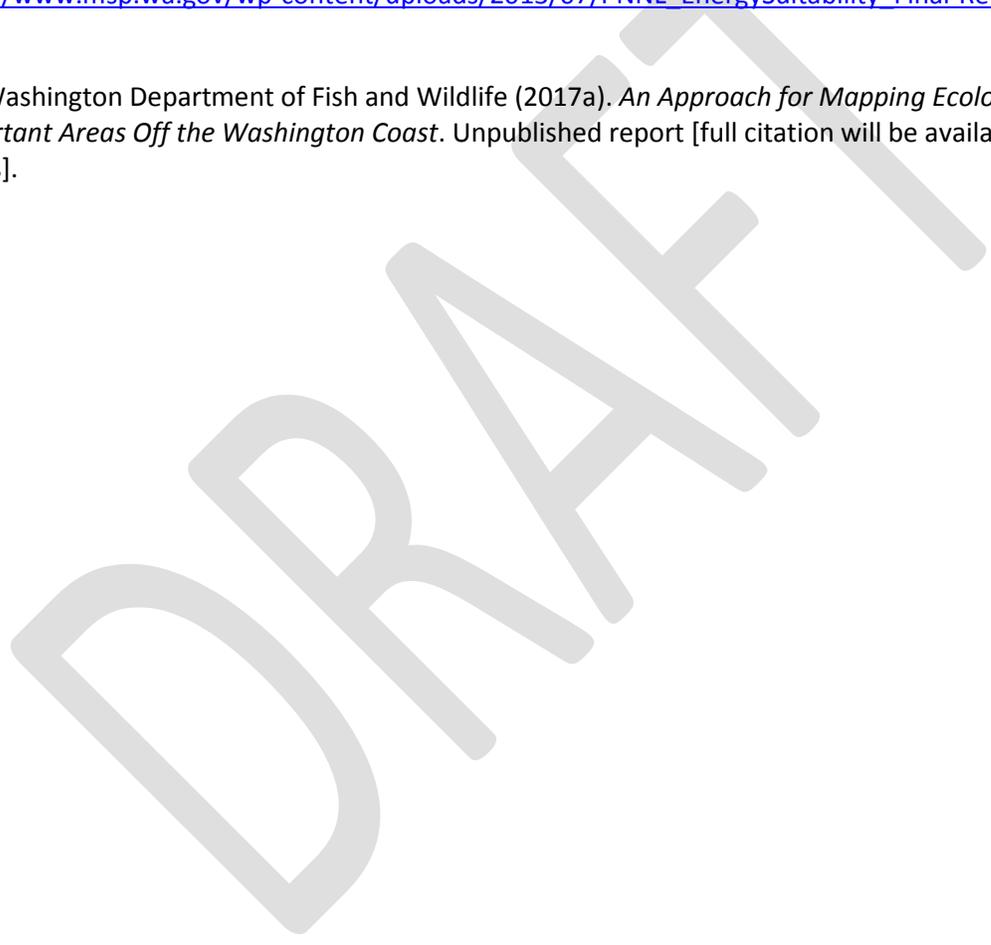
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Marine Spatial Plan for Washington's Pacific Coast

Section 4: Management Framework

- 4.1. Existing Policies and Authorities
- 4.2. State Plan Implementation
 - 4.2.1. Implementation: Process for Reviewing Ocean Uses
 - 4.2.2. Implementation: Other State Activities and Recommendations
- 4.3. Spatial Data, Designations, and Recommendations
- 4.4. Project and Site-Specific Data and Information
- 4.5. Effects Evaluation
- 4.6. Review Standards
- 4.7. Project Construction and Operation Plan
- 4.8. Standards Specific to New Use Type

Part 4 - Marine Spatial Plan and DRAFT Management Framework

4.1 Existing policies and authorities

4.1.2 Introduction to the Management Framework

The Marine Spatial Plan (MSP) for Washington’s Pacific Coast focuses on providing data, information, analyses and recommendations to address new potential ocean uses in Washington’s marine waters such as marine renewable energy, offshore aquaculture, mining for sand and gravel or methane hydrates, new dredge disposal locations, or bioextraction. The MSP does not address or alter requirements for existing marine uses such as shellfish aquaculture, commercial or recreational fishing, recreation, shipping or navigation. The MSP study area covers the Washington’s marine waters¹ along the Pacific Ocean from Cape Flattery to Cape Disappointment and from ordinary high water out to offshore waters to a distance offshore that follows the continental shelf at a water depth of 700 fathoms. The study area also includes the estuaries along the coast [Appendix A: Map 1].

The MSP Management Framework provides overall guidance and recommendations for applicants, agencies and third parties on using the plan in practice. The MSP should be used throughout the development of new ocean use proposals on Washington’s Pacific Coast and in all stages of decision-making. The information and processes outlined in the Management Framework are essential to assist agencies in evaluating whether a new ocean use project satisfies compliance with the Ocean Resources Management Act and its regulations.² In particular, applicants need to follow processes for coordination and engagement in Section 4.2.1, and need to demonstrate their project complies with the spatial designations and recommendations in Section 4.3, provide all information listed in Sections 4.4, 4.5, and 4.7, and address their compliance with applicable standards in Sections 4.6 and 4.8.

The development of the Management Framework was informed by recommendations from the Washington Coastal Marine Advisory Council (WCMAC), including concerns about the effects of new ocean uses on existing uses, coastal communities and the environment. Actions that relate to specific WCMAC recommendations are referenced throughout the management framework. For complete WCMAC concerns and recommendation language, please see Appendix B.

The Management Framework contains the following major sections:

- [Section 4.1](#) - Information on existing policies, authorities and requirements that guide implementation of the MSP.

¹ “Marine waters” is defined in RCW 43.372.010(9). Scoping further refined the study area for this specific plan.

² Depending on the project, other information may be required to process other permits or authorizations (see Section 4.1.5 for relationship to other state and local authorities). The Management Framework primarily focuses on the processes and specific information required for assessing compliance with the Ocean Resources Management Act and its regulations.

- [Section 4.2](#) - Process for reviewing and consulting on ocean use proposals and other state implementation activities.
- [Section 4.3](#) - Spatial designations and information to understand spatial limitations, potential conflicts and interactions; to inform project siting, development and design; and to identify appropriate parties to consult regarding potential proposals.
- [Section 4.4](#) – Project and site-specific information requirements
- [Section 4.5](#) - Contents of a written effects evaluation
- [Section 4.6](#) – Review standards and design considerations
- [Section 4.7](#) – Project construction and operation plans
- [Section 4.8](#) – Standards specific to new use type

4.1.3 Requirements to Implement the Final MSP

Washington’s marine waters planning and management law (RCW 43.372) requires state and local agencies to make decisions consistent with the final Marine Spatial Plan.³ At the same time, the Marine Spatial Plan law limits the state and local agencies to using their existing authorities to implement the plan and does not create any new authorities.⁴

4.1.4 Existing State Ocean Policies, Permit Criteria and Regulations

The Ocean Resources Management Act (ORMA) outlines specific state policies and regulations that specifically apply to policy, planning and permitting of ocean uses on Washington’s Pacific Coast [RCW 43.143].

1. General policies:

When the state of Washington and local governments develop plans for the management, conservation, use, or development of natural resources in Washington's coastal waters, the following policies shall guide the decision-making process [RCW 43.143.030(1)].

- a. When conflicts arise among uses and activities, priority shall be given to resource uses and activities that will not adversely impact renewable resources over uses which are likely to have an adverse impact on renewable resources. [RCW 43.143.010(3)]
- b. Recreational uses or currently existing commercial uses involving fishing or other renewable marine or ocean resources are not required to meet the planning and review criteria set forth in RCW 43.143.030. [RCW 43.143.010(5)]
- c. The state shall participate in federal ocean and marine resource decisions to the fullest extent possible to ensure that the decisions are consistent with the state's policy concerning the use of those resources. [RCW 43.143.010(6)]

³ Upon the adoption of the marine management plan under RCW 43.372.040, each state agency and local government must make decisions in a manner that ensures consistency with applicable legal authorities and conformance with the applicable provisions of the marine management plan to the greatest extent possible. [RCW 43.372.050(1)]

⁴ No authority is created under this chapter to affect in any way any project, use, or activity in the state's marine waters existing prior to or during the development and review of the marine management plan. No authority is created under this chapter to supersede the current authority of any state agency or local government. [RCW 43.372.060]

- d. There shall be no leasing of state tidal waters or submerged lands⁵ for oil or gas exploration, development or production [RCW 43.143.101(2)].
- e. Actively encourage the conservation of liquid fossil fuels, and to explore available methods of encouraging such conservation. [RCW 43.143.010(4)]

2. Ocean uses planning and project review criteria

Uses or activities that require federal, state, or local government permits or other approvals and that will adversely impact renewable resources, marine life, fishing, aquaculture, recreation, navigation, air or water quality, or other existing ocean or coastal uses, may be permitted only if the criteria below are met or exceeded [RCW 43.143.030(2)]:

- a. There is a demonstrated significant local, state, or national need for the proposed use or activity;
- b. There is no reasonable alternative to meet the public need for the proposed use or activity;
- c. There will be no likely long-term significant adverse impacts to coastal or marine resources or uses;
- d. All reasonable steps are taken to avoid and minimize adverse environmental impacts, with special protection provided for the marine life and resources of the Columbia river, Willapa Bay and Grays Harbor estuaries, and Olympic national park;
- e. All reasonable steps are taken to avoid and minimize adverse social and economic impacts, including impacts on aquaculture, recreation, tourism, navigation, air quality, and recreational, commercial, and tribal fishing;
- f. Compensation is provided to mitigate adverse impacts to coastal resources or uses;
- g. Plans and sufficient performance bonding are provided to ensure that the site will be rehabilitated after the use or activity is completed; and
- h. The use or activity complies with all applicable local, state, and federal laws and regulations.

Further regulations implementing the Ocean Resources Management Act are provided in WAC 173-26-360 and include general requirements [WAC 173-26-360(7)] and requirements for specific types of ocean uses [WAC 173-26-360(8)-(14)]. Since these existing regulations apply to various phases of project review, they are integrated and referenced throughout the relevant sections of the MSP management framework, including: project and site-specific information, effects evaluation, general review standards, and specific use review standards.

4.1.5 Relationship of Marine Spatial Plan to other existing state and local authorities and plans

Washington state law requires the Marine Spatial Plan (MSP) to be consistent with applicable state laws and programs and to be implemented through existing state and local authorities [RCW 43.372.040(6)(b) and RCW 43.372.040(6)(d)]. The law does not create new authority for state agencies nor does it affect projects or activities permitted prior to or during the development of the plan [RCW 43.372.060]. The Marine Spatial Plan does not create new regulations. All state and local agencies are

⁵ Applies specifically from mean high tide seaward and from Cape Flattery south to Cape Disappointment, in Grays Harbor, in Willapa Bay, and the Columbia River downstream from the Longview bridge.

responsible for implementing and adhering to the plan through existing regulatory and decision-making processes (see also interagency coordination in Section 4.2.2 and project and site-specific information in Section 4.4). Additional federal permits, licenses, leases, authorizations or consultations may also be required depending on the type and location of the ocean use activity.⁶ This section does not list out nor does it pertain to federal requirements.

1. State Permits and Authorizations

Most state and local authorities apply only within state waters between 0 and 3 nautical miles (n.m.) offshore. The Marine Spatial Plan provides the following key benefits to existing state and local authorities:

- a. Compiles inventory of baseline conditions and trends of uses and resources of the marine environment (Part 2 of Plan).
- b. Provides data analyses to fulfill plan requirements and support plan designations and recommendations (Part 3 of Plan).
- c. Provides recommendations on siting; site-specific information and assessments; effects analysis and monitoring and adaptive management for new ocean uses (Part 4 of Plan).
- d. Improves process for agency review, consultation and coordination. (Part 4 of Plan).
- e. Clarifies and further details the information needed to support the application of existing state laws and policies to potential new ocean uses (Part 4 of Plan).

The tables below provide more specific information on the existing state and local authorizations that may apply to projects in marine waters. The following state authorizations may be required for projects in marine environments, depending on the specific project type and location.

Table 4.1.5-1: State Permits or Authorizations for Aquatic Projects

State Action ⁷	Agency	Primary Authority	Location	Focus Area/Purpose
Section 401 Certification	WA Dept of Ecology	Federal Clean Water Act – delegated by EPA to Ecology. In some areas EPA or tribes issue permits.	State Waters	Certifies that the project will comply with state water quality standards and other appropriate State laws
CZMA Federal Consistency Determination	WA Dept of Ecology	Federal Coastal Zone Management Act	State and Federal waters	Evaluates federal actions to ensure consistency with CZM Program’s approved enforceable policies. Allows state to evaluate federal

⁶ Examples of these include: Olympic Coast National Marine Sanctuary authorizations, US Army Corps of Engineers Section 10 permits, Federal Energy Regulatory Commission licenses, and consultations required under the Endangered Species Act.

⁷ Actions may be a permit, lease, easement, or other authorization. As a part of these various processes there are formal and informal consultations among various federal, state, local, and tribal authorities. The coordination process will vary by permit and lead agency.

State Action ⁷	Agency	Primary Authority	Location	Focus Area/Purpose
		WA's approved Coastal Zone Management (CZM) Program		actions that will affect state's coastal resources.
NPDES Construction Stormwater General Permit⁸	WA Dept of Ecology	Federal Clean Water Act - Section 402 delegated to Ecology In some areas EPA or tribes issue permits.	State Waters	Prevents or minimizes sediment, chemicals, and other pollutants from entering surface water as a result of clearing, grading, and excavation activities.
Aquatic Use Authorization	WA Dept of Natural Resources	Public Lands Act RCW 79.105	State-owned Aquatic Lands	Administers leases, easements, and rights-of-entry to authorize use of the seabed and Washington's marine waters.
Hydraulic Project Approval	WA Dept of Fish and Wildlife	Hydraulic Code RCW 77.55	State Waters	Allows for hydraulic projects in state waters – applies to any project that includes construction in state waters. Evaluates adequacy of protection of fish life.
Scientific Collection Permit	WA Dept of Fish and Wildlife	RCW 77.12.047	State Waters	Allows for collection of fish, shellfish, wildlife or next of birds for scientific investigation (i.e. not commercial sale or personal consumption). Specific requirements on methods and amounts may apply.
Trial Commercial Fishery Permit	WA Dept of Fish and Wildlife	RCWs: 77.12.047, 77.50.050, 77.60, 77.70, and 75.08.080	State Waters	Allows for trial harvest of newly classified species, or harvest of previously classified species in a new area or by new means, but no need to limit participation.
Experimental Fishery Permit	WA Dept of Fish and Wildlife	RCWs: 77.12.047, 77.50.050, 77.60, 77.70, and 75.08.080	State Waters	Allows for harvest in an emerging commercial fishery or expanding commercial fishery (need to limit participation).
Marine Finfish Aquaculture	WA Dept of Fish and Wildlife	RCW 77.12.047, 77.15.030, 77.125	State Marine Waters	Allows for an aquatic farmer to possess any species, stock or race of marine finfish in net pens, cages or other rearing vessels. Must have escape prevention, reporting and recapture plan. No transgenic fish are allowed.
Shellfish Aquaculture Transfer	WA Dept of Fish and Wildlife	RCWs: 77.12.047	State Waters	Allows for transfer of shellfish, shellfish aquaculture products, aquaculture equipment or any marine organisms adversely affecting shellfish.

⁸ This permit is triggered if more than 1 acre of upland lands is disturbed.

State Action ⁷	Agency	Primary Authority	Location	Focus Area/Purpose
Right of Way Permit	WA State Parks and Recreation Commission	Seashore Conservation Area (SCA) RCW 79A.05.605	Coastal beaches in the SCA	Protects conservation areas for public recreation, cultural, and educational experiences.

2. Local Authorizations or Plans

Washington’s local governments, cities and counties, have a variety of authorizations and permits that may apply to ocean use projects, depending on the specific project type and location. The Marine Spatial Plan provides information, analyses and recommendations for local governments to consider and incorporate in these processes, particularly in updating and revising their local Shoreline Master Programs. To be consistent with the MSP, local governments on Washington’s Pacific Coast will need to update their local programs and incorporate information, analyses and recommendations from the final, adopted plan.⁹ Other management plans may exist that would benefit by incorporating the MSP.

Table 4.1.5-2: Local Permits and Other Authorities for Aquatic Projects

Action ¹⁰	Agency	Primary Authority	Location	Focus Area/Purpose
Shoreline Master Program Permits¹¹	Local County or City	Shoreline Management Act RCW 90.58 and WAC 173-27 (Ocean Use Guidelines – WAC 173-27-360). Local Shoreline Master Program	State Shorelines, including state marine waters	Protects shoreline natural resources and public access while encouraging water dependent uses.
Critical Areas Ordinance Permits	Local County or City	Growth Management Act RCW 36.70A	County/city lands and waters	Protects locally designated critical areas such as wetlands, habitat conservation areas, and frequently flooded areas.
Floodplain Development Permit	Local County or City	Flood Plain Management RCW 86.16	County/city floodplains	Reduces social and economic loss caused by flood events. Project may not increase potential for damage from flood waters.
SEPA	State agency or local – depends on project ¹²	State Environmental Policy Act RCW 43.21C	State (land or water) State or local review of project or plan	Requires state and local agencies to review proposals to identify environmental impacts.

⁹ RCW 43.372.040(10) – the plan must identify any provisions of existing management plans that are substantially inconsistent with the plan.

¹⁰ Formal and informal consultations among various federal, state, local, and tribal governments occur as part of these processes. The process varies by permit and lead agency.

¹¹ Permits may include Exemptions, Shoreline Substantial Development Permits, Conditional Use Permits, or Variances.

¹² Federal projects/plans may trigger NEPA regardless of location.

4.1.6 How the MSP builds upon Washington's existing Coastal Zone Management Program

The Marine Spatial Plan for Washington's Pacific Coast contains information, policies and recommendations that build upon and further refine Washington's existing Coastal Zone Management Program (CZMP). The enforceable policies of Washington's CZMP include provisions from the following state laws:

- Shoreline Management Act (SMA)
- State Environmental Policy Act (SEPA)
- State Water Pollution Control Act and Clean Water Act
- Clean Air Washington Act and Clean Air Act
- Energy Facility Site Evaluation Council (EFSEC)
- Ocean Resource Management Act (ORMA)

In particular, the Ocean Resources Management Act (ORMA) requires state approvals for ocean uses to meet a number of broad policies and permit criteria including avoiding and minimizing significant adverse impacts to the environment, economy, and society. The MSP assists implementation of ORMA's requirements by identifying and analyzing important ocean resources and uses upfront and by further detailing the data, information, analyses, and processes needed to apply the policies and standards in ORMA and its regulations to permits, licenses or leases for new ocean uses in coastal waters. This, in turn, provides the information needed for Ecology to evaluate whether a federal action may have reasonably foreseeable effects on the state's coastal uses or resources and to ensure information and analyses are provided that help the state determine whether a federal action is consistent with the state's enforceable policies.

As part of its CZMP, Washington State may study federal waters and identify uses, resources and areas of federal waters that are of interest to the state. The state may not establish enforceable policies or regulatory standards for federal agencies, federal waters or federal lands. However, the data, information, policies, standards and recommendations contained within the MSP should assist federal agencies in the siting and regulation of new ocean uses, such as conducting environmental reviews, in federal waters adjacent to state waters. Ecology will be able to use the MSP data and maps to assess coastal effects from a proposed project in federal waters, which will be helpful for conducting federal consistency reviews.

4.2 State Plan Implementation

The state will undertake a number of activities to implement the Marine Spatial Plan. These activities primarily fall into two categories: 1) Reviewing proposals for new ocean uses and 2) Other activities that assist in monitoring, evaluation, adaptation and revision of the plan.

Section 4.2.1, below, provides an overview of the state process for reviewing proposed new ocean uses, while Sections 4.3 - 4.8 provide spatial designations, standards, requirements, and recommendations that apply to proposed new ocean uses during different phases of the process. The following roadmap generally describes activities during these different phases of the process and sections of the management framework that apply to those phases.

New Ocean Uses Roadmap

Application Phase –

- Applicant consults MSP, review management framework, spatial designations, etc. and use to shape potential project ideas. (Entire MSP, Part 4, and Section 4.3)
- Applicant conducts pre-application meetings with agencies and stakeholder groups. Applicant continues to receive feedback from and respond to requests of agencies and others to refine proposed project. (Section 4.2.1)
- Applicant develops and submits required project and site-specific data and information through JARPA, SEPA checklist, and other mechanisms. (Section 4.4)
- Applicant submits additional project information, including construction/operation, mitigation, and other plans. (Section 4.7)

Review Phase –

- Lead agency assesses effects of and potential adverse impacts from project.
- Applicant submits written effects evaluation to Ecology. (Sections 4.5, 4.6 and 4.8)
- State agencies review project for consistency with existing laws and policies.

Section 4.2.2 outlines the other activities the state will take to implement the Marine Spatial Plan, such as monitoring and adapting the plan.

4.2.1 Implementation: Process for Reviewing Ocean Uses

1. State agency coordination of review of renewable energy and other new ocean uses

As noted in section 4.1, state and local agencies are required to implement the MSP consistent with their authorities (RCW 43.372.050). In addition, state and local agencies are required to follow the planning and project review criteria for ocean uses [RCW 43.143.030].

State law requires the MSP to develop a framework for coordinating state agency and local government review of proposed renewable energy developments and to provide for timely review and action upon renewable energy development proposals while ensuring protection of sensitive resources and minimizing impacts to other existing or projected uses in the area [RCW 43.372.040(6)(f)]. If renewable energy projects are proposed in federal waters off Washington, the state will evaluate requesting the establishment of a taskforce with Bureau of Energy Management (BOEM).

State and local agencies will coordinate their roles and review of new ocean use proposals, including the following:

- a. Pre-application Meetings – Request applicants hold meetings for potential project proposals with state and local agencies prior to submitting any applications for leases, licenses or permits. During the pre-application stage, state agencies will work together to:
 - i. Encourage applicants to use the Marine Spatial Plan to understand potential use and resource conflicts.
 - ii. Ensure applicants provide required data and information about the project and identify and coordinate with stakeholder groups as well as other governments, including local, tribal and federal government entities.
 - iii. Communicate state and local policies, procedures and requirements, including those referenced in the Marine Spatial Plan.
- b. Inventory – Review adequacy of site-specific inventory and requests for additional data or studies.
- c. Effects Analysis – Review adequacy of effects evaluation and proposed mitigation measures and best management practices.
- d. Plans – Review proposed construction and operation plans, including adequacy of prevention, monitoring, and response plans.

The interagency team (State Ocean Caucus) will assess needs to further specify how best to coordinate on individual, proposed projects and to create more detailed agreements for the review process, as needed.

2. Government coordination (local governments, tribes, federal agencies)

Tribes, local governments and federal agencies also play an important role in reviewing proposed ocean uses. The state is committed to collaborating and communicating with other government entities on the review of proposed ocean uses, including:

- a. Ensuring government entities receive early notification of proposed projects and activities. State agencies will share information regarding potential projects with other government entities and assist applicants in identifying other government entities to contact.
- b. Discussing and determining how best to communicate and coordinate given a proposed project's type, location and scale. This may include convening a government coordination and review team to streamline communication and coordination between the applicant and government entities.
- c. Understanding each others' interests, needs, and concerns regarding proposed ocean uses.
- d. Recommending best available scientific information and other information to evaluate potential impacts of a proposed ocean use.

3. Stakeholder input

- a. Applicants should involve stakeholders and the public in all aspects of project development and review, including:

- i. Working collaboratively with stakeholders, including but not limited to fishing, aquaculture, maritime commerce, conservation, tourism, and recreation interests, and the Washington Coastal Marine Advisory Council;
 - ii. Providing timely and effective notice, including early notification to the Washington Coastal Marine Advisory Council; and
 - iii. Initiating both formal and informal pre-application discussions between stakeholders and applicants. [WCMAC recommendation 3.1.1 and 3.1.3]
- b. Applicants and agencies should provide stakeholders and the public with early notice and opportunity to review and comment at key stages on various studies and assessments produced for the project, including social, economic, and environmental impact assessments. Applicants or agencies should provide response to comments and third party review of economic assessments. [WCMAC recommendations 1.1.1, 1.3.2]

4. Fisheries groups

The marine spatial planning law requires: “Any provision of the marine management plan that does not have as its primary purpose the management of commercial or recreational fishing but that has an impact on this fishing must minimize the negative impacts on the fishing. The team must accord substantial weight to recommendations from the director of the department of fish and wildlife for plan revisions to minimize the negative impacts.” [RCW 43.372.040(8)].

Therefore, the following process is set out for new ocean use projects to identify potential adverse impacts to state commercial and recreational fisheries and opportunities to avoid, minimize or mitigate those impacts [WCMAC recommendation 3.1.2 and RCW 43.143.030(2)].

- a. Applicants will notify the Washington State Department of Fish and Wildlife regarding a potential project proposal, as early as possible, including likely location(s) of the project.
- b. The Washington Department of Fish and Wildlife will then notify established fishing advisory groups and license and permit holders for potentially affected commercial and recreational fisheries.
- c. Applicants will coordinate with WDFW and commercial and recreational fisheries on an effective process and schedule to identify and discuss potential adverse impacts on commercial and recreational fisheries and opportunities to avoid, reduce, or minimize impacts, which may require multiple meetings. Applicants must hold at least one meeting with WDFW and affected commercial and recreational fisheries (See Section 4.2.1.5).
- d. The director of WDFW will provide recommendations on ways to minimize impacts to fishing to Department of Ecology’s federal consistency coordinator during the project review process [RCW 43.372.040(8)].

5. State's review of federal activities under the Coastal Zone Management Act and Necessary Data and Information:

The Washington Coastal Zone Management Program (administered by Department of Ecology) will review the consistency certification together with the required necessary data and information to ensure the project is consistent with the approved enforceable policies of the Washington Coastal Zone Management Program.

Specifically, 15 C.F.R part 930.58 describes that applicants for federal licenses, permits or leases must provide the Washington Coastal Zone Management Program with the consistency certification and:

- A detailed description of the proposed activity, its associated facilities, the coastal effects, and comprehensive data and information to support the applicant's consistency determination.
- Maps, diagrams, technical data and other relevant material, when written a description alone will not adequately describe the proposal.
- A copy of the federal application and all supporting material provided to the Federal agency.
- An evaluation that includes a set of findings related to the coastal effects of the proposal and its associated facilities to the relevant enforceable policies of the management program.

This Marine Spatial Plan Management Framework has organized and identified the specific information requirements that will satisfy these bullets above, for new ocean use projects; this includes: the fisheries process in Section 4.2, the spatial designations and recommendations in Section 4.3, information listed in Sections 4.4, 4.5, and 4.7, and compliance with applicable standards in Sections 4.6 and 4.8. Applicants will need to provide all of this information to enable the state to complete the consistency review process for a new ocean use project.

Additionally, for federal permit, license or lease applicants, the marine spatial plan identifies the following as Necessary Data and Information¹³ for purposes of starting the CZMA 6-month review period for federal license or permit activities under 15 C.F.R. part 930, subpart D, and OCS Plans under 15 C.F.R part 930, subpart E, pursuant to 15 C.F.R. 930.58(a)(3):

- A notice of proposed project that applicant provided to Washington Coastal Marine Advisory Council¹⁴ chair and membership (see Section 4.2.1.3(a)(ii)).

¹³ Other existing Necessary Data and Information is described in Washington's approved Coastal Program document.

¹⁴ The Washington Coastal Marine Advisory Council was established in the office of the governor by RCW 43.143.050 with duties outlined in 43.143.060.

- A meeting with WDFW and affected commercial and recreational fisheries (see [Section 4.2.1.4\(c\)](#)).
- A list of alternatives considered, including other project sites, and reasons they were rejected [RCW 43.143.030(2)(b)]. Alternatives considered should be commensurate with the need for the proposed use [WAC 173-26-360(7)(d)].
- An assessment of the short and long-term economic and social impacts to the local and regional economies and communities, including tourism, recreation, fishing, aquaculture, navigation, transportation, public infrastructure, public services and community culture [WAC 173-26-360(t)]. Without this information the state will not be able to begin evaluating whether a project has potential for long term significant adverse impacts to coastal uses or will comply with current enforceable policies regarding social and economic impacts and [RCW 43.143.030(2)(c)(e)].

Within federal waters adjacent to Washington's state waters, Department of Ecology will review federal decisions to permit, license, or otherwise authorize ocean uses that have reasonably foreseeable effects on the state's coastal resources or uses for consistency with the Marine Spatial Plan and the applicable enforceable policies of the Washington Coastal Zone Management Program pursuant to the federal Coastal Zone Management Act and federal consistency regulations at 15 CFR Part 930.¹⁵ The Department of Ecology may use the data and maps provided in the MSP for federal waters to assess coastal effects, but Washington's CZMA federal consistency concurrence or objection must be based on enforceable policies contained in the NOAA-approved Washington Coastal Zone Management Program. Federal actions, including the issuance of any federal authorizations that are subject to Washington's CZMP review, shall be supported by the information required in NOAA's regulations at either 15 CFR §§ 930.39, 930.58 or 930.76.¹⁶

6. Recommendations for federal agencies and federal waters

The state will follow the processes outlined above for reviewing new proposals for ocean uses. Furthermore, the state recommends federal agencies use the data,

¹⁵ Whether a particular federal license or permit activity proposed in federal waters is subject to Washington review depends on whether the state has, pursuant to 15 CFR § 930.53, (1) listed the federal authorization in the Washington Coastal Management Program, and (2) the proposed listed activity falls within a NOAA-approved "Geographic Location Description" (GLD). If Washington has not listed the activity and does not have a NOAA-approved GLD, the state can seek NOAA approval to review a project on a case-by-case basis as an "unlisted activity" pursuant to 15 CFR § 930.54. If a federal action, including the issuance of any federal authorizations, is subject to Washington CZMA review, it shall be supported by the information required in NOAA's regulations at either 15 CFR §§ 930.39, 930.58 or 930.76.

¹⁶ The regulations for federal consistency with approved state coastal programs are prescribed in 15 CFR Part 930. "Energy projects" are defined under 15 CFR § 930.123(c) to mean "projects related to the siting, construction, expansion, or operation of any facility designed to explore, develop, produce, transmit or transport energy or energy resources that are subject to review by a coastal State under subparts D, E, F or I of this part."

information, processes, and recommendations in the Marine Spatial Plan to guide their planning and review of proposed ocean uses, including in federal waters adjacent to Washington's Pacific Coast [as required by RCW 43.372.040(6)(d)]. Other sections that include references to federal activities or federal waters include Sections 4.2.1.5, 4.2.2, and 4.3.1.

4.2.2 Implementation: Other State Activities and Recommendations

Plan implementation by state agencies depends on available resources, capacity, priorities, and opportunities to leverage outside expertise and resources. To account for these factors and variations, the interagency team (State Ocean Caucus) will seek input on and further develop more detailed work plans that specify roles, tasks, timelines and processes for implementing these activities.

1. Finalize Ecosystem Indicators

Ecosystem indicators provide important context for decision-making. Ecosystem-level ecological integrity indicators provide important insights into the big-picture of ecosystem health. The current list of ecological and social indicators is too long to be an effective management tool or operationalized (Andrews, Coyle, & Harvey, 2015; Poe, Watkinson, Trosin, & Decker, 2015). While the economic indicators report provides a list of the top 5 economic indicators, the economic indicators report lists other potential economic indicators (Decker, 2015).¹⁷ More work is needed to refine and select key indicators for monitoring ecosystem health for Washington's Pacific Coast as required by RCW 43.372.040(6)(a).

In implementing the plan, state agencies will work with federal agencies, tribes, Washington Coastal Marine Advisory Council, and others to refine the current list of ecosystem indicators using the steps outlined below.

The state interagency team (State Ocean Caucus) will leverage existing expertise and seek additional resources, where necessary, to follow through on these process steps to finalize ecosystem (ecological, social, and economic) indicators:

- a. **Establish Management Priorities:** Convene state, federal and tribal resource managers to narrow large pool of potential ecosystem indicators to manageable list. Identify key priority indicators using conceptual models to refine why they are meaningful to various managers/management actions. Identify baselines and targets, where able.

¹⁷ From this report, suggested top economic indicators include: Gross Regional Product; Month-to-Month Unemployment, Per Capita Income, Job Diversity, and Poverty Rate.

- b. **Enlist Experts to Perform Sensitivity Assessments:** Use models to test sensitivity of key indicators to management actions and scenarios. Evaluate effectiveness of current monitoring strategies.
- c. **Monitor Indicators:** Create list of indicators for monitoring and pursue funding or adjustment in current monitoring efforts to address any gaps.
- d. **Evaluate and Adapt Indicators:** Revisit indicators on regular basis and revise list of indicators as needed to target most effective set of monitoring for management needs.

2. Science and Research Agenda

The interagency team (State Ocean Caucus) will develop and implement a Pacific Coast Science and Research Agenda using an inclusive process with researchers, tribal, federal, state and local governments, the Washington Coastal Marine Advisory Council and others, to improve scientific information available for managing ocean resources. The Science and Research Agenda will allow the state to:

- a. Continue to learn about Washington's Pacific Coast resources and activities;
- b. Better understand potential effects of future developments and other human impacts; and
- c. Increase understanding of projected impacts of climate change and other changes occurring in the marine system.

Building off of work begun in the marine spatial planning process, the state will bring together key scientists, ocean users, government agencies, and others to help the state identify data gaps, short- and long-term research priorities, potential partners and potential funding sources. Along with the efforts to finalize ecosystem indicators, the Science and Research Agenda provides a process to identify additional data gaps and to work to acquire new scientific data to strengthen plans [RCW 43.372.005(3)(b)] as well to determine how best to maintain, manage and update existing datasets, including enabling assessment of status and trends [WCMAC 4.1.1].

- 3. List substantially inconsistent existing management plans and provide recommendations on aligning plans [if needed, as required by 43.372.040(10)]
- 4. **Incorporate MSP into Washington's Coastal Zone Management Program.**

As required by RCW 43.372.040(12), Department of Ecology plans to submit the final MSP to NOAA to be incorporated into its federally-approved Coastal Zone Management Program (CZMP). Once NOAA approves of the incorporation of any

information and enforceable policies within the MSP into Washington's CZMP,¹⁸ they are applicable to those federal actions that affect the uses or resources of Washington's coastal zone and are subject to the federal consistency requirements of the federal Coastal Zone Management Act.¹⁹ (See 15 C.F.R. Part 923, Subpart H; and 15 C.F.R. § 930.53).

5. **Sediment management planning and coastal erosion monitoring**

Keeping sand in our coastal littoral systems (i.e. placing the sand on the beach or as close to the beach as possible) protects vulnerable coastal areas from the effects of coastal storms, helps maintain beaches and dunes, maintains and enhances important habitat, and supports public access and use of shorelines.

- a. As state funding allows, state agencies will continue to monitor shoreline change on the Washington coast and provide technical assistance to help communities understand the implications of data. [WCMAC rec. 1.2.4]
- b. State agencies will continue to support and advance implementation of the Mouth of the Columbia River Regional Sediment Management Plan and other local plans aimed at addressing navigation safety and beneficial use of dredge materials. [WCMAC rec 1.2.2]
- c. Through their permitting and authorizations, state agencies will work in partnership to evaluate new dredge disposal sites to ensure they are consistent with these other plans.

6. **Government Coordination**

Washington State is committed to coordination and communication with local governments, tribes, federal agencies and other states on Washington's Marine Spatial Plan on an ongoing basis. The interagency team (State Ocean Caucus) will pursue mechanisms that foster recognition of and implementation of each others' plans. Such efforts can:

¹⁸ According to NOAA regulations and guidance, to be incorporated and approved into Washington's CZMP, the spatial designations, recommendations, and other standards included in the MSP and applied to ocean uses should be based on coastal effects and substantial evidence. They should not discriminate against a particular use, user or activity.

¹⁹ Whether a particular federal license or permit activity proposed in federal waters is subject to Washington review depends on whether the state has, pursuant to 15 CFR § 930.53, (1) listed the federal authorization in the Washington Coastal Management Program, and (2) the proposed listed activity falls within a NOAA-approved "Geographic Location Description" (GLD). If Washington has not listed the activity and does not have a NOAA-approved GLD, the state can seek NOAA approval to review a project on a case-by-case basis as an "unlisted activity" pursuant to 15 CFR § 930.54. If a federal action, including the issuance of any federal authorizations, is subject to Washington CZMA review, it shall be supported by the information required in NOAA's regulations at either 15 CFR §§ 930.39, 930.58 or 930.76.

- a. Continue to improve our understanding of and management of ocean and human uses through ongoing data collection, maintenance, and prioritization.
- b. Foster greater collaboration and communication among government entities in an efficient and strategic manner.
- c. Assist in marine spatial plan implementation and adaptation, including integration with tribal plans and federal recognition and use of Washington's Marine Spatial Plan.

7. **Adaptive Management of plan and plan updates** [WCMAC 4.1.2]

Since conditions change over time, plans benefit by having a regular process to review and adapt the plan as needed. Recognizing this need, this section addresses the adaptive management element, which is also required by the MSP law.²⁰ Using the processes described in the plan implementation section:

- a. The interagency team will address minor revisions to update information and clarify plan processes on an ongoing basis, as needed.
- b. The interagency team will identify new information and update data on the website, as resources allow. The mapping application is designed to automatically receive updated data from many, but not all, data sources.

Using the Plan Performance Monitoring and Ecosystem Indicator Monitoring processes, the Washington Coastal Marine Advisory Council and others will be involved in regularly reviewing implementation of the Marine Spatial Plan and in identifying potential revisions to the Marine Spatial Plan. The interagency team recommends reviewing the entire plan at least every 8 years and that funding be provided for the plan review process. The interagency team will evaluate if conditions warrant a more major revision to the plan prior to the suggested review period.

8. **Plan Monitoring and Reporting Measures**

This is the performance monitoring goal, include "establish a performance management system to monitor implementation of any new marine spatial plan" [as required by RCW 43.372.005(3)(g)] and "Ensure all plans are linked to measureable environmental outcomes" [as required by RCW 43.372.005(3)(f)].

The agencies will monitor plan performance to assess progress on implementation, including the following monitoring activities:

- a. Regularly engage Washington Coastal Marine Advisory Council, the public and others in discussions and reviews of implementation of the Marine Spatial Plan including: exchanging new research findings, information and data; discussing strategies to strengthen implementation, including

²⁰ In addition, the plan should incorporate existing adaptive management strategies underway by local, state, or federal entities and provide an adaptive management element to incorporate new information and consider revisions to the plan based upon research, monitoring, and evaluation. [RCW 43.372.0040(6)(a)]

identifying any existing management plans that are inconsistent with the Marine Spatial Plan²¹; and identifying emerging issues and potential plan revisions.

- b. On an ongoing basis, the state agencies will assess progress of the Marine Spatial Plan including the following activities:
 - i. Establishing and monitoring ecosystem indicators.
 - ii. Other activities implementing the plan described in this section.
 - iii. Plan effectiveness and governance, including decisions, policy implementation, lessons-learned and adaptations.

This information will be conveyed on the website and formally reported to the public annually.

- c. Four years following the adoption of the Marine Spatial Plan, Ecology, in coordination with the interagency team (State Ocean Caucus), will report to the State Legislature (i.e. marine waters committees in the House and Senate) on provisions of existing management plans that are substantially inconsistent with the Marine Spatial Plan and make recommendations for eliminating the inconsistency per RCW 43.372.050(3) (see Section 4.1.5).

4.3 Spatial Data, Designations and Recommendations

This section provides spatial designations and recommendations regarding use of spatial data developed in the plan. These spatial designations and recommendations are designed to provide early guidance on criteria for avoiding significant adverse impacts to important resources and uses through initial site selection [43.143.030(2)]. While this section can assist applicants in identifying impacted resources and users and in early elimination of potential sites and scales of projects, using the spatial designations below does not guarantee that a project will satisfy state criteria.

4.3.1 Federal Waters and MSP maps

States do not have direct permitting authority in federal waters and the Coastal Zone Management Act (CZMA) does not confer such authority. Therefore, to meet CZMA requirements, state plans, enforceable policies, and Important Sensitive and Unique (ISU) areas must only apply to areas of state jurisdiction. The Washington Marine Spatial Plan is a planning framework for the state and will be incorporated into the NOAA-approved Washington Coastal Zone Management Program (CZMP). To meet the CZMA's definition of "enforceable policy" and NOAA's corresponding regulations, the Marine Spatial Plan only applies to state waters (3 nautical miles). Under the CZMA (15 CFR 930.53 and 930.54), Washington has the opportunity to review federal activities outside of state waters that have reasonably foreseeable effects on coastal resources and uses of the state. Any enforceable policies, ISUs and other designations in this MSP that ultimately get approved by NOAA would be applicable to this process [see section 4.2.2(5)].

²¹ This will assist with reporting required four years after adoption of the plan per RCW 43.372.050(3).

The MSP maps [see Appendix A] and available on the MSP website, accompany the plan's enforceable policies to show spatially where certain areas and resources are located in both state and federal waters. The data and maps pertaining to federal waters are not enforceable elements of the Marine Spatial Plan for Washington's Pacific Coast [see sections 4.1.6 and 4.2.2.5 for more details on the linkage to the state's federally approved Coastal Zone Management Program].

4.3.2 Marine Spatial Planning Data and Analyses

The data and analyses contained in the MSP provides important context to enable the state to review and influence projects in federal waters. It also provides important information for federal agencies to use when reviewing proposals for leases, licenses or permits and for applicants to consider when proposing ocean uses. The plan's information provides applicants and governments with the ability to:

- View other known activities, resources, interests, designations and authorities that may conflict or complement with a proposal.
 - Identify potential ways to avoid, minimize and mitigate adverse impact prior to submitting an application, including alternative locations and configurations of projects.
 - Identify appropriate parties to discuss the proposal with prior to submitting an application.
1. For projects in federal or state waters, applicants and agencies should use data presented in the Washington Marine Spatial Plan to understand and evaluate potential impacts to existing uses and resources, including any updated data available. Additional site specific analyses will be needed to further evaluate potential impacts from a particular proposal. Major data sources of the plan that should be reviewed and considered, include:
 - a. Baseline information on Washington's Pacific Coast, including maps of existing uses and resources (see Part 2).
 - b. Spatial analyses that aggregate and illustrate this information in various ways and convey key findings (see Part 3).
 - c. Spatial designations, recommendations and approaches that identify areas that are incompatible for certain projects or activities in state waters (Part 4 – this section).
 - d. The online, Marine Spatial Planning [Mapping Application](#) provides a reference to access and view baseline information on existing human uses and ocean resources, including any updated data available after adoption of the plan.
 2. Other Ocean Uses - The Marine Spatial Plan provides baseline information and analyses that can assist applicants and agencies in evaluating potential impacts from other potential new ocean uses such as offshore aquaculture, mining (sand/gravel, methane hydrate), bioextraction, and new dredge disposal sites. There is limited spatial data available on the areas of interest for these potential uses and the spatial scale of some uses is too small for some of the plan's analyses (see Part 3) to be helpful in guiding specific siting.

4.3.3 Important, Sensitive and Unique Areas (ISUs)

State law requires the Marine Spatial Plan to identify environmentally sensitive and unique resources that warrant protective measures [RCW 43.372.040(6)(c)]. Therefore, the plan is designating Important, Sensitive and Unique (ISU) Areas in state waters to protect these areas

from new ocean use developments while allowing existing uses such as fishing that currently occur within them. ISUs are specific areas that meet established criteria with the goal of protecting areas that have high conservation value, historic value or areas with key infrastructure from offshore development. Consistent with this goal, all offshore development is presumptively excluded from ISUs occurring in state waters.

The following ISUs have been proposed by reviewing current knowledge and available data developed through the MSP process [see Appendix A: Maps 56-59]. Data gaps exist in mapped information for ISUs and maps presented in the plan depicting ISUs may be superseded by more detailed, site-specific maps created with finer resolution data. ISU designation extends to those areas defined below wherever those ISUs occur and regardless of data gaps. Additional ISUs may be identified and designated at a later date. The criteria below were used to identify the current, proposed ISUs:

1. ISU Criteria

- a. Areas that are environmentally sensitive or contain unique or sensitive species or biological communities that must be conserved and warrant protective measures [RCW 43.372.040(6)(c)].
- b. Areas with known sensitivity and where the best available science indicates the potential for development to cause significant adverse impacts.
- c. Areas with features that have limited, fixed and known occurrence.
- d. Areas with inherent risk or infrastructure incompatibilities (e.g. buoys or cables).

2. ISUs

- a. Biogenic Habitats: Aquatic vegetation and coral
- b. Rocky Reefs
- c. Bird colonies
- d. Pinniped haul-outs
- e. Historic and archaeological sites
- f. Buoys and cables
- g. Forage fish spawning areas

Offshore development²² of any size is presumptively excluded from these ISUs within state waters, whether they are mapped or not. This presumption is rebuttable, if an applicant can demonstrate: i) that the ISU maps do not accurately characterize the resource or use based on new or substantial information or ii) by clear and convincing evidence that the project will cause no significant alteration of the resources of the ISU.

Coastal estuaries, including Grays Harbor and Willapa Bay, are important ecological areas and are heavily used by existing uses and their associated infrastructure. They are home to critical

²² Development under the jurisdiction of the Shoreline Management Act is defined at RCW 90.58.030(3)(a) as “a use consisting of the construction or exterior alteration of structures; dredging; drilling; dumping; filling; removal of any sand, gravel, or minerals; bulkheading; driving of piling; placing of obstructions; or any project of a permanent or temporary nature which interferes with the normal public use of the surface of the waters overlying lands subject to this chapter at any state of water level.” For purposes of the MSP, “offshore development” means any development occurring in the plan study area that also meets the definition of a new ocean use.

saltwater habitats²³ and Priority Habitats and Species²⁴, such as spawning and juvenile rearing areas, aquatic habitats (e.g. eelgrass, kelp, mudflats, and shellfish beds), state-listed or candidate species, vulnerable aggregations, and species of commercial, recreational or tribal importance. While estuaries themselves are not designated as an ISU, many ISUs occur within estuaries. Since the density of uses and resources is higher in estuaries and the resolution and availability of current data is inadequate to aid in detailed siting, a more detailed and finer-scaled analysis for proposed projects will be required to provide special protection to the marine life and resources of the estuaries and to ensure all reasonable steps are taken to avoid and minimize impacts to the habitats, species, and uses in estuaries [RCW 43.143.030(2)(d) and RCW 43.143.030(2)(e)].

4.3.4 Spatial Recommendations

1. Further evaluation of proposed projects, in state waters, should occur on a case-by-case basis. Projects would still need to provide information, meet criteria and statutory requirements, and follow the process described in the MSP. When proposing any projects, applicants should seek to avoid adverse impacts to existing uses and ecological areas in state waters. The greater the number of existing uses and ecologically important areas or the greater intensity of uses or ecologically important areas will likely result in a more difficult permitting process.
2. Specific to Renewable Energy: Where particular uses have similar coastal effects (e.g. structures or cables), applicants should use the criteria, information and process described for renewable energy as a starting point.

In state waters on Washington's Pacific Coast, industrial-scale renewable energy facilities should not be permitted to avoid significant adverse impacts to existing uses and resources. Community-scale renewable energy facilities proposed for state waters will be further evaluated for consistency with state policies, plans and authorities through existing permitting processes. The following definitions apply:

- a. **Industrial-scale Renewable Energy Facilities:** are those projects designed to provide energy at a scale for the regional power grid. Their size and energy generation is larger than those described as community-scale facilities and, therefore, would result in a larger footprint for development.
- b. **Community-scale Renewable Energy Facilities:** are those projects designed to provide energy at scale for a local community, subset of a community, or group of communities. Community-scale energy projects have:
 - i. A smaller size and energy generation levels more suited to the needs of a community than production and distribution to the regional grid and, therefore, a smaller footprint for development than an industrial-scale facility.
 - ii. Strong local participation in and support for the project. Support may be demonstrated by a letter from city's Mayor or City Council.

²³ "Critical Saltwater Habitat" is defined in Shoreline Management Regulations at: WAC 173-26-221(2)(c)(iii)(C).

²⁴ Washington Department of Fish and Wildlife identifies and maintains information about "Priority Habitats and Species", more information at: <http://wdfw.wa.gov/conservation/phs/>.

- iii. Demonstrated economic benefit for the local community.

4.4 Project and Site-specific Data and Information

Applicants shall provide information listed below to regulating agencies at the earliest stage to assist with local and state required processes, permit, and leases [see WACs 197-11-100, 197-11-315, and 197-11-960]. This information enables evaluation of the magnitude of a project, the likelihood of effects from a project, and the significance of resources and uses that the project may affect. Applicants for construction and development activities in state marine waters can complete a Joint Aquatic Resources Permit Application (JARPA), which consolidates the initial information needed for multiple local, state, and federal permits and provides information on the status of SEPA review.

The list of project and site-specific data and information below is consistent with these existing application requirements (WAC 197-11-315) and provides specific details support agency implementation of existing state ocean policies and regulations and the MSP for Washington’s Pacific Coast. In addition, applicants shall produce a written effects evaluation that addresses the requirements with any review standards that apply (See Sections 4.5, 4.6, and 4.8).

Table 4.4-1 Project and Site-specific data and information requirements

Type of Information	Including, but not limited to:	Specific types of data and information
Project information	Project purpose, need (i.e. local, state, or national need) and anticipated benefits Location of alternative sites considered and why they were rejected [RCW 43.143.030(2)(b)] Total project footprint: number and sizes of equipment, structures, and anchors Methods, techniques and activities Transportation and transmission systems for service and support Onshore facilities Utility corridors used or created Materials to be disposed and methods Physical and chemical properties of any hazardous materials used or produced Proposed time schedule	Alternatives considered should be commensurate with the proposed need of project (e.g. national need requires, national alternatives) [WAC 173-26-360(7)(d)].
Physical and chemical conditions	Water depth Wave regime Current velocities Mixing characteristics (horizontal transport, vertical mixing and dispersal) Meteorological conditions Water quality	Survivability assessment for structures based on physical and geological conditions at the site and expected in the future. [WCMAC 1.2.6] Adjacent area affected by physical changes in currents, waves or sediment transport

		caused by project. [WAC 173-26-360(10)(a)]
Bathymetry	Bottom topography (bathymetry) Shoreline topography	
Geologic structure	Bottom substrate type (rock, mud, sand) Faults Submarine landslides Other geologic hazards Mineral deposits Hydrocarbon resources	
Biological features	Critical and sensitive habitats: wetlands; sea stacks; estuaries, etc. Areas used for breeding, spawning, nursery, foraging and areas of high productivity areas for marine biota: upwelling and estuaries. Bird colonies Marine species migration routes Fish and shellfish stocks and other biologically important species Endangered and threatened species or their habitats Recreationally or commercially important finfish or shellfish Scientific preserves, sanctuaries, parks, refuges, and other protected areas [WAC 173-26-360(7) and WCMAC 1.3.1]	
Historical, cultural or archaeological resources	Historic or culturally significant sites, including any archaeological sites or objects. [WAC 173-26-360(7)(l)]	For new uses that will impact the ocean floor, conduct a high-resolution seafloor archeological assessment [WCMAC 1.2.3]
Economic, social and cultural uses	Aquaculture operations (private and public lands), oyster reserves, shellfish growing areas. Commercial and recreational fishing Coastal communities economy Designated dredge disposal sites, ports and navigation Recreation, including parks and designated recreation areas [WAC 173-26-360(7)(k)] Scientific research Military uses Tourism Aesthetic resources Existing aquatic land leases Local shoreline master program environment designation [WCMAC 3.1.4]	Where applicable, inventory should include information on established, traditional and recognized times of uses. Current information on uses, including data covering multiple years and seasons, when available. [WCMAC 4.1.3] Conceptual site drawings of visual impacts [WCMAC 1.2.5]

	Waste water or other discharge [WAC 173-26-360(7)(t)]	
Infrastructure	Existing infrastructure: navigation aids, cables, buoys or other fixed structures. Utility or pipeline corridors and transmission lines [WAC 173-26-360(7)(t)]	
Tribal uses	Usual and Accustomed Areas Tribal fishing and other uses	

Regulating agencies may determine and request other information from applicants to enable the evaluation of the effects of a proposed project [WAC 197-11-335].

4.5 Effects Evaluation

To enable evaluation of compliance with the state’s ocean use policies and regulations, including the criteria at RCW 43.143.030(2), applicants must provide a written effects evaluation that complies with the contents in Section 4.5 and the applicable Review Standards (Sections 4.6 and 4.8). The evaluation must include the reasonably foreseeable adverse effects associated with the development, placement, operation, and decommissioning of a proposed new ocean use on Washington State’s coastal resources or uses. This section does not provide the full list of other state laws and policies or requirements with which an applicant will have to demonstrate compliance (see Section 4.15 and 4.1.6).

The processes set out in Section 4.2.1 will assist applicants in identifying potentially adverse impacts to Washington’s coastal resources and uses. For purposes of the evaluation, the submittal shall base the determination of “reasonably foreseeable adverse effects” on scientific evidence. Applicants should use up-to-date data that is adequate to evaluate the project and its potential effects. If new data gathering is required, it should be done at the applicants’ expense. When it exists, data should include multiple years and multiple seasons within those years [WCMAC 4.1.3].

In addition, applicants shall provide information that addresses their compliance with the applicable review standards [Sections 4.6 and 4.8]. The evaluation shall describe the potential short-term and long-term effects of the proposed new ocean use on marine resources and uses of Washington’s marine waters, continental shelf, onshore areas and coastal communities based on the required project and site-specific data [Section 4.4] and the following considerations:

1. Ecological Effects

Ecological effects include those on critical marine habitats and other habitats, and on the species those habitats support. The evaluation shall determine the probability of exposure and the magnitude of exposure and response, as well as the level of confidence (or uncertainty) in those determinations. The evaluation need not discuss highly speculative consequences. However, the evaluation shall discuss catastrophic environmental effects of low probability. Factors to consider include, but are not limited to:

- The time frames/periods over which the effects will occur;
- The maintenance of ecosystem structure, biological productivity, biological diversity, and representative species assemblages;
- Maintaining populations of threatened, endangered, or sensitive species;

- Vulnerability of the species, population, community, or the habitat to the proposed actions; and
- The probability of exposure of biological communities and habitats to adverse effects from operating procedures or accidents.

The following additional factors should be specifically evaluated and addressed:

- a. Impacts to habitats and species, including:
 - i. Impacts on migration routes and habitat areas of species listed as endangered or threatened, environmentally critical and sensitive habitats such as breeding, spawning, nursery, foraging areas, bird colonies, sea stacks, and wetlands, and areas of high productivity for marine biota such as upwelling and estuaries [WAC 173-26-360(7)(j)(n) and WCMAC 1.3.1]
 - ii. Impacts to sensitive and important habitat of commercially, recreationally and ecologically valuable species [WCMAC 1.3.1]
 - iii. Potential for direct injury or harm to species, including ESA listed and commercially valuable species (e.g. strikes, entanglement, etc.), or indirect injury related to exposure to noise, light, vibration, electromagnetic fields or other related stressors associated with the new use. [WCMAC 1.3.1]
 - iv. Risk for invasive species introductions and impacts, if applicable. [WCMAC 1.3.1 and 1.3.4]
- b. Effects to air and water quality [WAC 173-26-360(7)(t)], including potential degradation of water quality (chemicals, petroleum products, nutrients, oxygen, temperature, acidification, etc.). [WCMAC 1.3.1]
- c. Effects to physical processes, including, but not limited to, currents and waves, sediment processes, coastal erosion and accretion, electromagnetic fields, acoustics and wave amplification. [WCMAC 1.3.1]
 - i. For marine renewable energy projects, assess effects on upwelling oceanographic, ecosystem processes, beach accretion or erosion, and wave processes. [WAC 173-26-360(10)(a)(b)]
- d. Effects of projected coastal erosion, future sea-level rise, and other climate change impacts on the proposed project over the anticipated life of the project [WCMAC 1.2.4]
- e. Unintended impacts, including, but not limited to, impacts to the food chain, changes to physical processes, introduction of disease or genetic pollution, and access to existing resources. [WCMAC 1.3.1]

2. Current Uses

Evaluate the effects of the project on current uses and the continuation of a current use of ocean resources such as fishing, recreation, navigation, and port activities. Factors to consider include, but are not limited to:

- a. Social and economic impacts to local and regional economies and communities; including tourism, recreation, fishing, aquaculture, navigation, transportation, public infrastructure, public services and community culture [WAC 173-26-360(t)]. The assessment should address:
 - i. Short and long-term economic and social costs and benefits to the affected community, including social costs to vulnerable ocean users, potential impacts on taxpayers. The costs and benefits to larger economy (state, regional, national). Assessment of various scenarios, including full project footprint and

- scenarios where new use fails or is abandoned or decommissioned. [WCMAC recommendation 1.1.1]
- ii. The risk proposed structures pose for entangling fishing gear or other debris [WCMAC 1.2.7]
- iii. Established, traditional and recognized times of renewable ocean resource uses and site-specific impacts to current uses, including, but not limited to, fishing, aquaculture, and recreation. [WAC 173-26-360(7)(m) and WCMAC 3.1.4]
- b. Recreational activities and experiences such as public access, aesthetics, and views [WAC 173-26-360(7)(s) and WCMAC 1.2.5]
- c. Archeological and historical resources [WAC 173-26-360(7)(l)]; and
- d. Transportation safety and navigation, including
 - i. A vessel traffic risk assessment or a risk-based modeling to evaluate navigational safety risks. [WCMAC 1.2.1]

3. Natural and Other Hazards

Evaluate the potential risk to the new ocean use, in terms of its vulnerability to certain hazards and the probability that those hazards may cause loss, dislodging, or drifting of structures, buoys, or facilities. Consider both the severity of the hazard and the level of exposure it poses to the renewable marine resources and coastal communities. Hazards to be considered shall include:

- a. Based on the characteristics of the use and the environment, risk of and potential impact from a probable disaster, including explosions, spills, and other disasters, on the environment, adjacent uses, and communities. [WAC 173-26-360(7)(o) and WCMAC 1.3.1]

4. Cumulative Effects

Evaluate the cumulative effects of a new ocean use project, including the shoreland components, in conjunction with effects of any prior phases of the project, past projects, other current projects, and probable future projects²⁵. The evaluation shall analyze the biological, ecological, physical, and socioeconomic effects²⁶ of the new ocean use project and of other

²⁵ Under NEPA, “cumulative impact” means “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.” 40 CFR. § 1508.7

²⁶ “Effects” and “impacts” include: (a) Direct effects, which are caused by the action and occur at the same time and place. (b) Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

“Effects” and “impacts” as used in NEPA regulations are synonymous. Effects includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance the agency believes that the effect will be beneficial.

projects along the Washington coast, while also taking into account the effects of existing and future human activities, environmental baseline and variability, the regional effects of global climate change, and potential to reach tipping points of harm for existing uses or ocean resources [WCMAC 3.1.5].

In conducting the cumulative effects analysis, the applicant shall focus on the specific resources and uses that may be affected by the incremental effects of the proposed project and other projects in the same geographic area. The evaluation shall include but not be limited to consideration of whether:

- a. The resource and uses are especially vulnerable to incremental effects;
- b. The proposed project is one of several similar projects in the same geographic area;
- c. Other developments in the area have similar effects on the resources and uses;
- d. These effects have been historically significant for the resource and uses; and
- e. Other analyses in the area have identified a cumulative effects concern.

4.6 Review Standards

This section provides the detailed review standards for applicants and for agencies to consider in determining possible significant adverse effects²⁷ from an ocean use project²⁸ on coastal uses and resources. An applicant's written effects evaluation (Section 4.5) must address compliance with the standards noted in this section and any specific standards that apply to the particular type of new use (Section 4.8). The regulating agencies shall use best available maps and data and may consider new information that is sufficient and applicable. Furthermore, the processes outlined in Section 4.2.1 will further assist applicants in identifying approaches that will prevent, avoid and minimize impacts.

4.6.1 Siting and development standards for the construction, deployment or maintenance of an ocean use facility.

1. Consider practicable alternative deployment and placement of structures in proximity to the proposed project area that would have less adverse impact on identified resources and uses, including social and economic impacts to coastal communities [WAC 173-26-360(7)(a)(b)].
2. For marine renewable energy, be located, constructed, and operated in a manner that has no detrimental effects on beach accretion or erosion and wave processes. [WAC 173-26-360(10)(a)]
3. Be located to avoid adverse impacts on proposed or existing environmental and scientific preserves and sanctuaries, parks, and designated recreation areas. [WAC 173-26-360(7)(k)]
4. In locating mining facilities or oil and gas facilities, avoid and minimize impacts on shipping lanes or routes traditionally used by commercial and recreational fishermen to reach fishing areas. [WAC 173-26-360(7)(x)]

²⁷ In applying ORMA's policies, "significant adverse impacts" must be consistent with the SEPA rules and process. WAC 173-26-360(7)(e): "The determination of significant adverse impacts should be consistent with WAC 197-11-330(3) and 197-11-794. The sequence of actions described in WAC 197-11-768 should be used as an order of preference in evaluating steps to avoid and minimize adverse impacts."

²⁸ This section details the general ocean use standards contained in WAC 173-26-360(7), which specifically apply to ocean uses that require a shoreline permit. Development under the jurisdiction of the Shoreline Management Act is defined at RCW 90.58.030(3)(a).

5. Routing:

Ocean uses and their distribution, service, and supply vessels and aircraft should be:

- a. Located, designed, and operated in a manner that minimizes adverse impacts on fishing grounds, aquatic lands, or other renewable resource ocean use areas during the established, traditional, and recognized times they are used or when the resource could be adversely impacted. [WAC 173-26-360(7)(m)]
- b. Routed to avoid environmentally critical and sensitive habitats such as sea stacks and wetlands, preserves, sanctuaries, bird colonies, and migration routes, during critical times those areas or species could be affected. [WAC 173-26-360(7)(n)]

6. Associated on-shore facilities: In locating and designing on-shore facilities:

- a. Special attention should be given to the environment, the characteristics of the use, and the impact of a probable disaster, in order to assure adjacent uses, habitats, and communities adequate protection from explosions, spills, and other disasters. [WAC 173-26-360(7)(o)]
- b. Minimize impacts on existing water dependent businesses and existing land transportation routes to the maximum extent feasible. [WAC 173-26-360(7)(p)]
- c. Be located in communities where there is adequate sewer, water, power, and streets. Within those communities, if space is available at existing marine terminals, the onshore facilities should be located there. [WAC 173-26-360(7)(q)]
 - i. For marine renewable energy projects, locate distribution facilities and lines in existing rights of way and corridors, whenever feasible [WAC 173-26-360(10)(c)]

7. Construction and Operation

- a. Use methods and scheduling of construction activities that minimizes impacts on tourism, recreation, commercial fishing, local communities and the environment [WAC 173-26-360(7)(r)].
- b. Use methods and designs that prevent, avoid, and minimize adverse impacts such as noise, light, temperature changes, turbidity, water pollution and contaminated sediments on the marine, estuarine or upland environment. Such attention should be given particularly during critical migration periods and life stages of marine species and critical oceanographic processes. [WAC 173-26-360(7)(u)]
- c. For mining, marine renewable energy or oil and gas uses, be designed, constructed, and operated in a manner that minimizes environmental impacts on the coastal waters environment, particularly the seabed communities, and minimizes impacts on recreation and existing renewable resource uses such as fishing. [WAC 173-26-360(7)(w)]

8. Compensation for impacts

- a. Impacts on commercial resources, such as the crab fishery, on noncommercial resources, such as environmentally critical and sensitive habitats, and on coastal uses, such as loss of equipment or loss of a fishing season, should be considered in determining compensation to mitigate adverse environmental, social and economic impacts to coastal resources and uses. [WAC 173-26-360(7)(f)]

- b. Allocation of compensation to mitigate adverse impacts to coastal resources or uses should be based on the magnitude and/or degree of impact on the resource, jurisdiction and use. [WAC 173-26-360(7)(g)]

4.6.2 Additional standards and recommended approaches to protect specific coastal resources and uses of the state

The following table provides additional state standards and recommended approaches for new ocean uses²⁹ designed to protect state coastal resources and uses. Additional standards requirements apply to offshore aquaculture, disposal, and mining (See Section 4.8).

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²⁹ Requirements of WAC 173-26-360(7) apply to ocean uses that require a shoreline permit.

Table 4.6.2-1. Goals, Additional Standards and Approaches to Protect Washington State Coastal Uses and Resources

Key Washington Ocean Resource Policies ³⁰ & MSP Objectives	Standards	Approaches include, but are not limited to:
Ecological		
<ul style="list-style-type: none"> Foster healthy and resilient marine ecosystem functions, biodiversity and habitats. (MSP Objective 3) ORMA 43.143.030(2)(d). 	<ul style="list-style-type: none"> Prevent, avoid, and minimize adverse impacts on migration routes and habitat areas of species listed as endangered or threatened, environmentally critical and sensitive habitats such as breeding, spawning, nursery, foraging areas and wetlands, and areas of high productivity for marine biota such as upwelling and estuaries [WAC 173-26-360(7)(j)]. 	<ul style="list-style-type: none"> Schedule construction to avoid critical migration times, vulnerable life stages of species, and important oceanographic processes. Use designs and methods that prevent, avoid and minimize disturbance to species, habitats, water quality, and ecological processes.
Historic or Cultural Resources		
<ul style="list-style-type: none"> Sustain diverse traditional uses and experiences to ensure continuity of WA’s coastal identity, culture, and high quality of life. (MSP Objective 2) Provide recommendations for uses that protect and enhance the aesthetic quality of marine environment, maritime activities, marine culture and sense of place. (MSP actions) 	<ul style="list-style-type: none"> Avoid and minimize adverse impacts on historic or culturally significant sites in compliance with chapter 27.34 RCW. Permits in general should contain special provisions that require permittees to comply with chapter 27.53 RCW if any archaeological sites or archaeological objects such as artifacts and shipwrecks are discovered. [WAC 173-26-360(7)(l)] 	<ul style="list-style-type: none"> Conduct high-resolution seafloor surveys for resources.
Coastal Uses: Existing uses such as aquaculture, fishing, navigation, recreation and tourism		
<ul style="list-style-type: none"> Protect and preserve healthy existing natural resource- based economic activity on the Washington Coast. (MSP Objective 1). ORMA 43.143.030(2)(e). 	<ul style="list-style-type: none"> Minimize impacts on existing water dependent businesses and existing land transportation routes to the maximum extent feasible. Avoid and minimize adverse social and economic impacts, including detrimental effects to tourism, recreation, fishing, aquaculture, navigation, transportation, public infrastructure, public services, and community culture. [WAC 173-26-360(7)(p)(t)]. 	<ul style="list-style-type: none"> Space structures to maximize compatibility with existing uses. Minimize project footprint. Schedule construction activities to minimize impacts to existing users. Mitigate possible hazards to navigation and, provide practicable opportunities for vessel transit, at the project location.

³⁰ This list is not exhaustive and is intended to highlights particular policies that are relevant to particular state coastal resources and uses.

4.6.3 Recommended Additional Approaches To Avoid and Minimize Impacts to Coastal Uses

In addition to the goals, standards, and approaches noted above, the following provides a list of specific approaches for applicants to consider in project siting, design, engineering, construction and operation. These approaches may contribute toward addressing Washington's ocean use standards to avoid and minimize adverse impacts to particular coastal uses. Use of any or all of these recommended approaches does not guarantee issuance of state or local permits or authorizations.

1. Aquaculture
 - a. Minimize impacts to existing shellfish aquaculture growing areas and operations.
 - b. Minimize disruption to physical processes and water quality of estuaries.
2. Fishing
 - a. Minimize the number of and size of anchors, spacing structures for greater compatibility with existing uses, and burying cables in the seafloor and through the shoreline. [Potential new WCMAC recommendation]
 - b. Minimize the displacement of fishers from traditional fishing areas, and the related impact on the travel distance and routing required to fish in alternative areas.
 - c. Minimize the compaction of fishing effort caused by the reduction in the areas normally accessible to fishers.
 - d. Minimize the economic impact resulting from the reduction in area available for commercial and recreational fishing for the effected sectors and ports.
 - e. Limit the number and size of projects that are located in an area to minimize the impact on a particular port or sector of the fishing industry.
 - f. Consider the distribution of projects and their cumulative effects.
3. Navigation
 - a. Minimize disruption to traditional and heavily used vessel transit routes, particularly those navigation lanes that are federally-designated or negotiated with other users.
4. Recreation
 - a. Minimize restrictions on public access, particularly in areas with high intensity of use or with a community of historical users.
 - b. Minimize impacts to areas with unique or special qualities, including the natural environment and aesthetics, associated with recreational use relative to the state or region.
 - c. Include measures that ensure protection of public health and safety.

4.7 Project Construction and Operation Plan

An applicant must submit a construction and operation plan as a condition of approval for a state permit, license, lease, or other authorization. The construction and operation plan must describe the procedures and methods the operator will employ to ensure facility compliance with standards and other conditions of the permit, license related to effects on the environment, safety and coastal uses. At a minimum, the construction and operation plan must include the following components:

1. **Facility Development Plan**, which describes the detailed physical and operational components of the proposed facility and includes technical information on the installation and deployment activities and methods, structures, easements, vessels, and construction schedule.
2. **Contingency Plan**, which describes how facility operator will respond to emergencies caused by a structural or equipment failure due to human error, weather, geologic or other natural event.
3. **Inspection Plan**, which describes the routine inspection program to ensure mechanical, structural and operational integrity of facilities.

4. **Monitoring Plan**

Agencies shall require applicants to provide pre-project environmental baseline inventories and assessments and monitoring of ocean uses when little is known about the effects on marine and estuarine ecosystems, renewable resource uses and coastal communities or the technology involved is likely to change. [WAC 173-26-360(7)(v)]

A monitoring plan provides for a standardized program to assess for potential impacts identified by the inventory and effects evaluation. Impacts of particular concern to address, where applicable, include:

- An invasive species prevention, monitoring and control plan for projects that pose a risk for invasive species introductions. [WCMAC 1.3.4]
- A plan to monitor structures for fishing gear and other debris entanglement and a plan to mitigate impacts. [WCMAC 1.2.7]
- For aquaculture facilities: prevention, monitoring and response plans that address escapement, disease and nutrient pollution. [WCMAC 2.1.1]

Monitoring shall be sufficient to accurately document and quantify the short-term and long-term effects of the actions on the affected resources and uses. At a minimum, monitoring plans shall describe:

- a. Specific study objectives and methods, including collection of baseline data, hypotheses tested, field sampling and data analysis, and controls (such as control sites).
 - b. Documentation that study design is scientifically appropriate and adequate to address objectives.
 - c. Methods for reporting and delivering data, analyses to agencies and for public involvement in review of monitoring activities.
5. **Adaptive Management Plan**, which provides a mechanism for incorporating new information and findings into the operation and management of the project. The plan shall describe processes for applying adaptive measures. When monitoring results indicate standards are not being met, adaptive measures designed to bring the operation into compliance will be applied to operation of the project.

6. **Decommissioning Plan**

An applicant must demonstrate that “plans and sufficient performance bonding are provided to ensure that the site will be rehabilitated after the use or activity is completed” [RCW 43.143.030(2)(g)]. The decommissioning plan³¹ must include:

- a. A proposed schedule and description of removal methods.
- b. Plans for disposing of the removed facilities.
- c. The resources, conditions and uses that could be affected by the decommissioning activities and methods for minimizing impacts to renewable ocean uses such as fishing [WAC 173-26-360(7)(y)].
- d. Mitigation to protect sensitive resources during decommissioning
- e. Use of new information and new technologies about environmental impacts to ensure state-of-the-art technology and methods are used [WAC 173-26-360(7)(h)].
- f. Methods to survey area after removal to determine any effects on marine life
- g. Rehabilitation measures to restore seabed to original state to the maximum extent feasible [WAC 173-26-360(7)(y)].

7. Financial Assurance Plan

The applicant shall provide a financial assurance compliance plan that describes how the holder will comply with the state requirements for financial assurance. The plan must assure insurance, bonds or other financial securities are adequate to address: resources required to decommission and rehabilitate the site, “the effects of planned and unanticipated closures, completion of the activity, reasonably anticipated disasters, inflation, new technology, and new information about the environmental impacts to ensure that state of the art technology and methods are used” [WAC 173-26-360(7)(h)]. Washington State Department of Natural Resources has authority to require financial security based on the cost of enforcing terms and conditions for leases of state-owned aquatic lands [RCW 79.105.330 and WAC 332-30-122].

4.8 Standards Specific to New Use type

Since different uses may generate different impacts, this section provides the additional, existing requirements and standards that are specific to a particular types of new ocean uses³² based on their potential effects to specific coastal resources or uses of concern, including offshore aquaculture, energy production, ocean mining, and ocean disposal.

³¹ Discontinuance or shutdown of oil and gas, mining or energy producing ocean uses should be done in a manner that minimizes impacts to renewable resource ocean uses such as fishing, and restores the seabed to a condition similar to its original state to the maximum extent feasible. [WAC 173-26-360(7)(y)]

³² The MSP scope specifically address certain other new ocean uses, however, existing ocean use regulations in WAC 173-26-360 provide standards specific to these other uses such as ocean research, ocean salvage, transportation and oil and gas activities.

Table 4.8-1: Additional Requirements Specific to New Use Type

Ocean Use	Definition	Effects Evaluation	Use-Specific Standards	Other related recommendations or requirements
Offshore Aquaculture	ADD DEFINITION.	Assess the risk of pesticide controls [WCMAC 2.1.4]	Avoid and minimize impacts to pinnipeds, cetaceans, sharks and other species through facility design, siting and operation. [WCMAC 2.1.2]	Deny permits for offshore aquaculture facilities with species that pose a significant risk of introducing disease, impairing fish health, or potentially introducing genetic pollution into the area, in accordance with WAC 276-76-100. ³³ [WCMAC 2.1.3]
Ocean mining	Ocean mining includes such uses as the mining of metal, mineral, sand, and gravel resources from the sea floor. [WAC 173-26-360(9)]	Assess effects on beach and sediment processes.	Located and operated to: <ul style="list-style-type: none"> • Avoid detrimental effects on ground fishing or other renewable resource uses. • Avoid detrimental effects on beach erosion or accretion processes. [WAC 173-26-360(9)(a)(b)] 	Consider habitat recovery rates in reviewing permits. [WAC 173-26-360(9)(c)]
Energy production	Energy production uses involve the production of energy in a usable form directly in or on the ocean rather than extracting a raw material that is transported elsewhere to produce energy in a readily usable form. [WAC 173-26-360(10)]	Assess the effect on upwelling and other oceanographic and ecosystem processes. [WAC 173-26-360(10)(b)]	Located, constructed and operated in manner that: <ul style="list-style-type: none"> • Has no detrimental effects on beach accretion or erosion and wave processes • Located in existing utility rights of way and corridors whenever feasible, rather than creating new corridors (associated distribution facilities) [WAC 173-26-360(10)(c)] 	

³³ WAC 276-76-100: A permit may be denied based on the determination by the director [of Washington Department of Fish and Wildlife] of significant genetic, ecological or fish health risks of the proposed fish rearing program on naturally occurring fish and wildlife, their habitat or other existing fish rearing programs.

Ocean Use	Definition	Effects Evaluation	Use-Specific Standards	Other related recommendations or requirements
Ocean disposal	Ocean disposal uses involve the deliberate deposition or release of material at sea, such as solid wastes, industrial waste, radioactive waste, incineration, incinerator residue, dredged materials, vessels, aircraft, ordnance, platforms, or other man-made structures. [WAC 173-26-360(11)]	Habitat enhancement.	Sites: <ul style="list-style-type: none"> Located and designed to prevent, avoid, and minimize adverse impacts on environmentally critical and sensitive habitats, coastal resources and uses, or loss of opportunities for mineral resource development. For which the primary purpose is habitat enhancement may be located in a wider variety of habitats. [WAC 173-26-360(11)(c)] 	<ul style="list-style-type: none"> Storage, loading, transporting, and disposal of materials shall be done in conformance with local, state, and federal requirements for protection of the environment. Allowed only in sites that have been approved by Ecology, DNR, US EPA, and US Army Corps of Engineers, as appropriate. [WAC 173-26-360(11)(b)] Sited in areas where the (dredge) disposal will provide beneficial use to the greatest extent possible. [WCMAC 1.2.2]
Oil and gas uses and activities	Oil and gas uses and activities involve the extraction of oil and gas resources from beneath the ocean. ³⁴ [WAC 173-26-360(8)]		Sites: <ul style="list-style-type: none"> When feasible, facilities located and designed to permit joint use in order to minimize adverse impacts to coastal resources and uses and the environment. Upland disposal of oil and gas construction and operation materials and waste products such as cuttings and drilling muds should be allowed only in sites that meet applicable requirements. [WAC 173-26-360(8)(a)(f)] Facilities including pipelines should be located, designed, constructed, and maintained in conformance with	Special attention to: <ul style="list-style-type: none"> The availability and adequacy of general disaster response capabilities in reviewing ocean locations for oil and gas facilities. The response times for public safety services such as police, fire, emergency medical, and hazardous materials spill response services in providing and reviewing onshore locations for oil and gas facilities. Adequacy of plans, equipment, staffing, procedures, and demonstrated financial and performance capabilities for preventing, responding to, and

³⁴Note: RCW 43.143.010(2) prohibits leasing of Washington’s state waters for oil or gas exploration, development or production.

Ocean Use	Definition	Effects Evaluation	Use-Specific Standards	Other related recommendations or requirements
			applicable requirements but should at a minimum ensure adequate protection from geological hazards such as liquefaction, hazardous slopes, earthquakes, physical oceanographic processes, and natural disasters. [WAC 173-26-360(8)(e)].	mitigating the effects of accidents and disasters such as oil spills. If a permit is issued, it should ensure that adequate prevention, response, and mitigation can be provided before the use is initiated and throughout the life of the use. [WAC 173-26-360(8)(c)]
Transportation	Ocean transportation includes such uses as: Shipping, transferring between vessels, and offshore storage of oil and gas; transport of other goods and commodities; and offshore ports and airports. Addresses transportation activities that originate or conclude in Washington's coastal waters or are transporting a nonrenewable resource extracted from the outer continental shelf off Washington. [WAC 173-26-360(12)]	<ul style="list-style-type: none"> Assess impact on renewable resource activities such as fishing and on environmentally critical and sensitive habitat areas, environmental and scientific preserves and sanctuaries. [WAC 173-26-360(12)(a)]	<p>Siting:</p> <ul style="list-style-type: none"> When feasible, hazardous materials such as oil, gas, explosives and chemicals, should not be transported through highly productive commercial, tribal, or recreational fishing areas. If no such feasible route exists, the routes used should pose the least environmental risk. Located or routed to avoid habitat areas of endangered or threatened species, environmentally critical and sensitive habitats, migration routes of marine species and birds, marine sanctuaries and environmental or scientific preserves to the maximum extent feasible. [WAC 173-26-360(12)(b)(c)]	
Ocean research	Ocean research activities involve scientific investigation for the purpose of		<ul style="list-style-type: none"> Located and operated in a manner that minimizes intrusion into or disturbance of the coastal waters environment consistent with the 	<ul style="list-style-type: none"> Complies with scientific collection requirements per RCW 77.12.047, if relevant. Encourage:

Ocean Use	Definition	Effects Evaluation	Use-Specific Standards	Other related recommendations or requirements
	<p>furthering knowledge and understanding.³⁵ [WAC 173-26-360(13)]</p>		<p>purposes of the research and the intent of the general ocean use guidelines</p> <ul style="list-style-type: none"> Completed or discontinued in a manner that restores the environment to its original condition to the maximum extent feasible, consistent with the purposes of the research. <p>[WAC 173-26-360(13)(c)(d)].</p>	<ul style="list-style-type: none"> Coordination with other ocean uses occurring in the same area to minimize potential conflicts. Public dissemination of ocean research findings. <p>[WAC 173-26-360(13)(a)(e)]</p>
Ocean salvage	<p>Ocean salvage uses share characteristics of other ocean uses and involve relatively small sites occurring intermittently. Historic shipwreck salvage which combines aspects of recreation, exploration, research, and mining is an example of such a use.</p> <p>[WAC 173-26-360(14)]</p>		<p>Nonemergency ocean salvage:</p> <ul style="list-style-type: none"> Conduct in a manner that minimizes adverse impacts to the coastal waters environment and renewable resource uses such as fishing. Not be conducted in areas of cultural or historic significance unless part of a scientific effort sanctioned by appropriate governmental agencies. <p>[WAC 173-26-360(14)(a)(b)]</p>	

³⁵ WAC 173-26-360 also states: “Investigation activities involving necessary and functionally related precursor activities to an ocean use or development may be considered exploration or part of the use or development. Since ocean research often involves activities and equipment, such as drilling and vessels, that also occur in exploration and ocean uses or developments, a case by case determination of the applicable regulations may be necessary.” RCW 43.143.010(2) prohibits leasing of state waters for oil or gas exploration, development or production.

Citations

Andrews, K. S., Coyle, J. M., & Harvey, C. J. (2015). *Ecological indicators for Washington State's outer coastal waters*. Seattle, WA: Northwest Fisheries Science Center. Report to the Washington Department of Natural Resources. Retrieved from http://www.msp.wa.gov/wp-content/uploads/2015/03/NWFSC_EcosystemIndicatorReport.pdf [Source type 11].

Decker, K. (2015). *Economic Indicators Report* (Prepared for: The Washington Coastal Marine Advisory Council by Washington Sea Grant). Retrieved from http://www.msp.wa.gov/wp-content/uploads/2015/03/SeaGrant_EconomicIndicatorReport.pdf [Source type 11]

Poe, M. R., Watkinson, M. K., Trosin, B., & Decker, K. (2015). *Social indicators for the Washington coast integrated ecosystem assessment* (A report to the Washington Department of Natural Resources; Interagency Agreement No. IAA 14-204). Retrieved from http://www.msp.wa.gov/wp-content/uploads/2015/03/SeaGrant_SocialIndicatorsReport.pdf [Source Type 11]

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Marine Spatial Plan for Washington's Pacific Coast

Appendices

Appendix A: Plan Maps

Appendix B: WCMAC Recommendations

Appendix C: Data Sources, Methods and Gaps

Appendix D: Definitions

Appendix E: Acronyms

Maps: Table of Contents and Sources

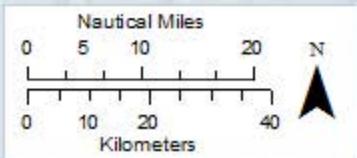
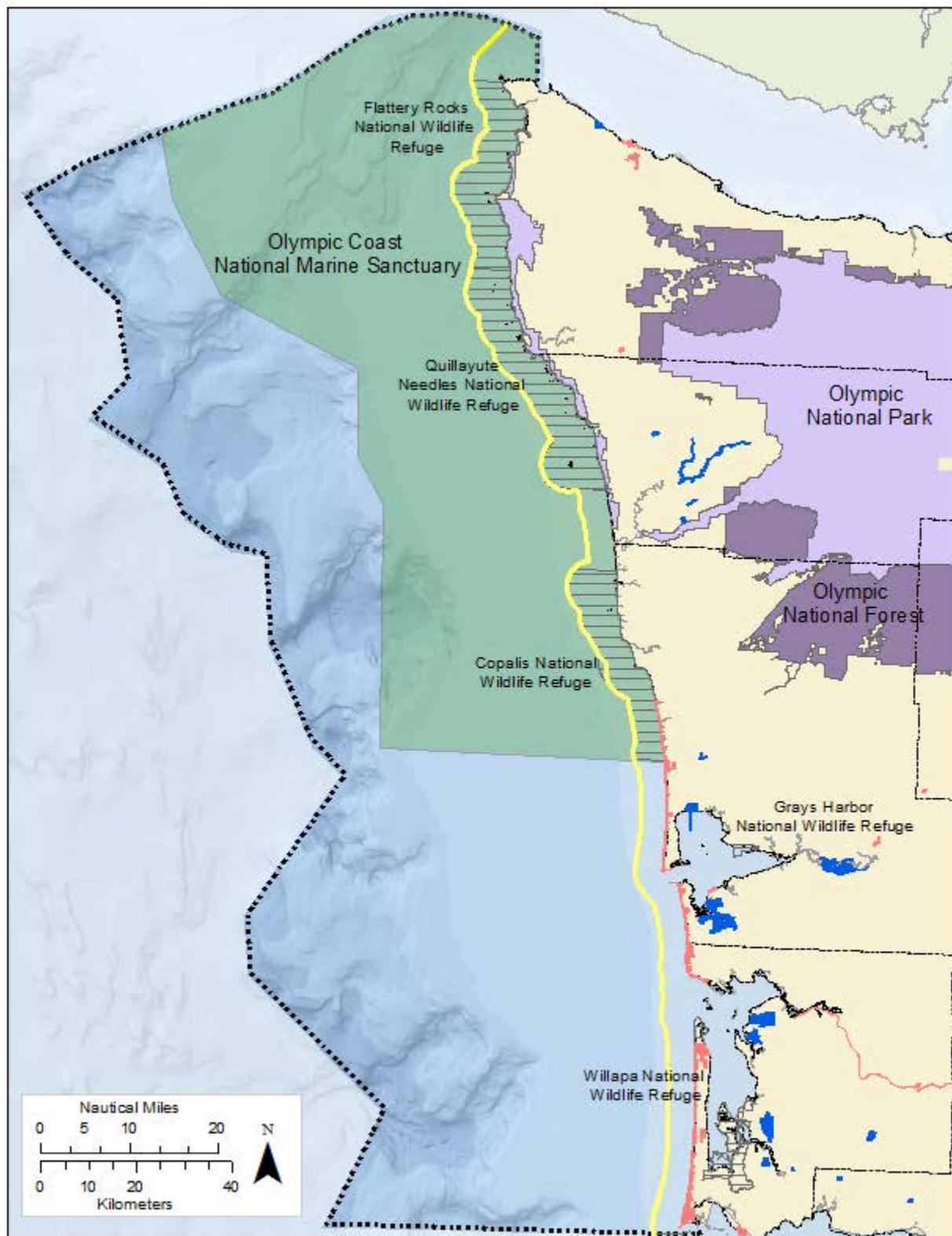
Key for Sources Cited

1	Department of Archaeology and Historic Preservation
2	Department of Ecology
3	Department of Fish and Wildlife
4	Department of Health
5	Department of Natural Resources
6	Department of Transportation
7	State Ocean Caucus
8	Washington Sea Grant
9	U.S. Army Corps of Engineers
10	Department of Agriculture: Olympic National Forest
11	Department of Commerce: National Oceanic and Atmospheric Administration
12	Department of Defense: United States Department of the Navy
13	Department of Energy: Pacific Northwest National Laboratory
14	Department of Homeland Security: United States Coast Guard
15	Department of the Interior: Bureau of Ocean and Energy Management
16	U.S. Environmental Protection Agency
17	U.S. Fish and Wildlife Service
18	National Park Service
19	Bonneville Power Administration
20	Integrated Ocean Observing System (NANOOS)
21	The Nature Conservancy
22	Point 97 and the Surfrider Foundation
23	U.S. Geological Survey
24	Olympic Coast Natural Resource Center

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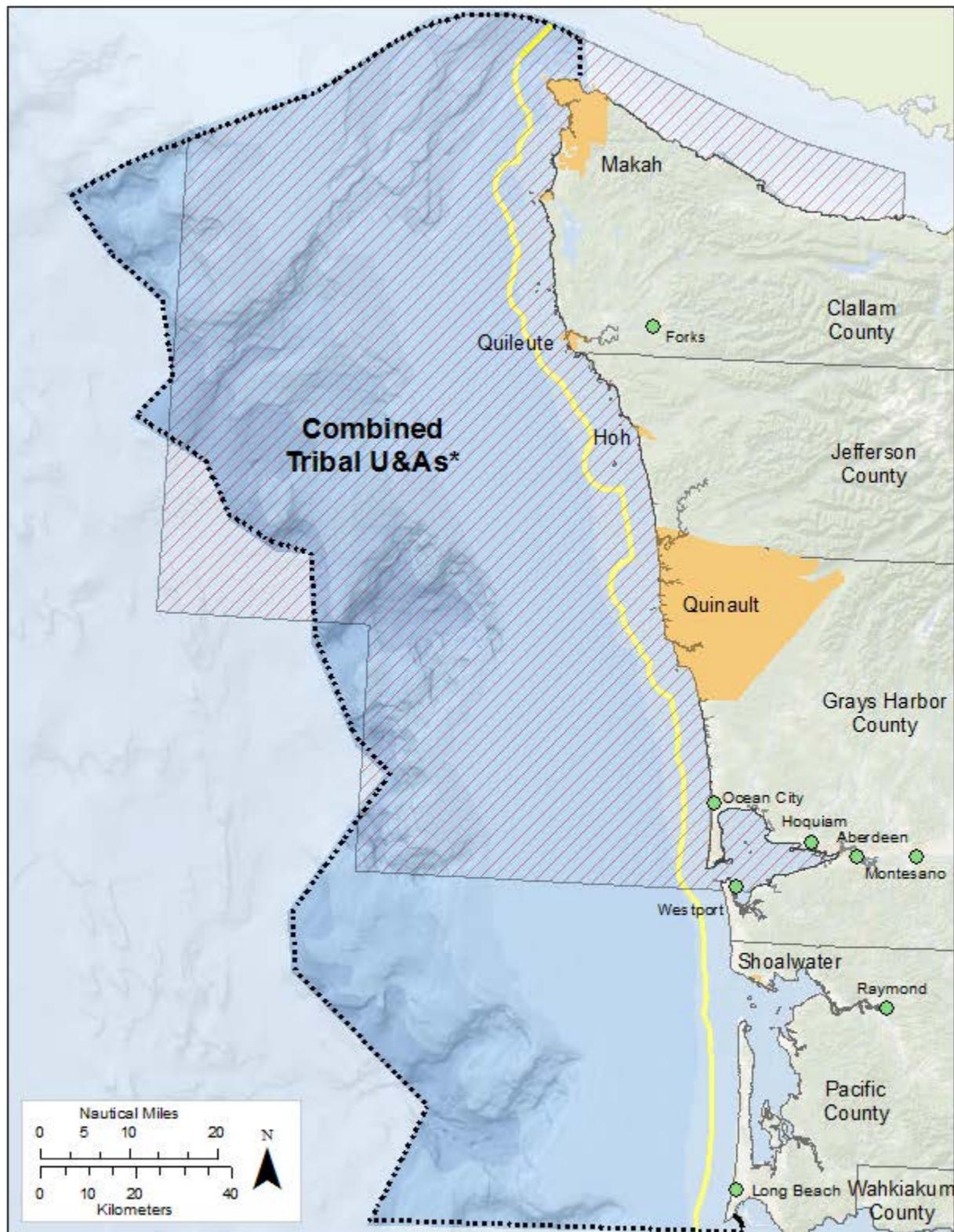
- | | | |
|---|---|---|
|  National Park Service Lands ¹² |  National Forest Service Lands ¹⁰ |  MSP Study Area ⁷ |
|  State Park Seashore Conservation Areas ⁵ |  National Wildlife Refuges and Acquisition Areas ¹¹ |  State Boundary ⁹ |
|  National Marine Sanctuary ¹³ |  State DNR Conservation Areas ⁵ |  County Boundary ⁸ |



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 2: Cities, Coastal Tribal Reservations, and Combined Tribal Usual and Accustomed Areas (U&As)

PRELIMINARY DRAFT

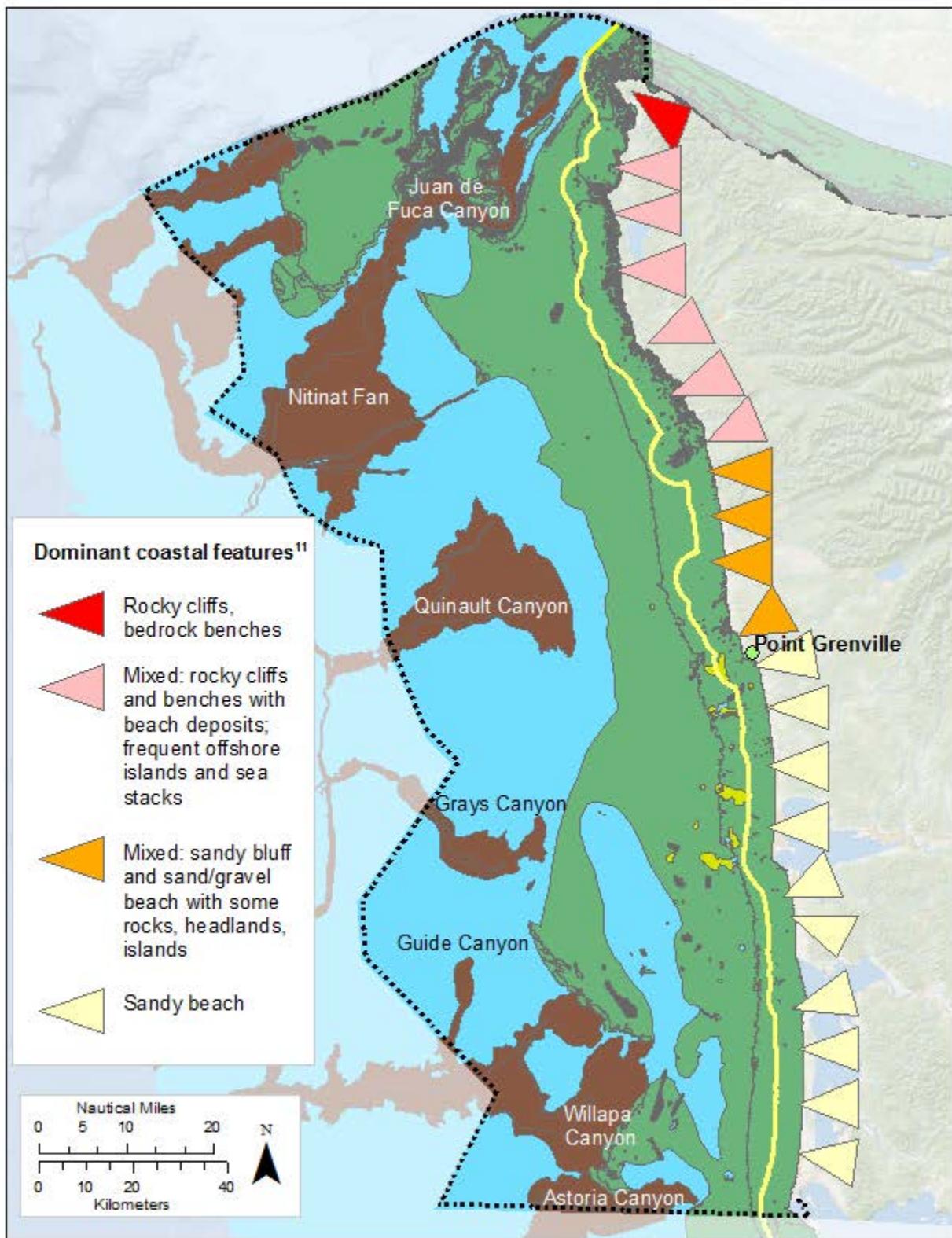


**This represents the combined U&A footprints for the Hoh, Quileute, Quinault and Makah tribes. Each tribe's individual U&A varies within this area.*

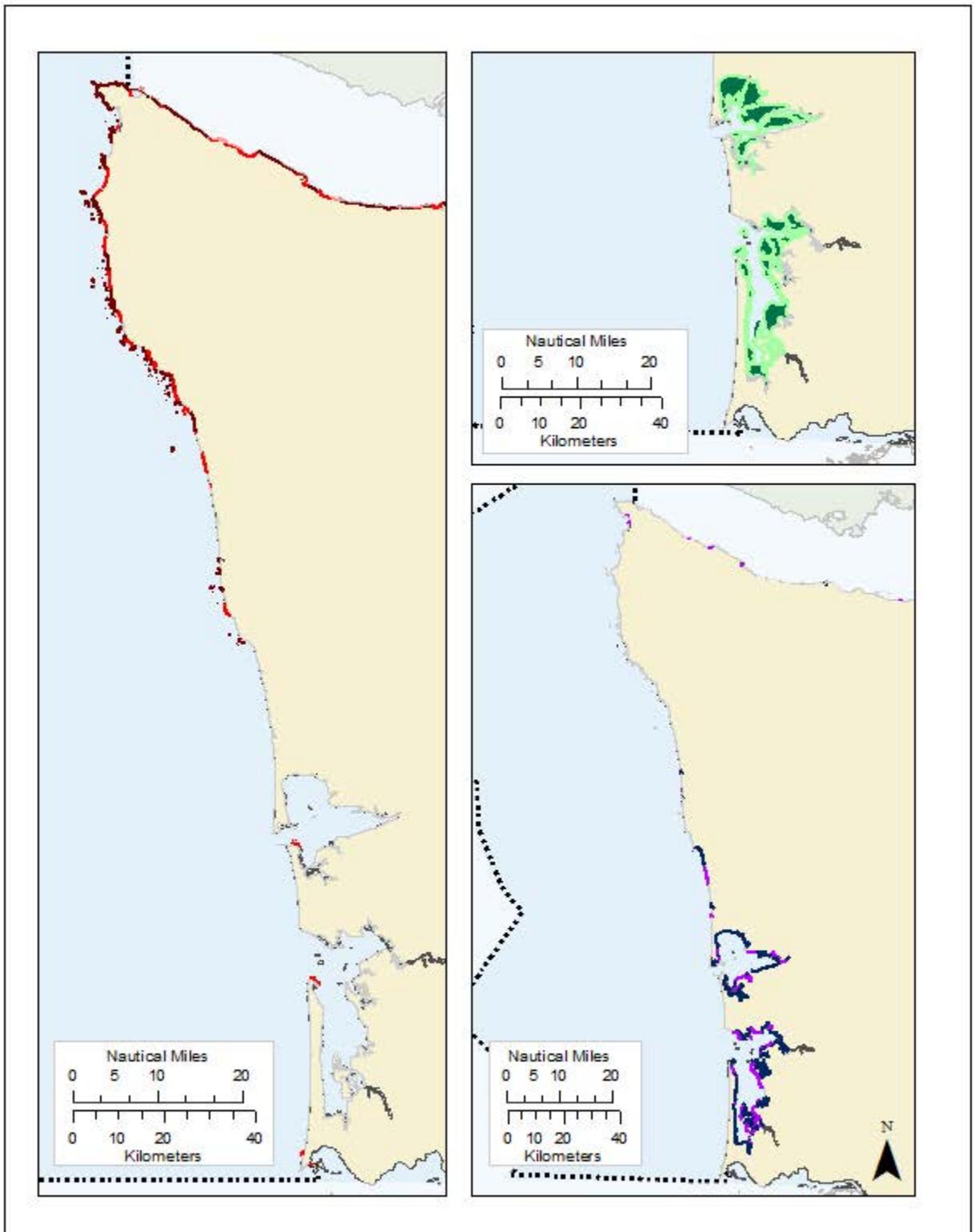


- Washington Coastal Tribal Reservations²
- Incorporated City²
- County Boundary²
- Washington MSP Study Area⁷
- WA State Boundary⁸
- Combined Tribal U&As¹⁰

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Map 4: Kelp, Eelgrass, and Saltmarsh

Marine Vegetation²

Kelp

- Continuous
- - - Patchy

Eelgrass (both native and non-native species)

- Continuous
- - - Patchy

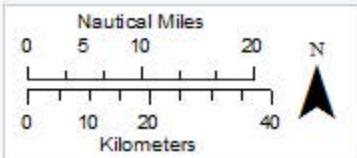
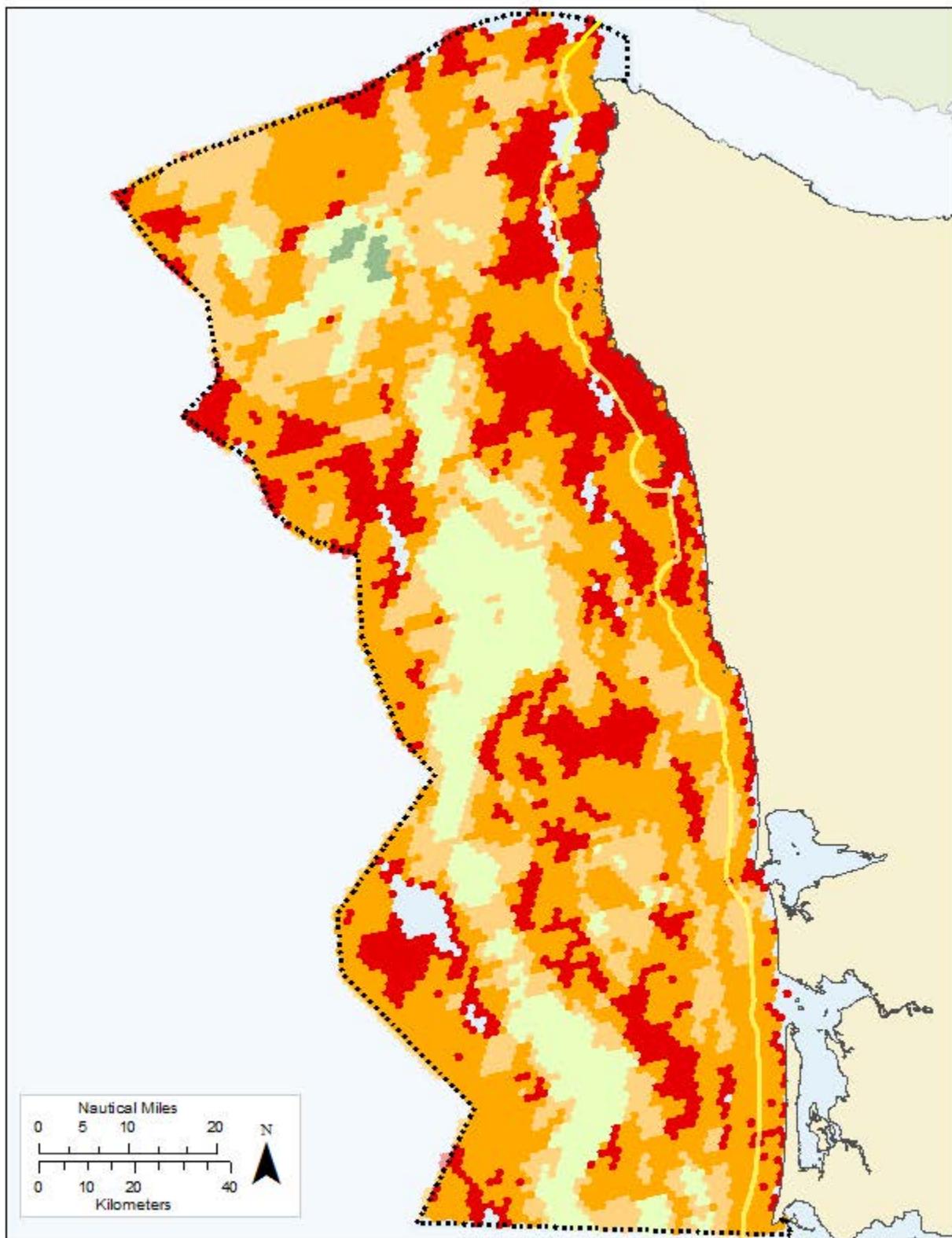
Salt Marsh

- Continuous
- - - Patchy

- - - - MSP Study Area¹— WA State Boundary³

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.





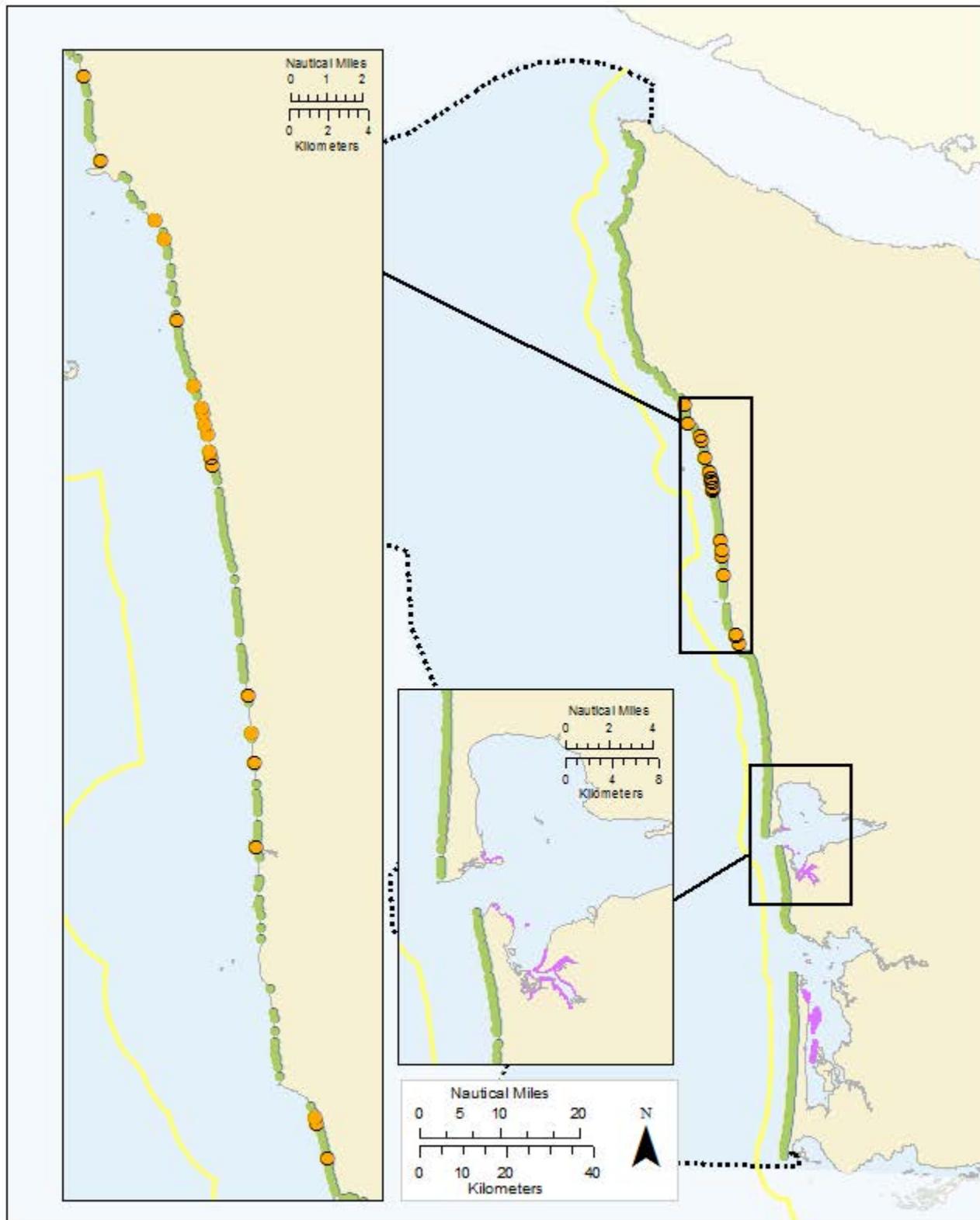
Ecological Importance²



- Washington MSP Study Area¹
- WA State Boundary²



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Forage Fish Survey Results¹

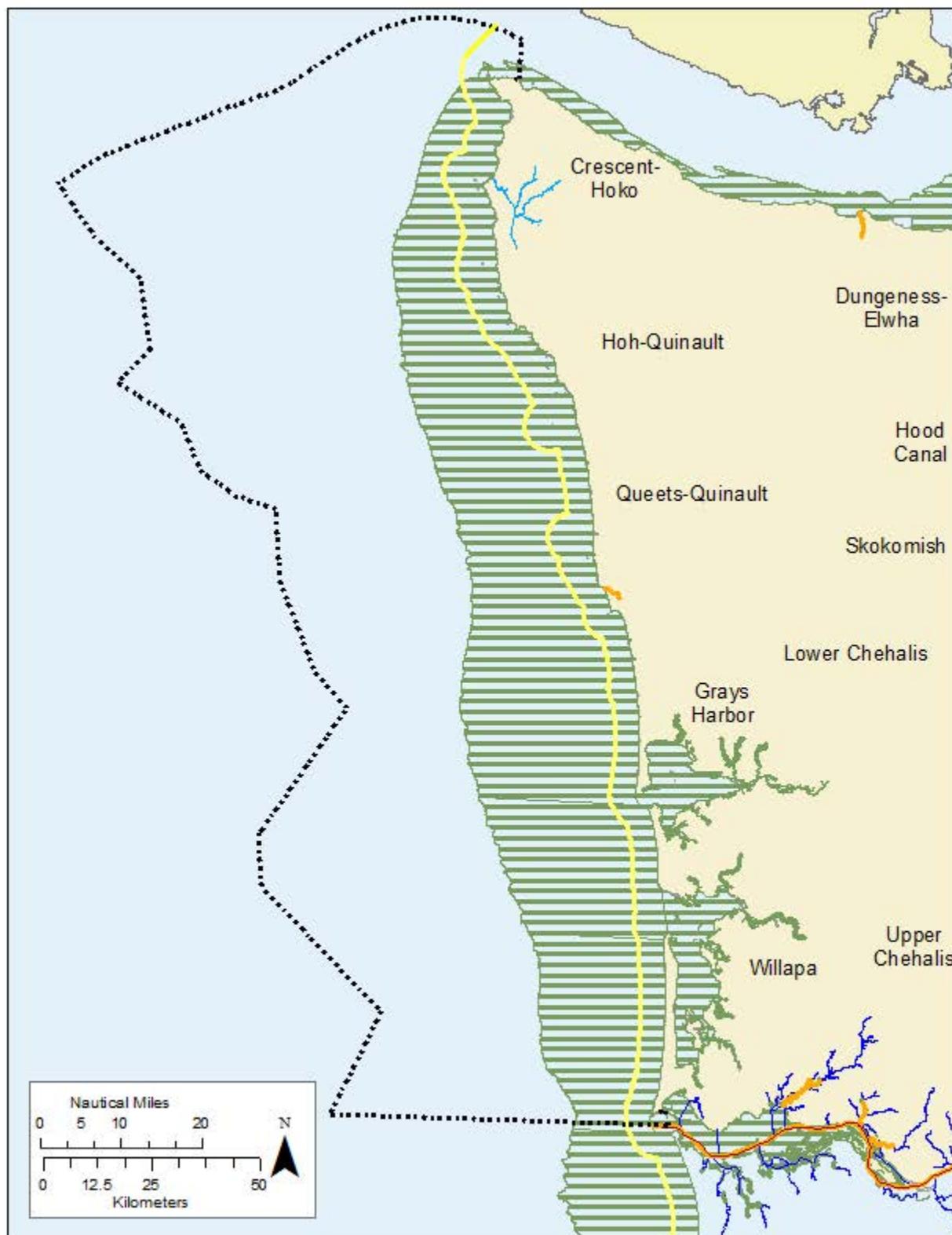
- Present
- Absent

■ Herring Spawning Area²

Washington MSP Study Area³

WA State Boundary⁴

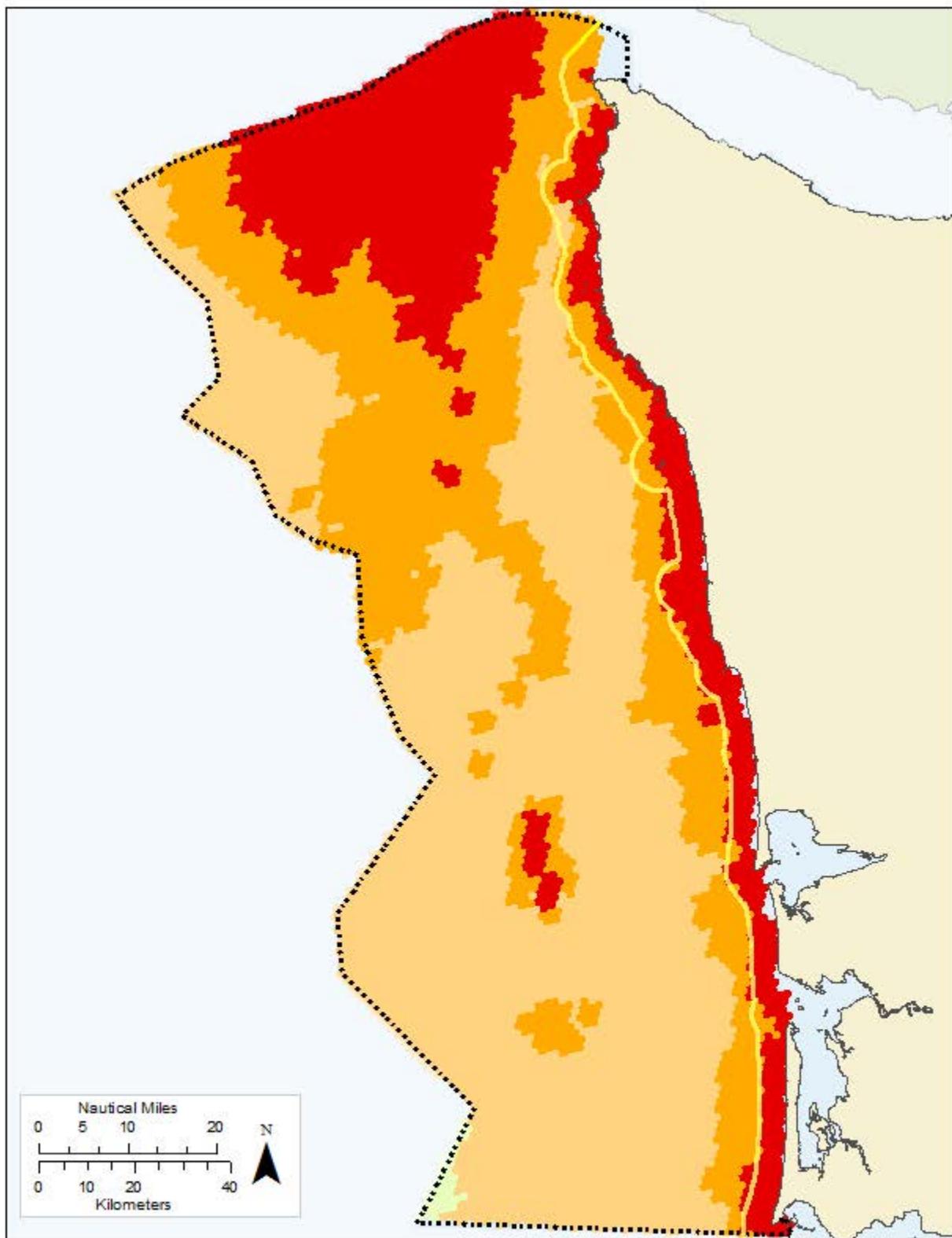
Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Critical Habitat¹¹

- | | | |
|-------------------------|----------------|--------------------------------|
| Chinook and Chum Salmon | Steelhead | WA State Boundary ² |
| Ozette Sockeye Salmon | Green Sturgeon | WA MSP Study Area ¹ |
| Eulachon Southern DPS | | |

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



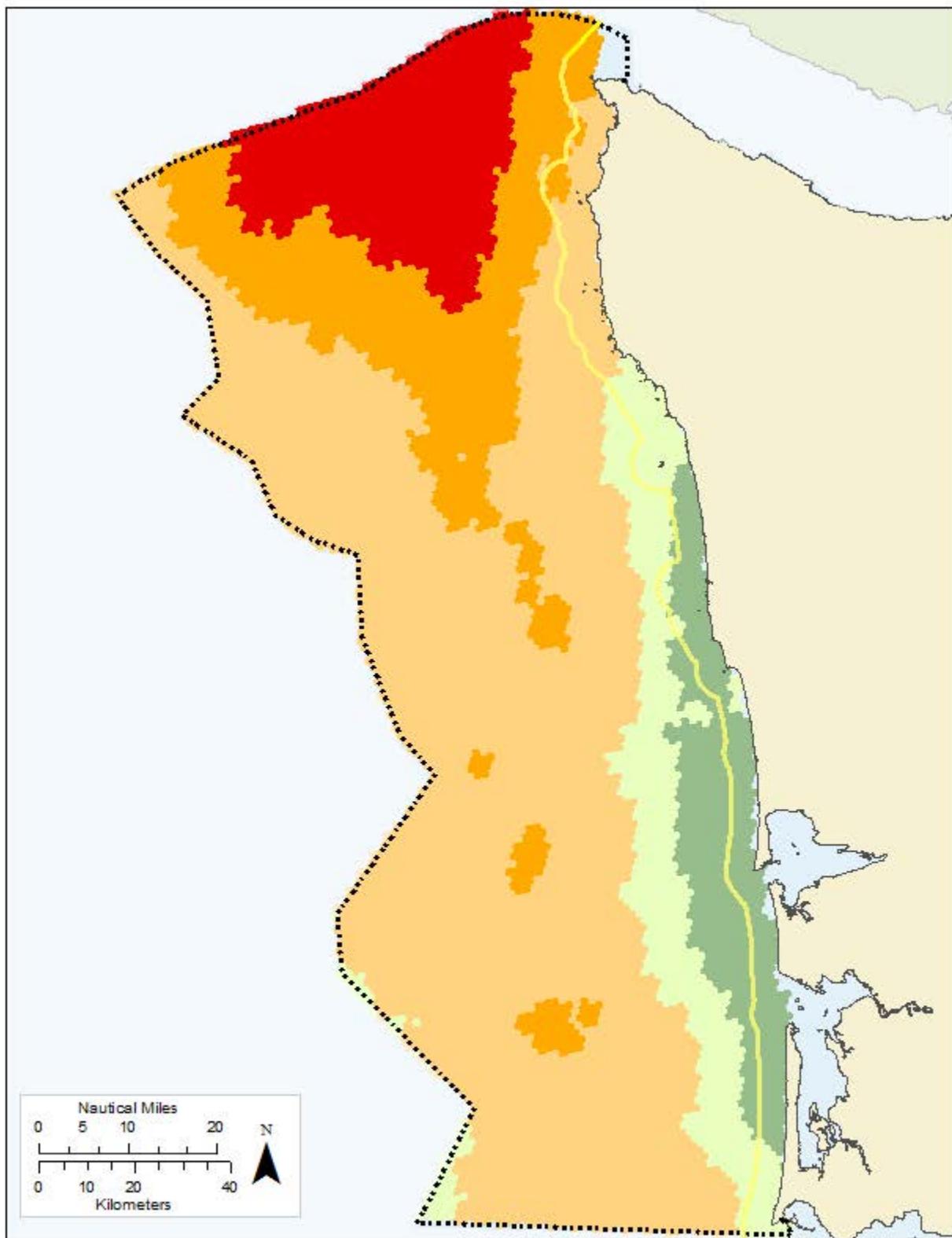
Ecological Importance²



..... Washington MSP Study Area¹

— WA State Boundary²

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Ecological Importance²

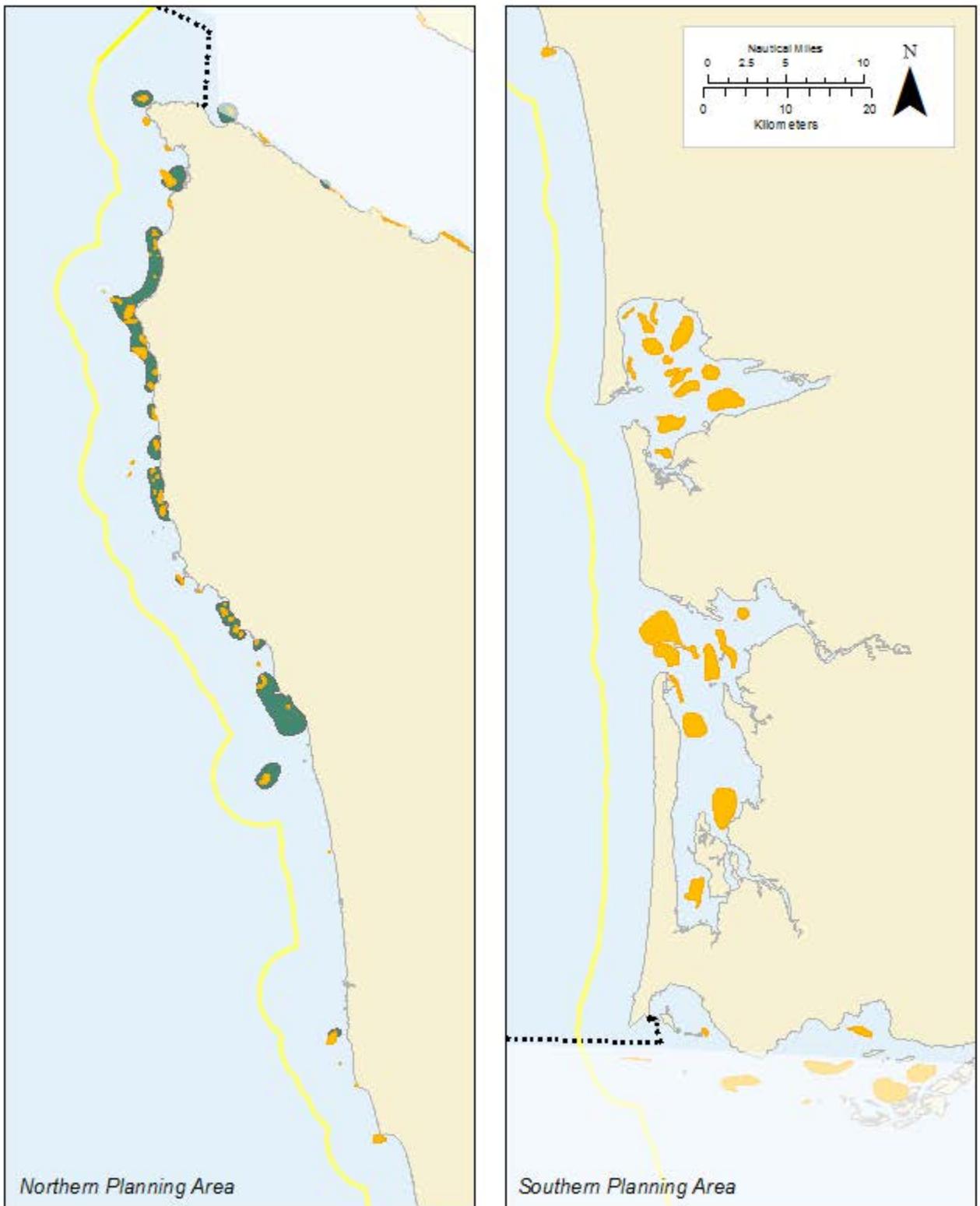


..... Washington MSP Study Area¹

— WA State Boundary²

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

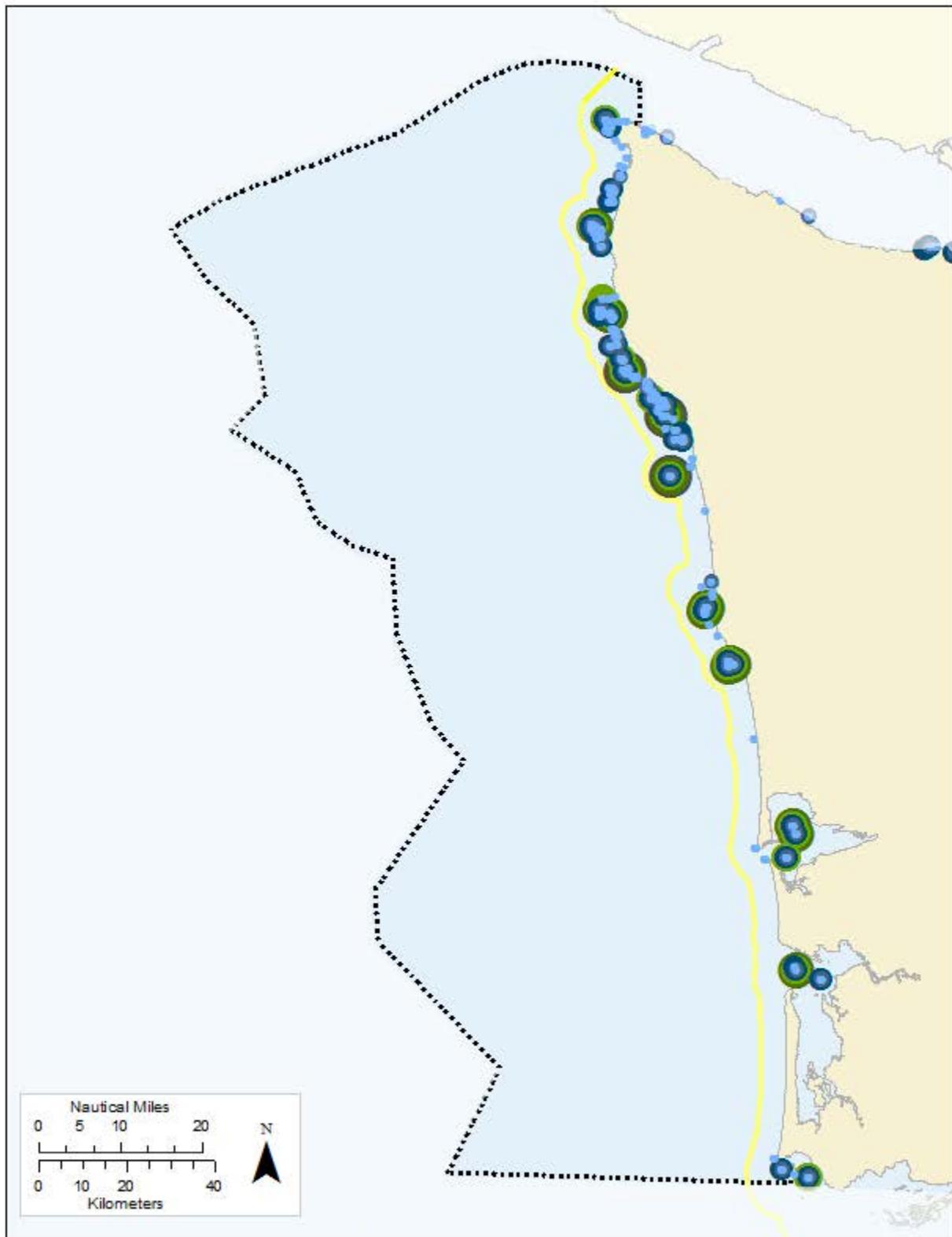
Map 10: Sea Otter Concentration Areas and Pinniped Haulouts



- Washington MSP Study Area¹
- Northern Sea Otter Summer Concentration Areas²

- WA State Boundary³
- Haulout Locations²
Harbor seal, California Sea Lion
Stellar Sea Lion, and Northern Elephant Seal

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



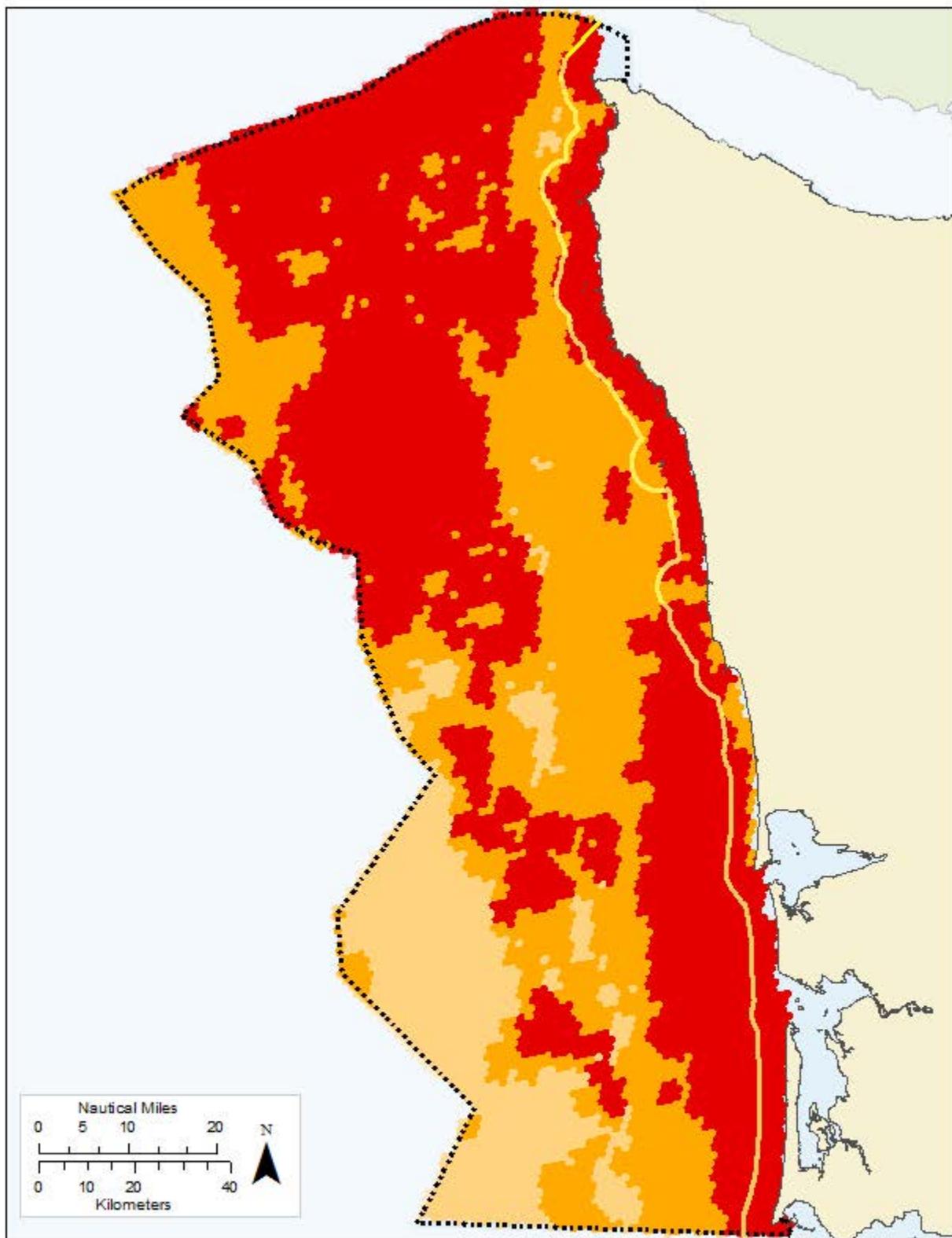
Seabird Colony Size³

- 0 - 50
- 1001 - 5000
- >20000
- 51 - 100
- 5001 - 20000

- WA State Boundary⁶
- ⋯ Washington MSP Study Area⁷



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Ecological Importance²



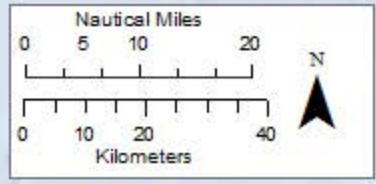
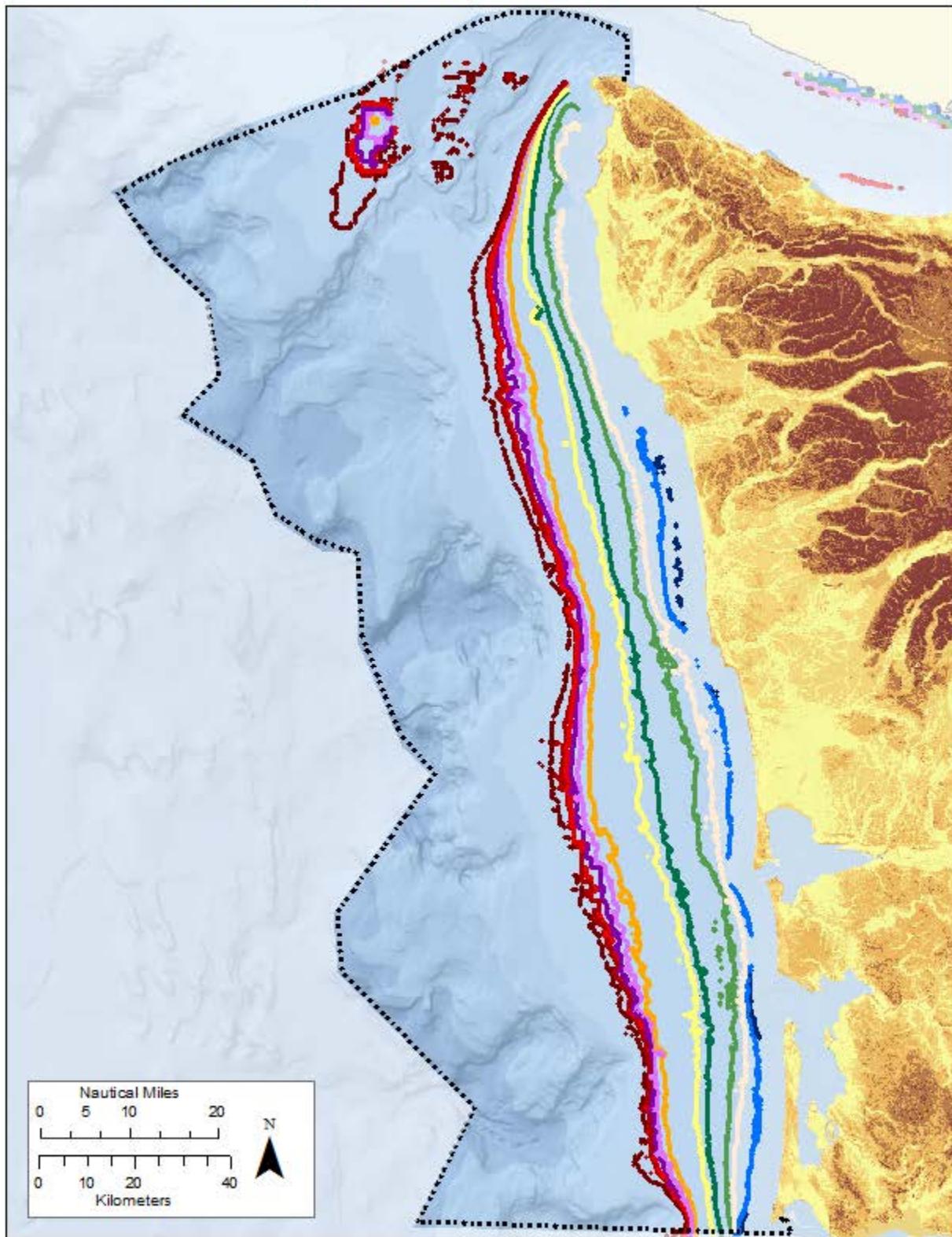
..... Washington MSP Study Area¹

— WA State Boundary²

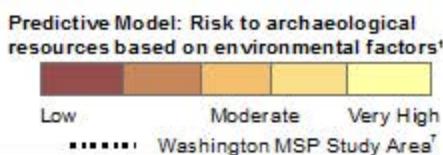
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Map 13: Modeled Paleoshorelines and Predictive Model for Risk to Upland Archaeological Resources

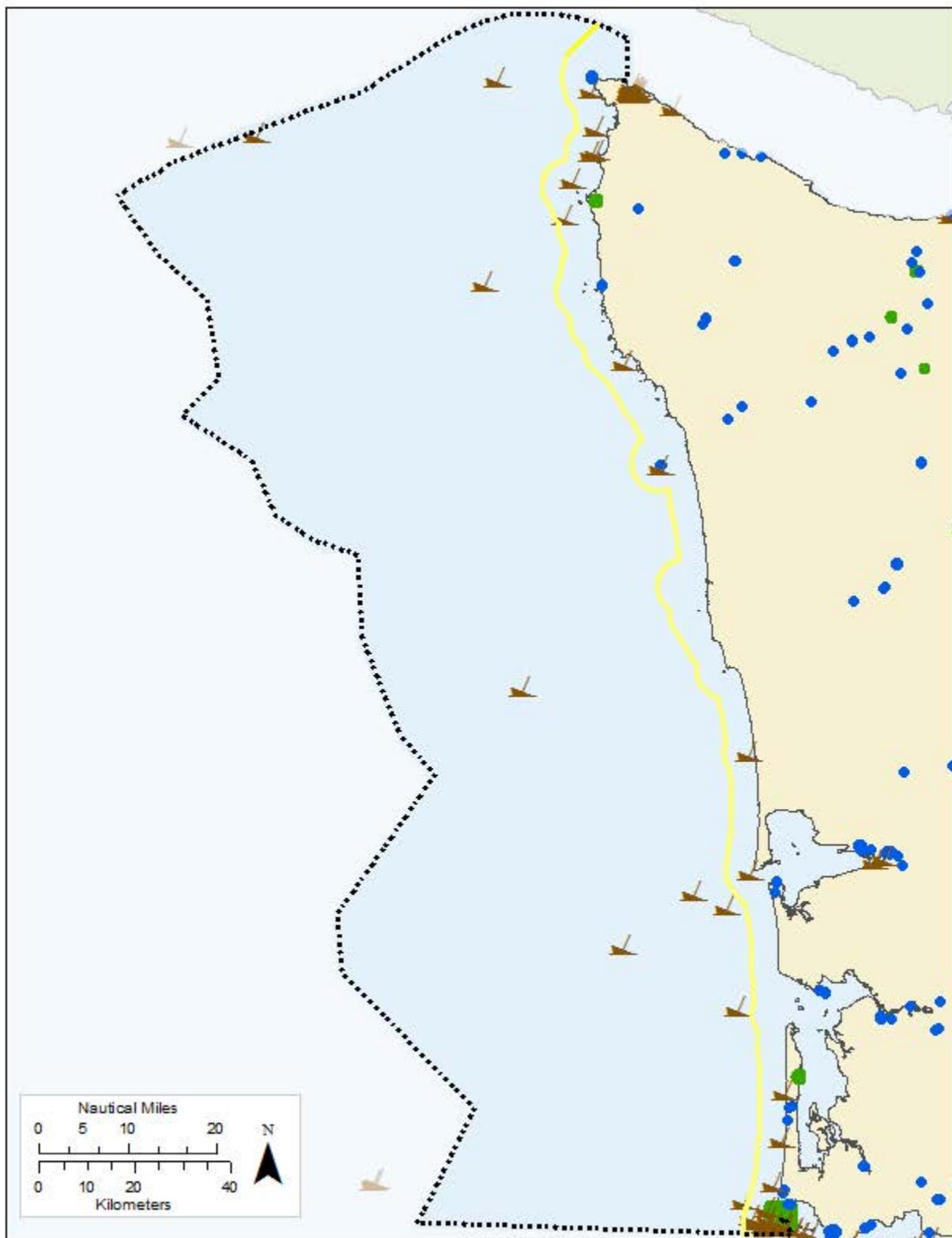
PRELIMINARY DRAFT



- Paleoshorelines (kya = thousand years ago)¹²
- | | | |
|--------|--------|--------|
| 8 kya | 12 kya | 16 kya |
| 9 kya | 13 kya | 17 kya |
| 10 kya | 14 kya | 18 kya |
| 11 kya | 15 kya | 19 kya |



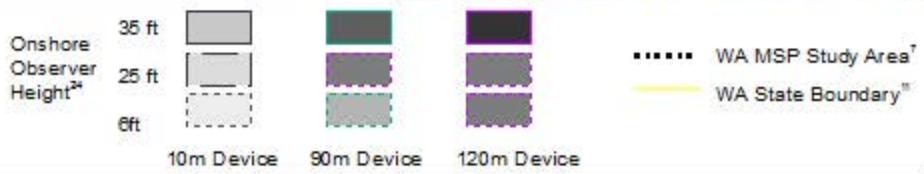
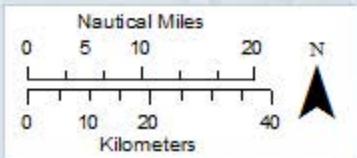
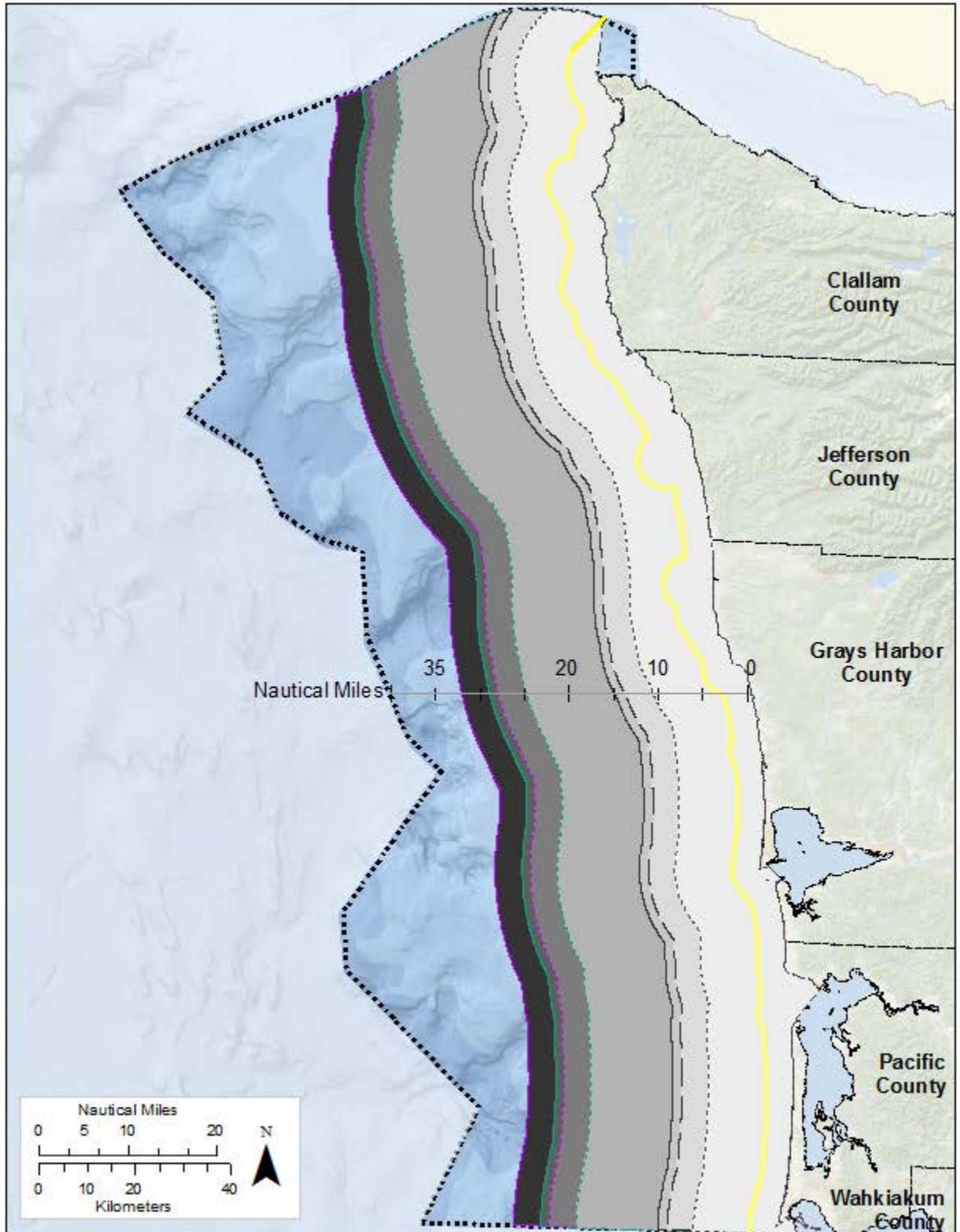
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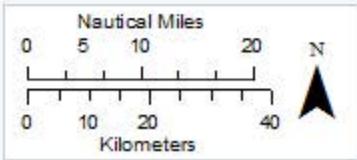
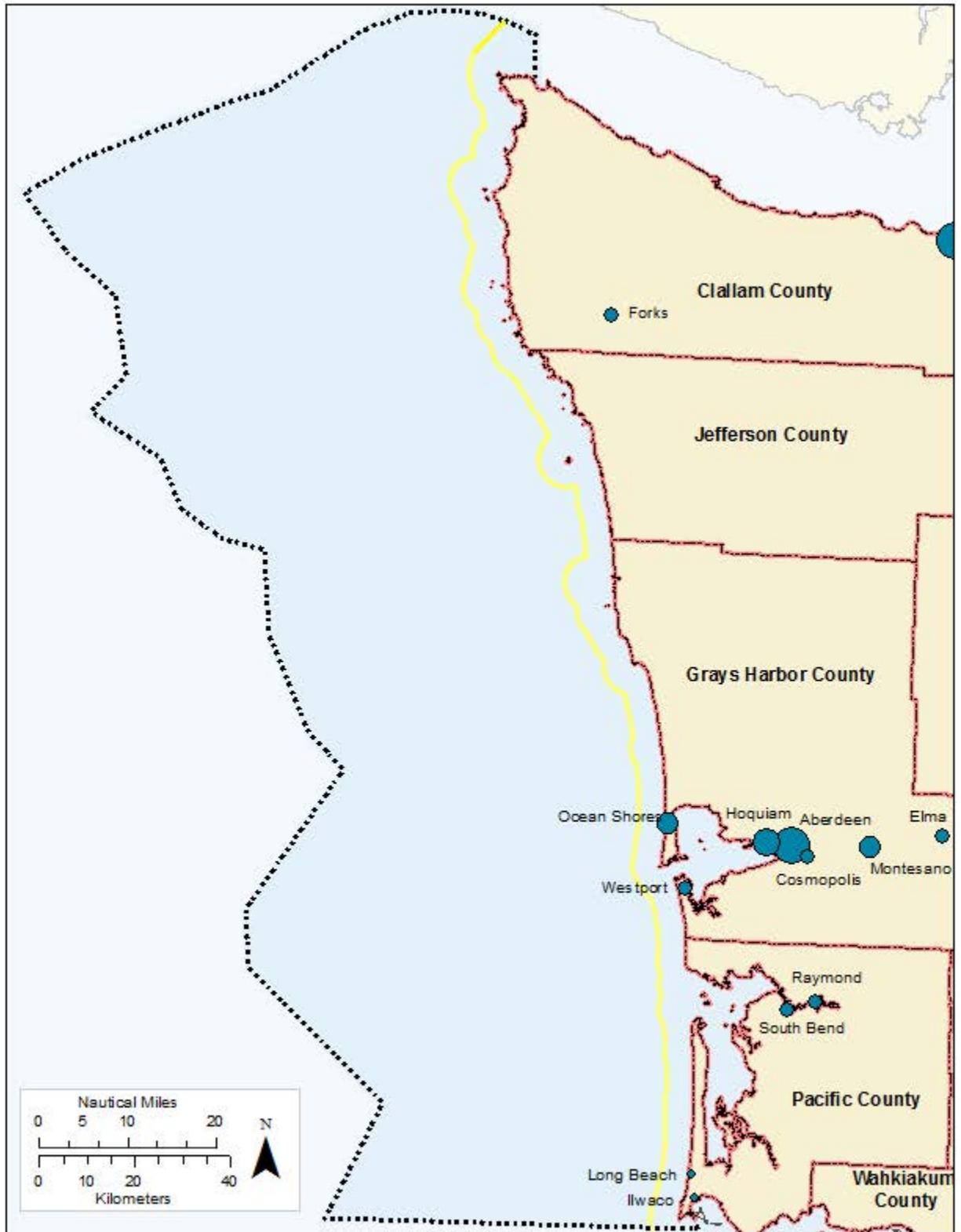
- Historic Registered Properties¹
- Historic Registered Districts¹
- Wrecks and Obstructions¹⁰
- Washington MSP Study Area¹
- Washington State Boundary²

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

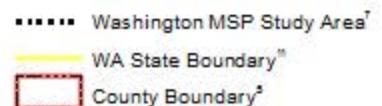
Map 15: Offshore Facilities Viewshed



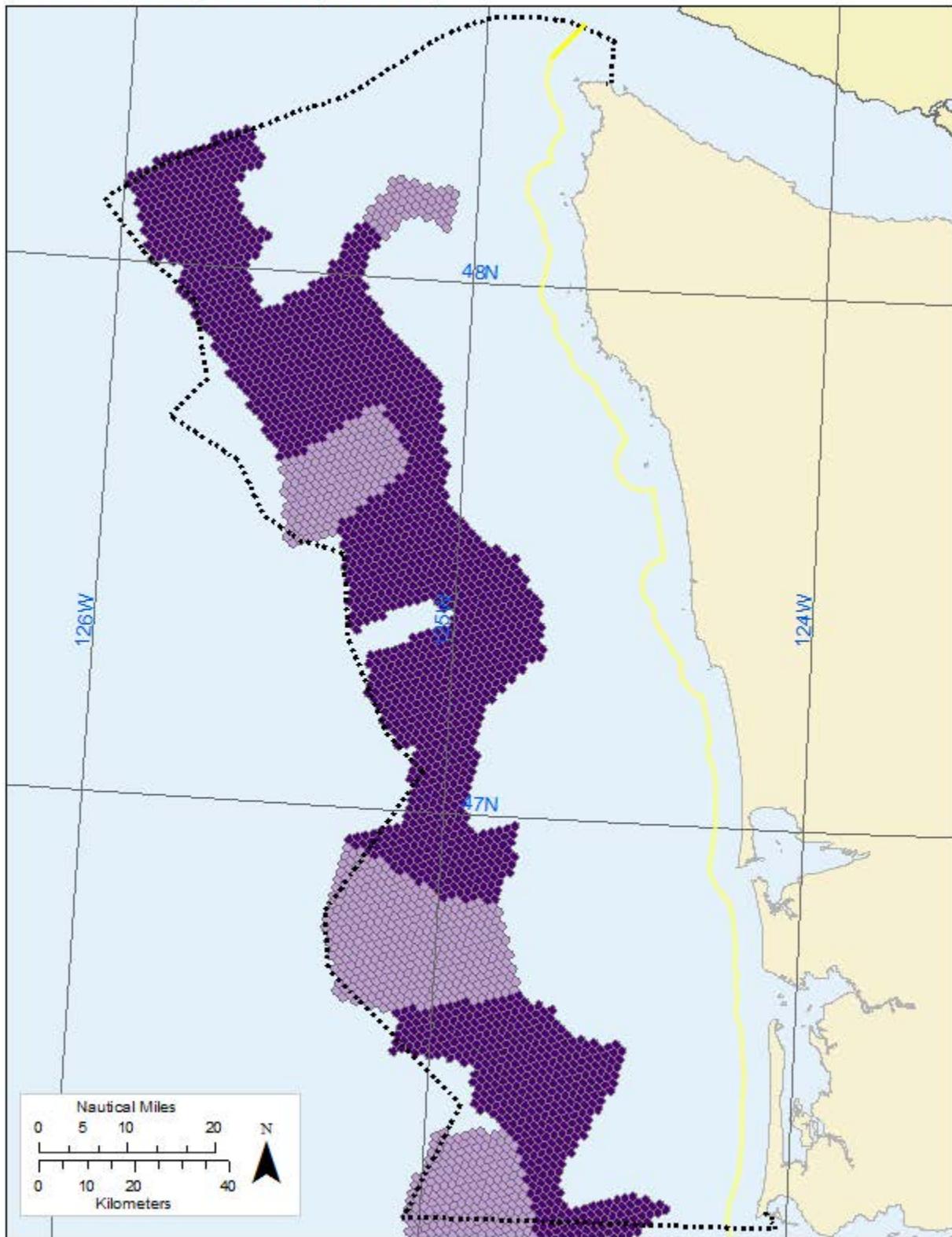
Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



City Populations⁶



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

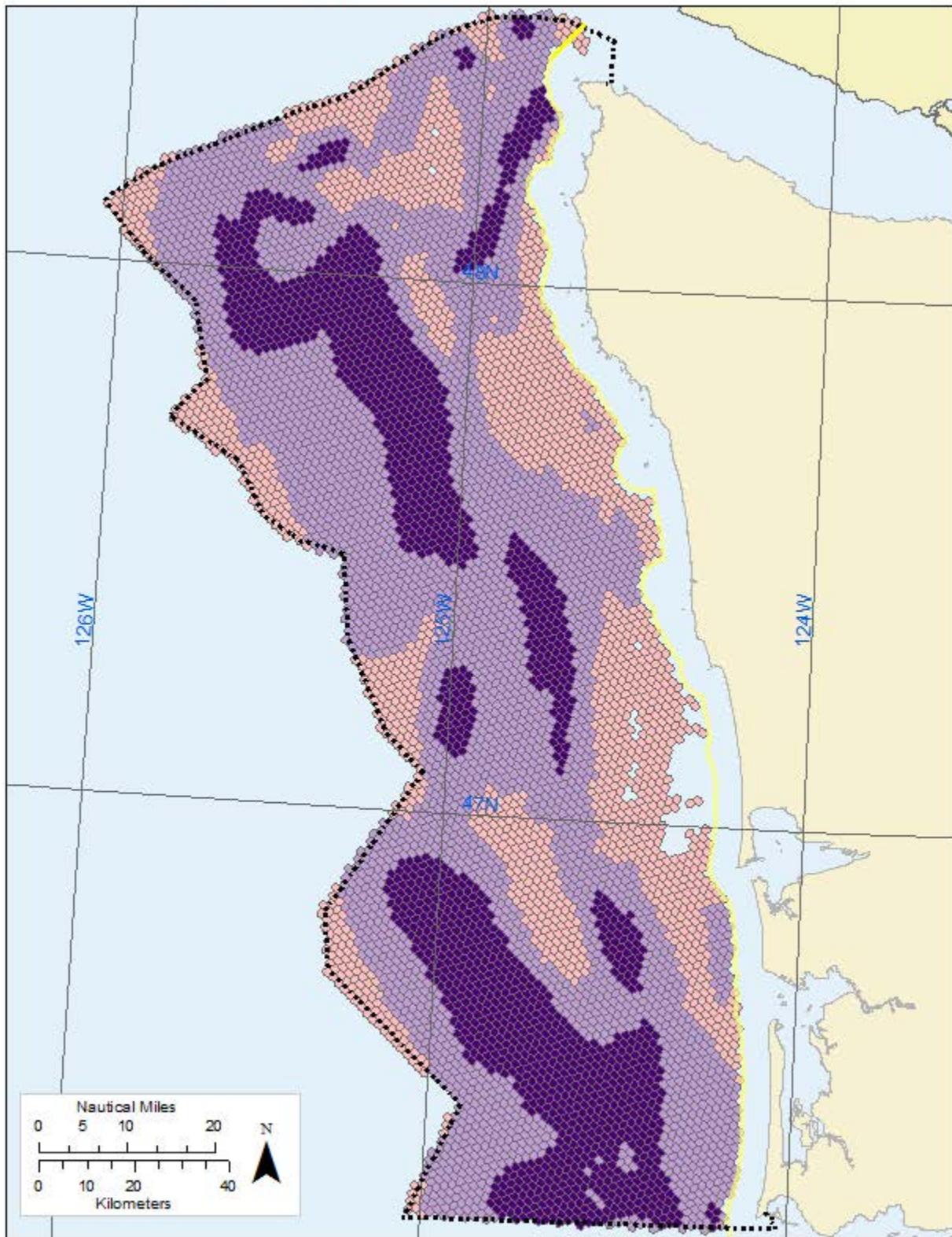


Commercial Sablefish Fishing Intensity (Fixed Gear)²

- Medium
- High

- WA State Boundary¹⁰
- Washington MSP Study Area⁷
- World Latitude and Longitude Grids²⁸

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

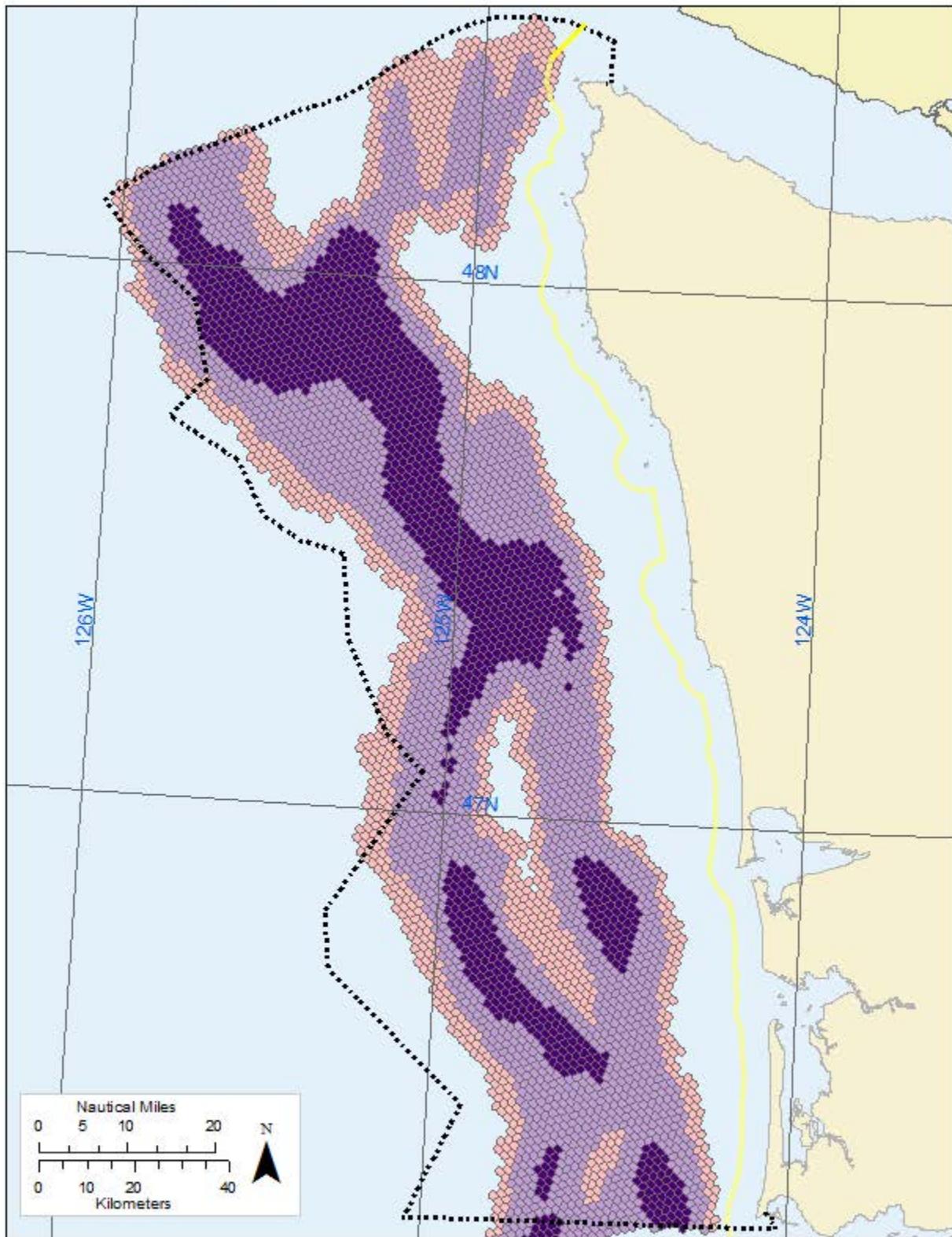


Commercial Groundfish Fishing Intensity (Bottom Trawl) ²

- | | | | |
|---|--------|---|--|
|  | Low |  | WA State Boundary ¹¹ |
|  | Medium |  | Washington MSP Study Area ⁷ |
|  | High |  | World Latitude and Longitude Grids ²² |



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



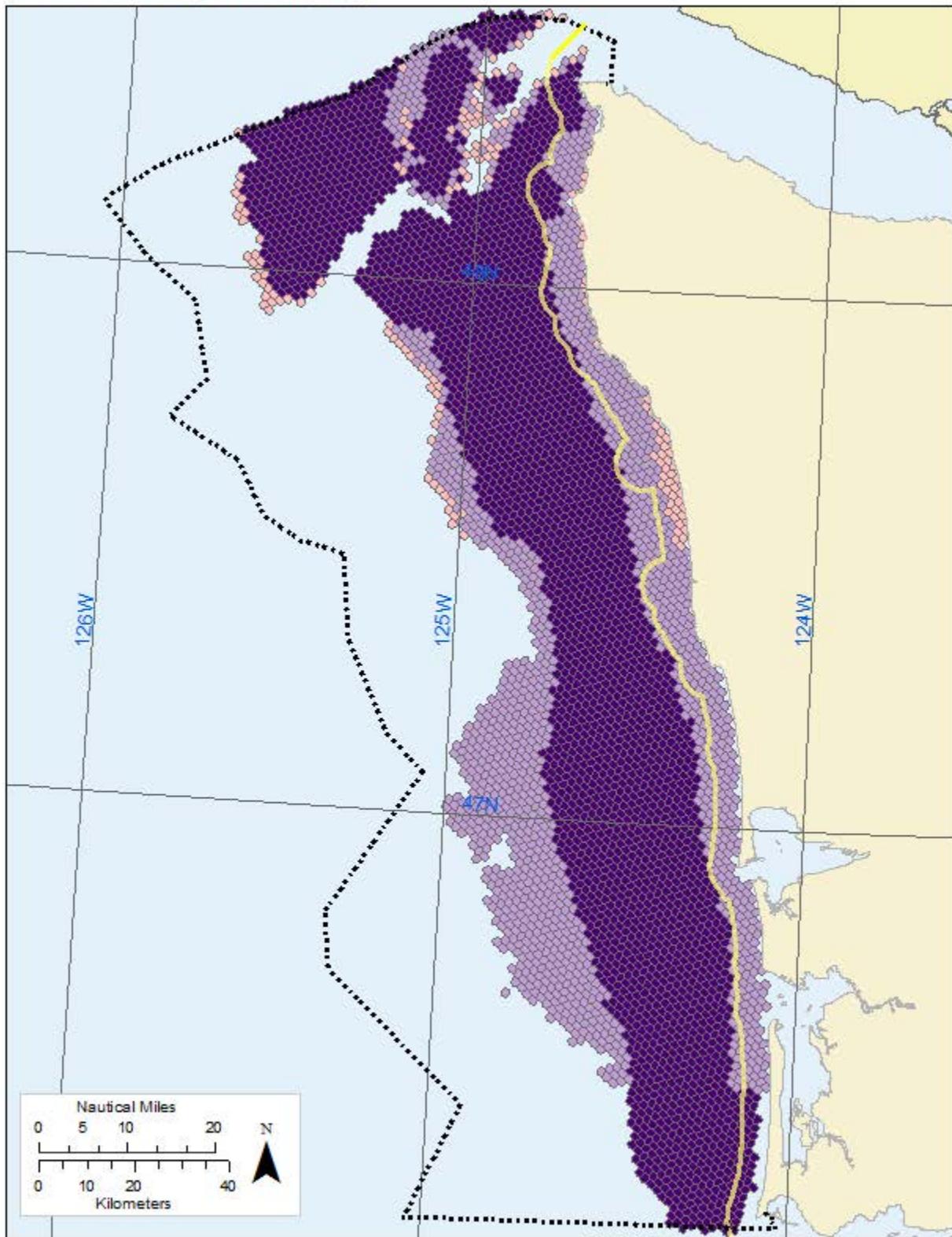
Commercial Pacific Whiting Fishing Intensity ³

- Low
- Medium
- High

- WA State Boundary ⁶
- Washington MSP Study Area ⁷
- World Latitude and Longitude Grids ^{2a}



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

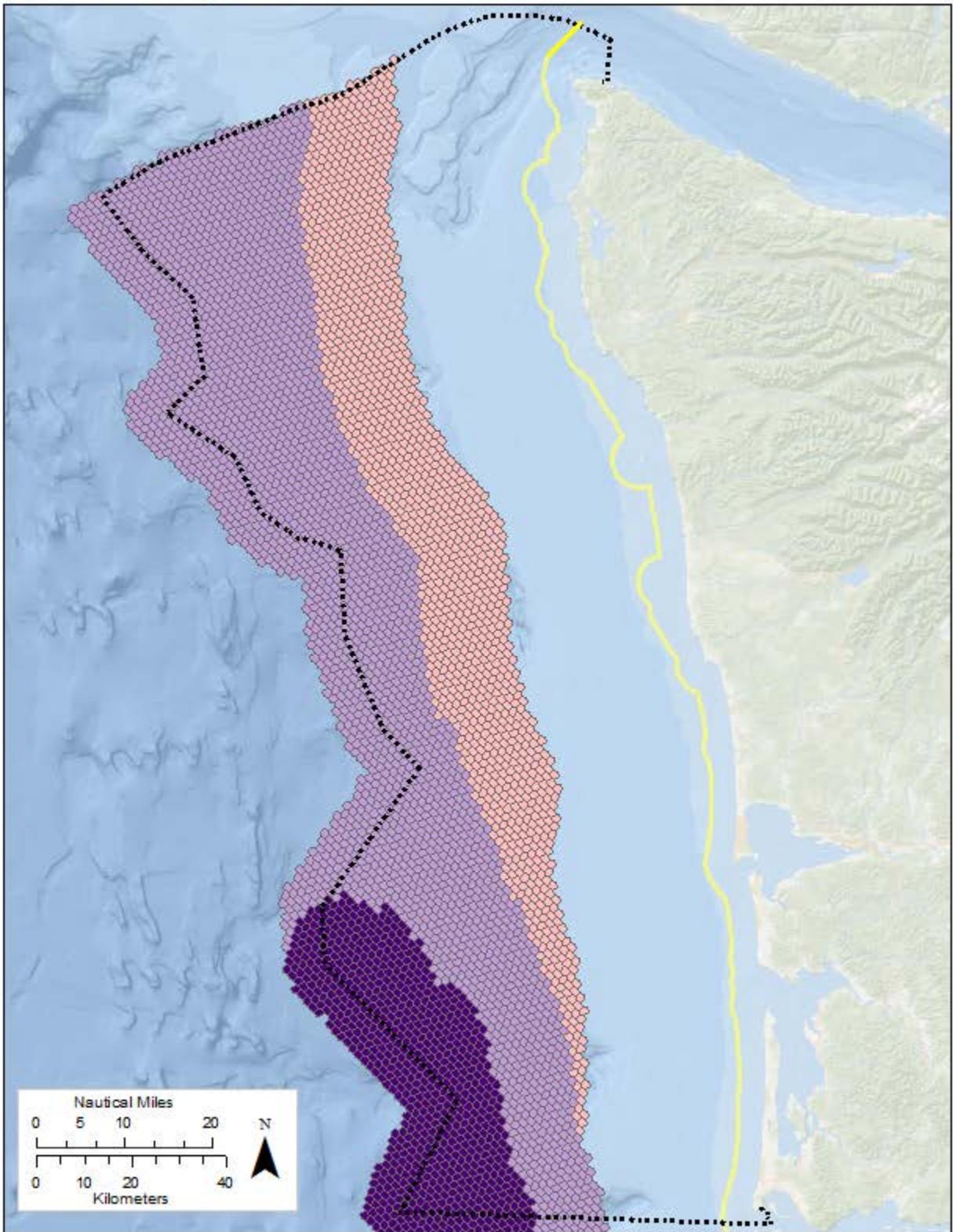


Commercial Salmon Troll Intensity ³

-  Low
-  Medium
-  High

-  WA State Boundary ¹¹
-  Washington MSP Study Area ⁷
-  World Latitude and Longitude Grids ²⁸





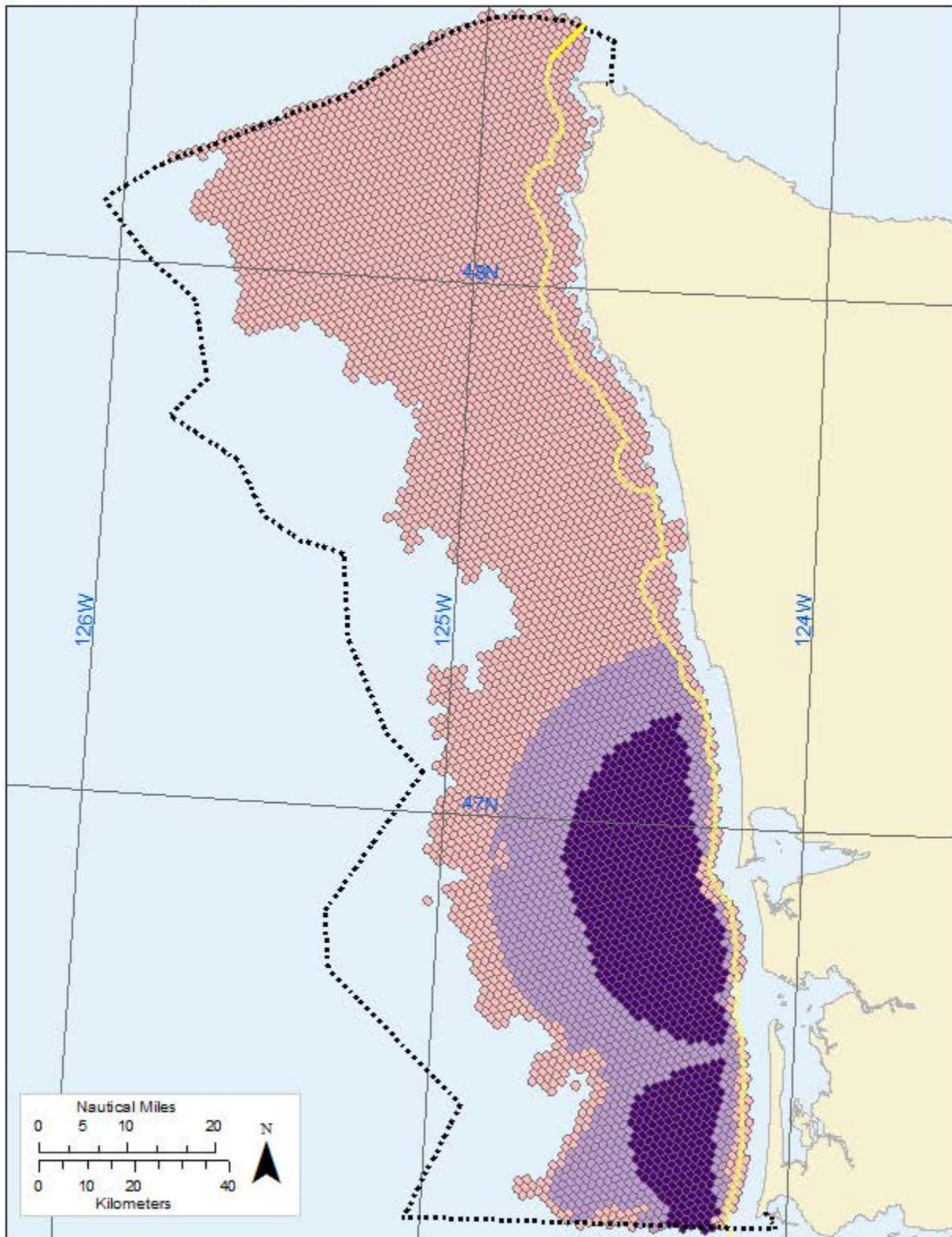
Recreational Albacore Fishing Intensity ³

-  Low
-  Medium
-  High

-  WA State Boundary ⁶
-  Washington MSP Study Area ⁷
-  World Latitude and Longitude Grids ^{2a}



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



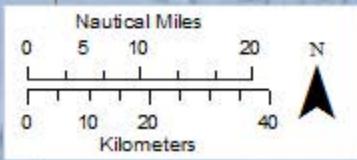
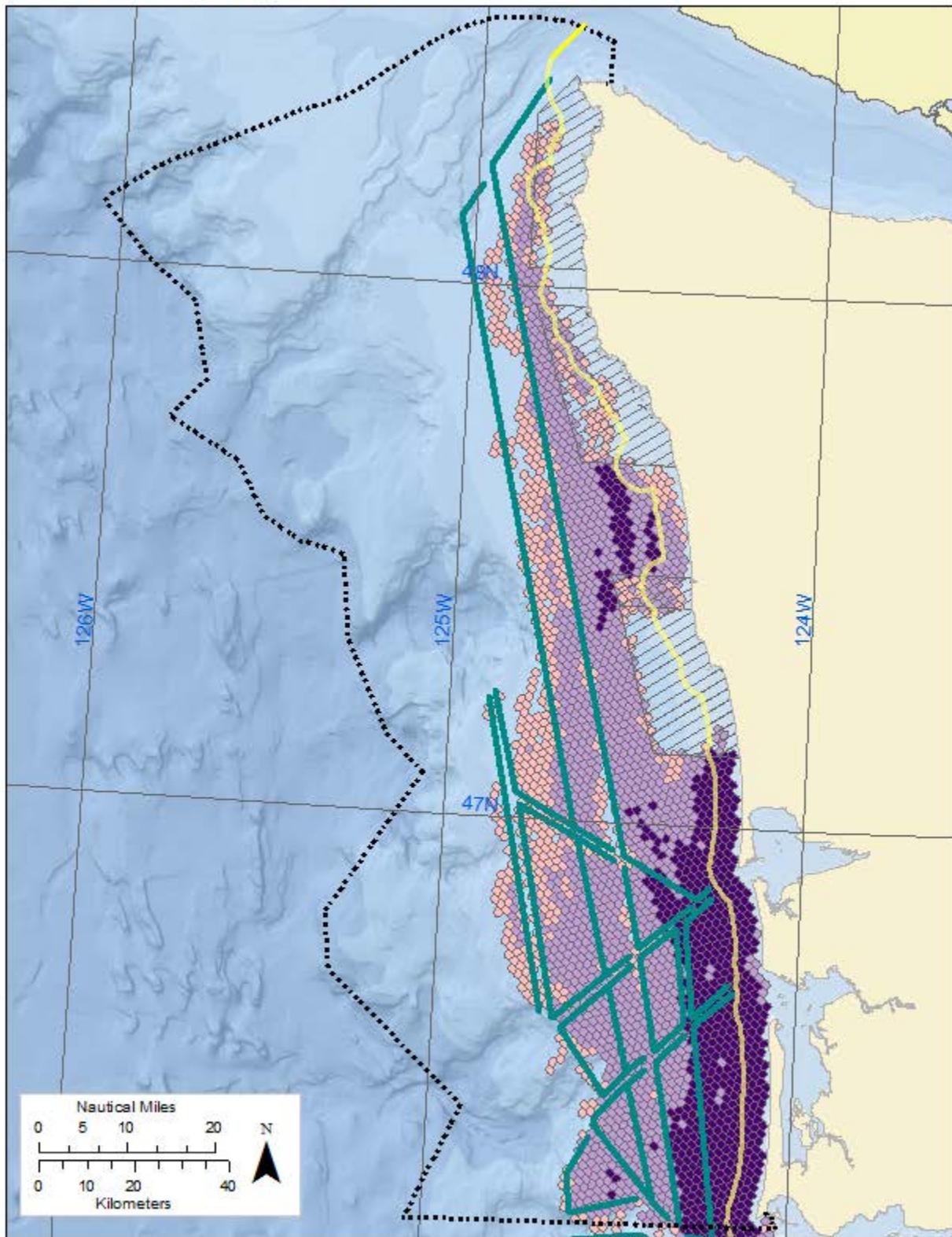
Commercial Pacific Sardine Fishing Intensity ³

- Low
- Medium
- High

- WA State Boundary ⁷
- Washington MSP Study Area ⁸
- World Latitude and Longitude Grids ²⁸



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Commercial Crabbing Intensity ²

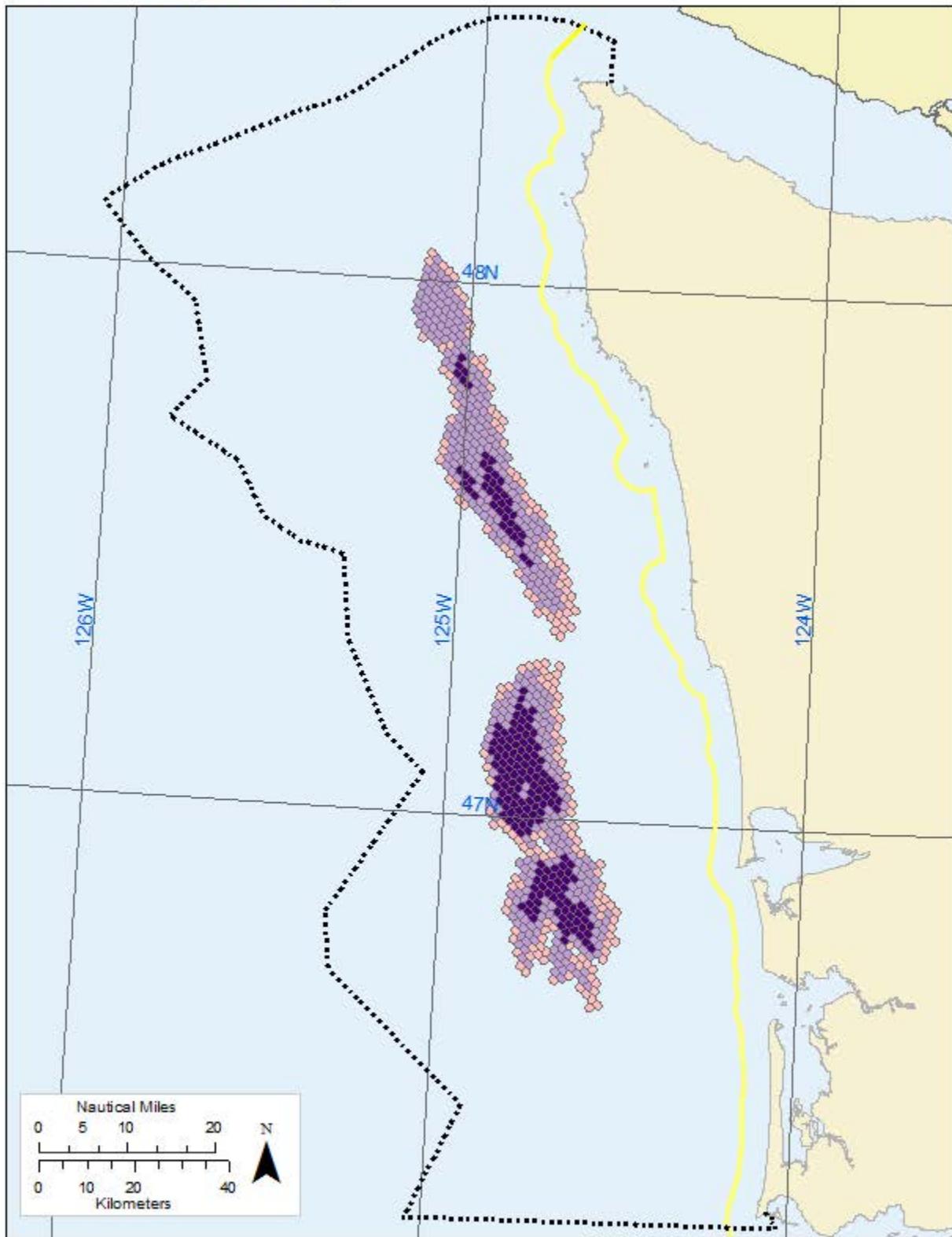
- Low
- Medium
- High

Special Management Areas ²

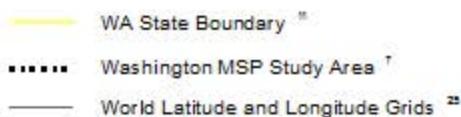
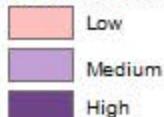
- Special Management Areas ²
- Towboat Lanes ²
- WA State Boundary ²
- Washington MSP Study Area ¹

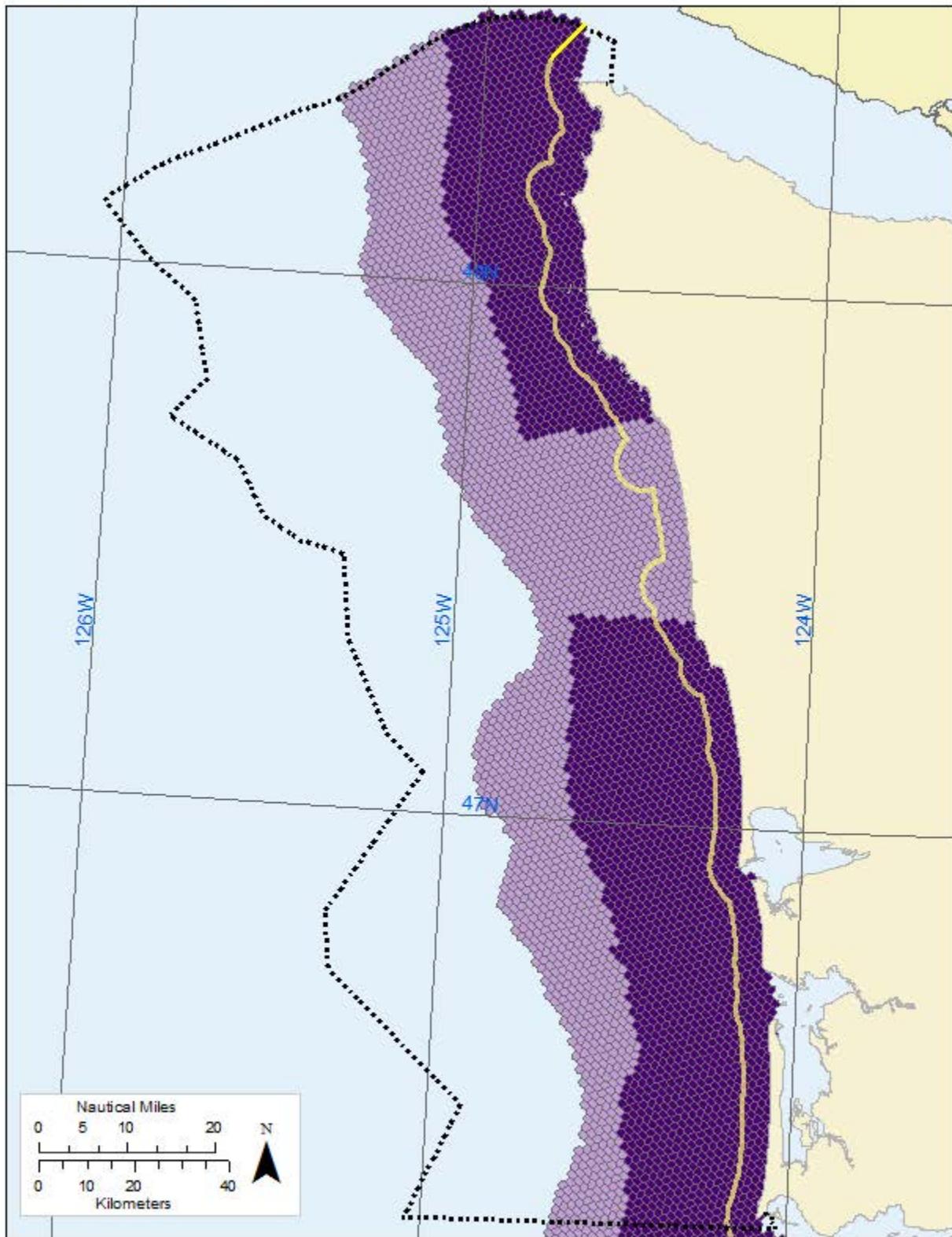


Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Commercial Pink Shrimp Trawl Intensity ³



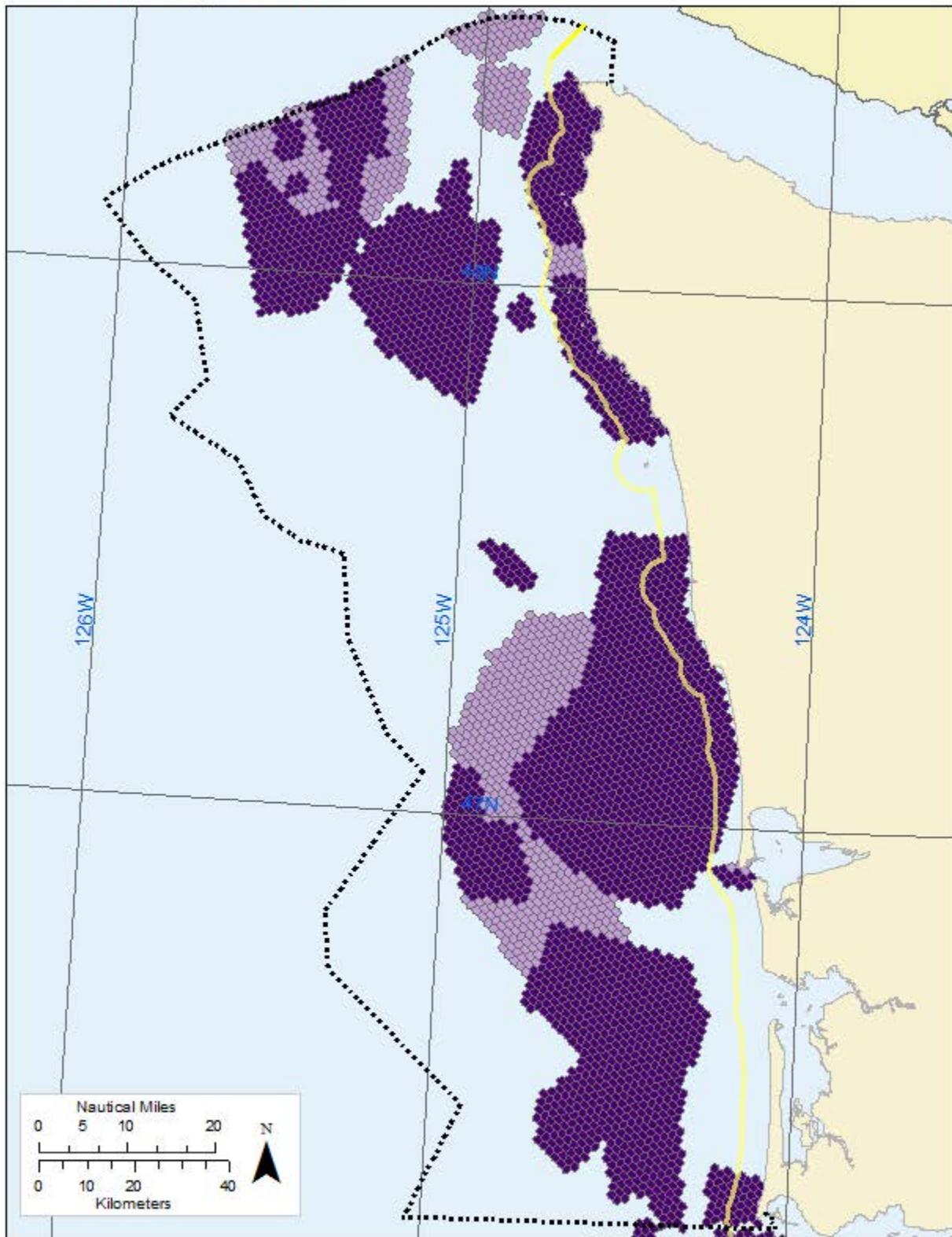


Recreational Salmon Fishing Intensity ¹

- Medium
- High

- WA State Boundary ²
- Washington MSP Study Area ³
- World Latitude and Longitude Grids ^{2a}



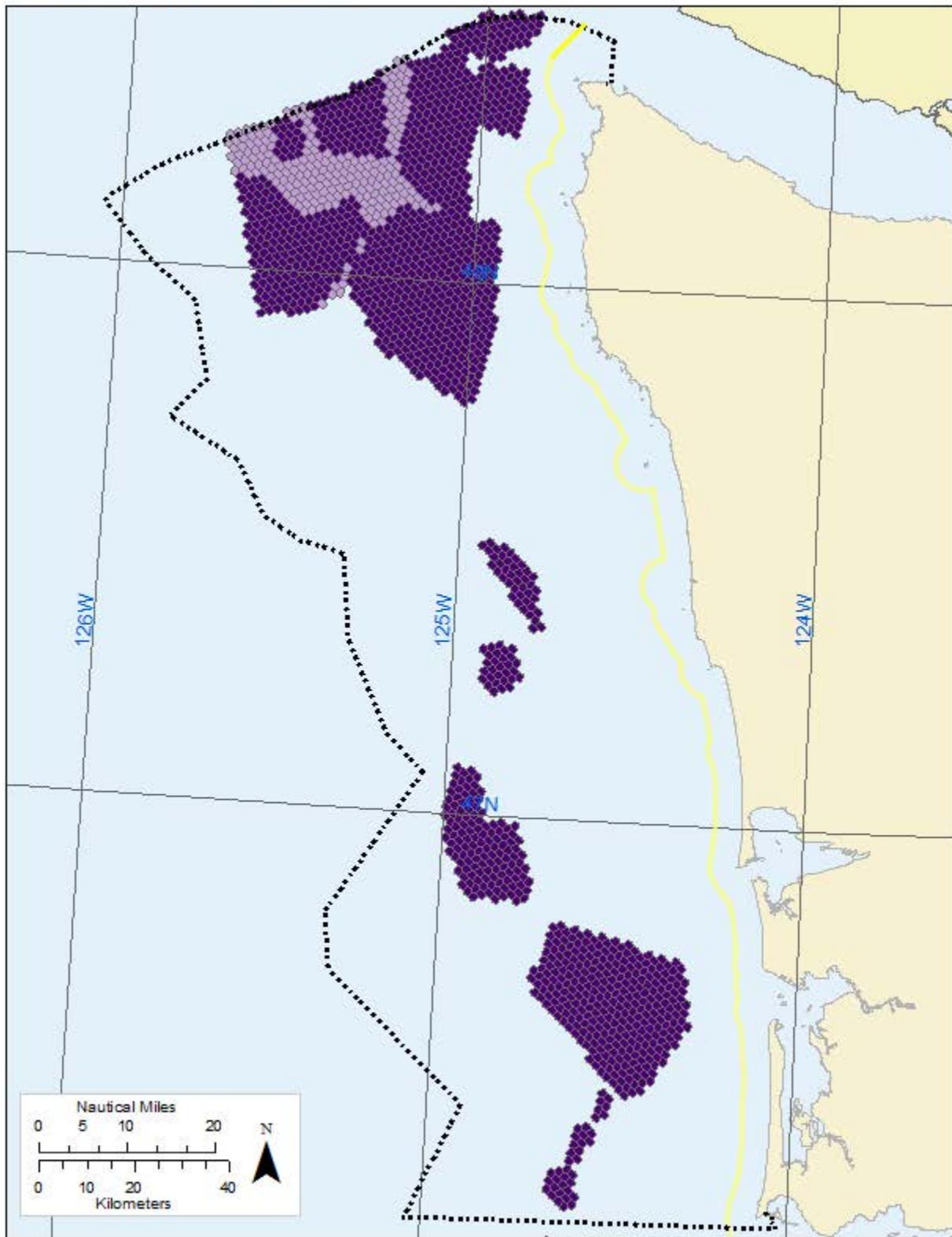


Recreational Bottomfish Fishing Intensity ³

- Medium
- High

- WA State Boundary ¹¹
- Washington MSP Study Area ⁷
- World Latitude and Longitude Grids ²²

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Recreational Pacific Halibut Fishing Intensity

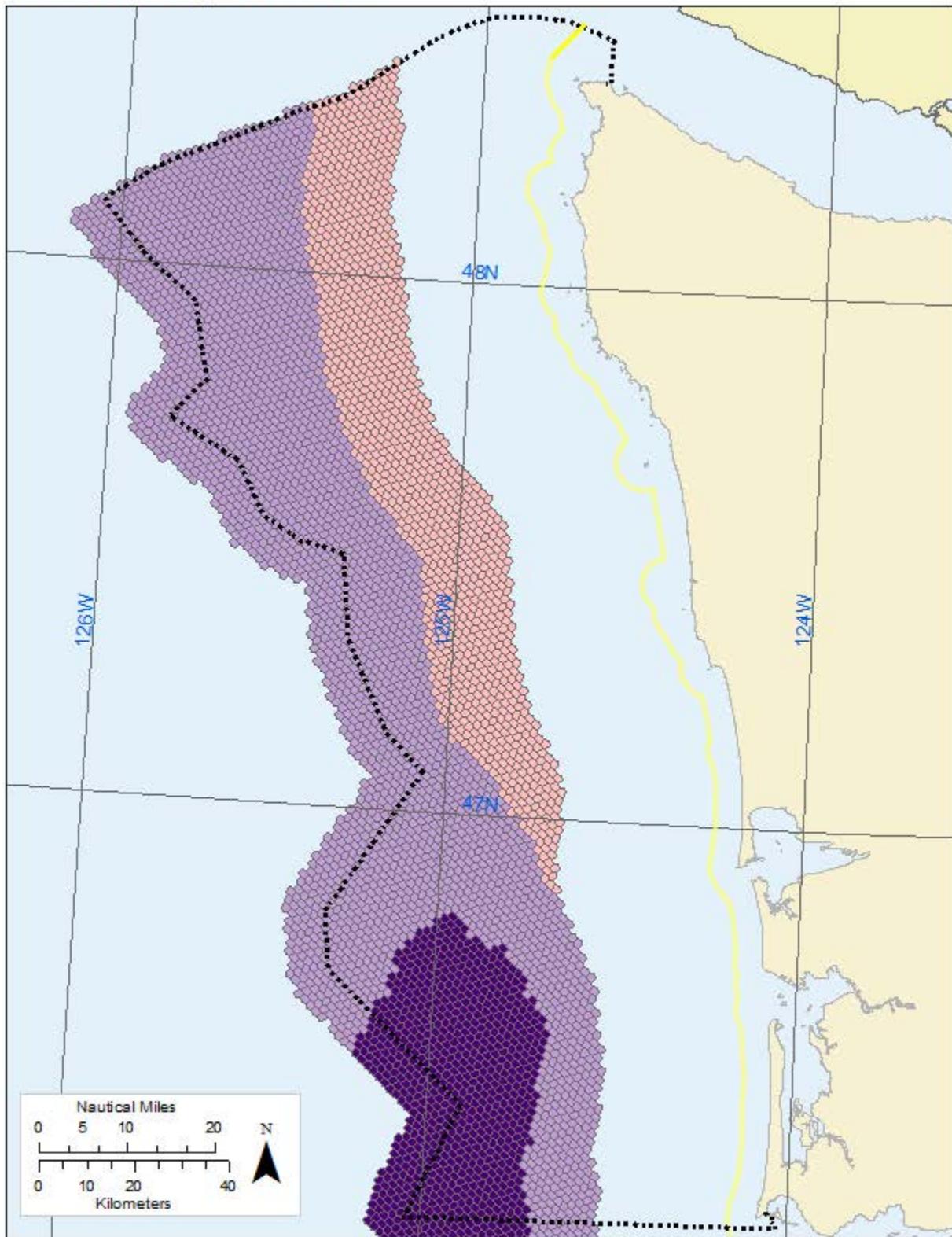
- Medium
- High

WA State Boundary¹⁸

Washington MSP Study Area⁷

World Latitude and Longitude Grids²²

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Recreational Albacore Tuna Fishing Intensity²

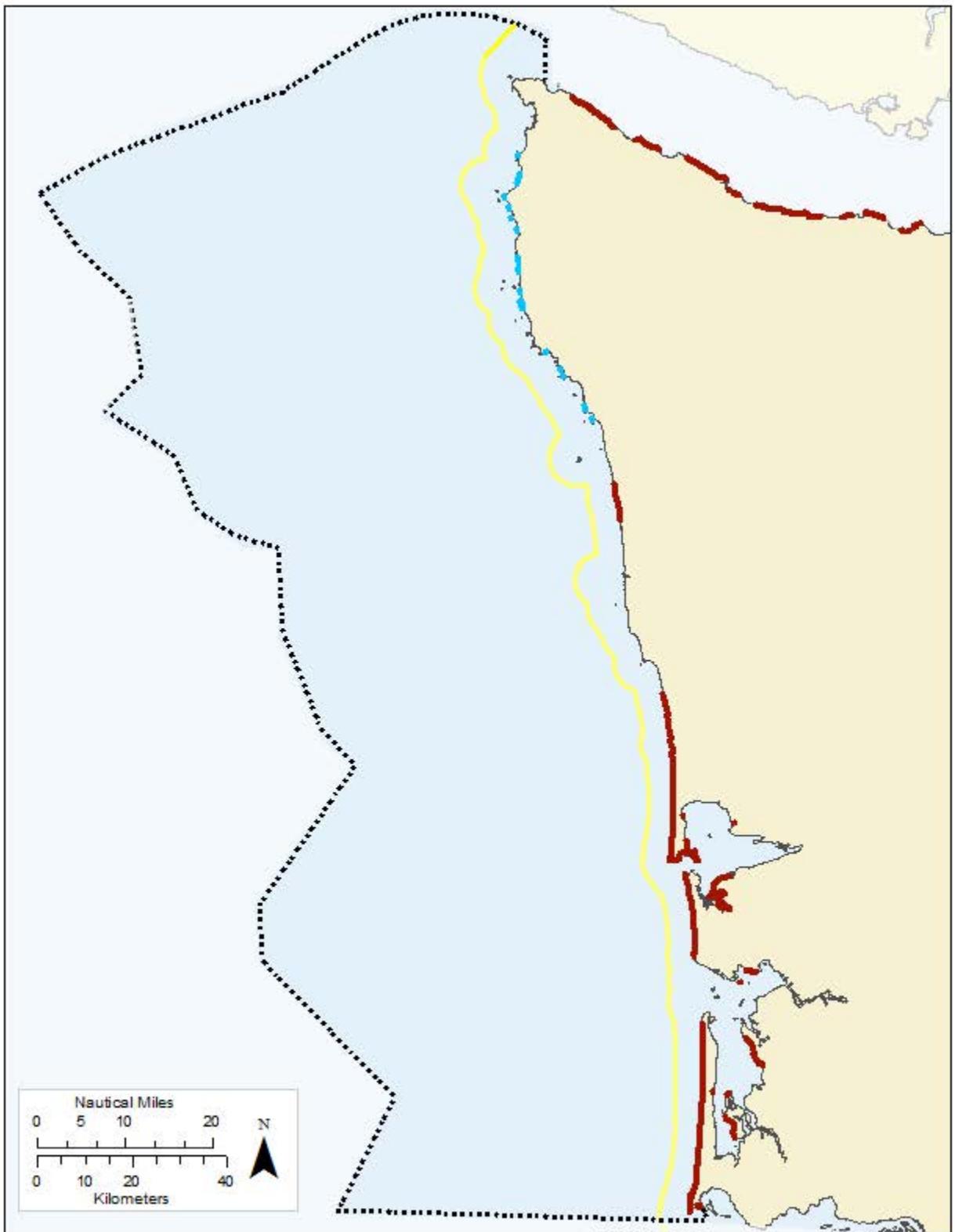
- Low
- Medium
- High

- WA State Boundary¹
- Washington MSP Study Area¹
- World Latitude and Longitude Grids^{2a}



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 29: Recreational Shellfish Beaches and Hardshell Clam Beaches

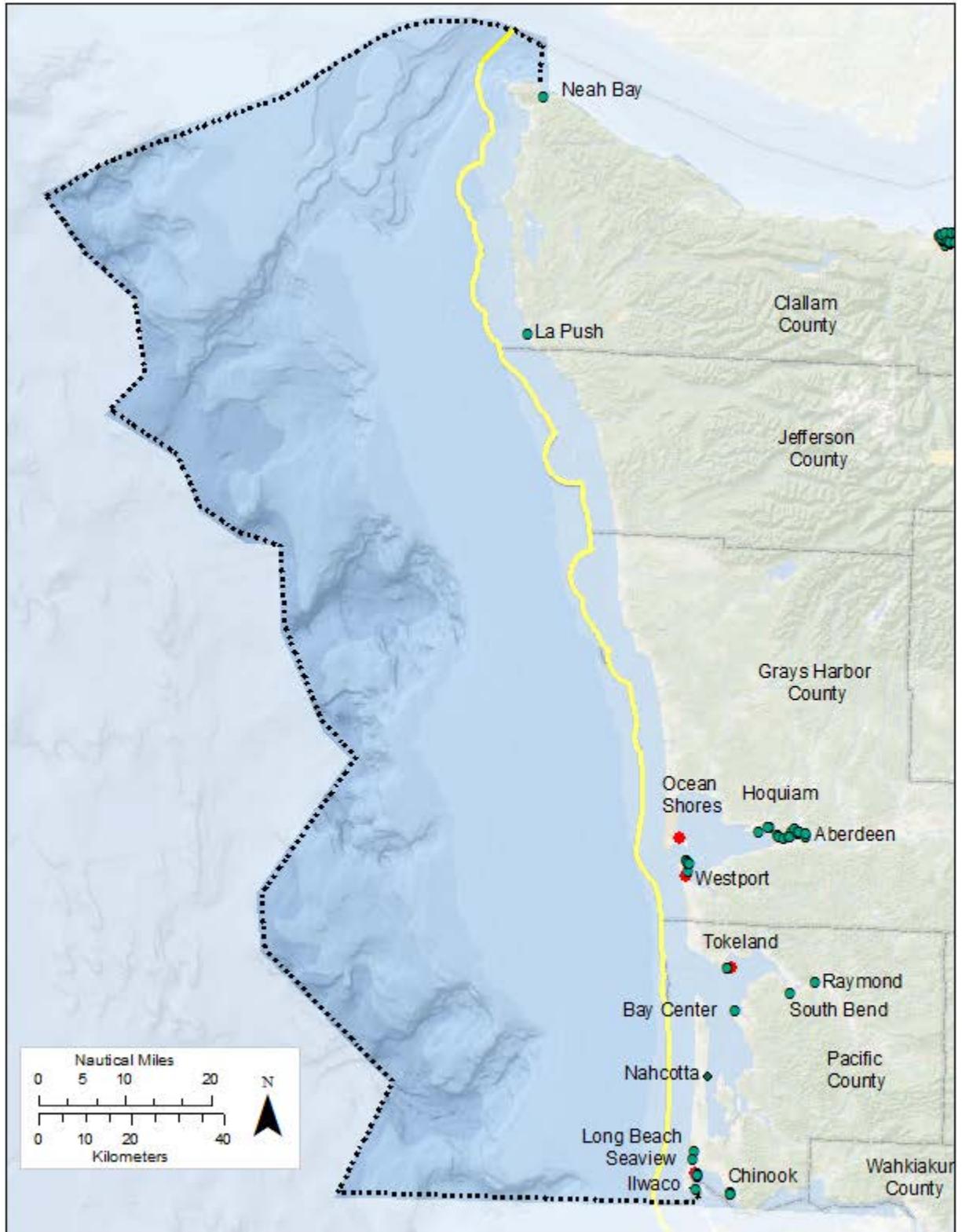


..... Washington MSP Study Area⁷

— WA State Boundary⁸

— Recreational Shellfish Beaches⁴

— Hardshell Clam Beaches¹²



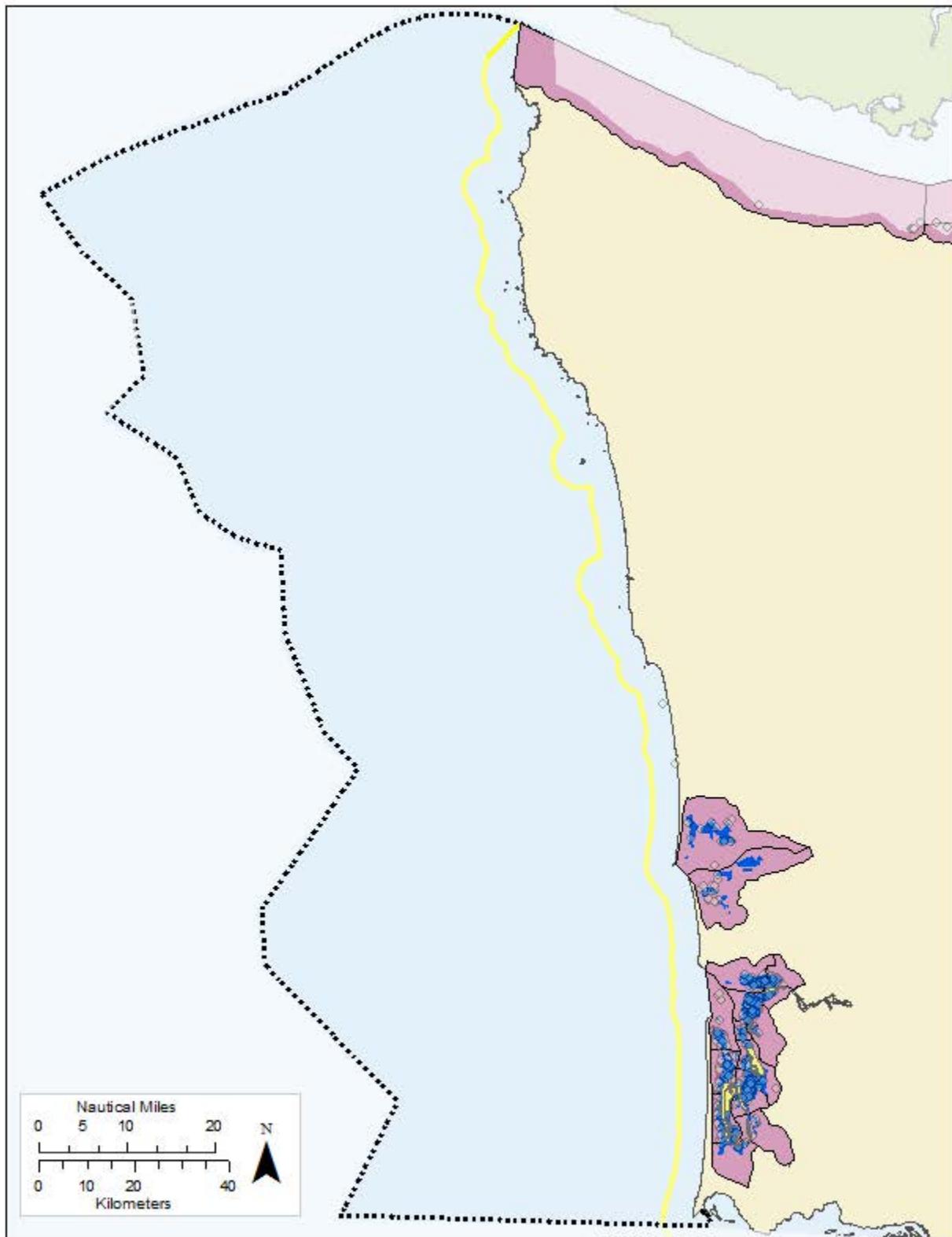
◆ Ports²²

◆ Marinas²

..... Washington MSP Study Area⁷

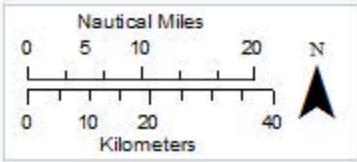
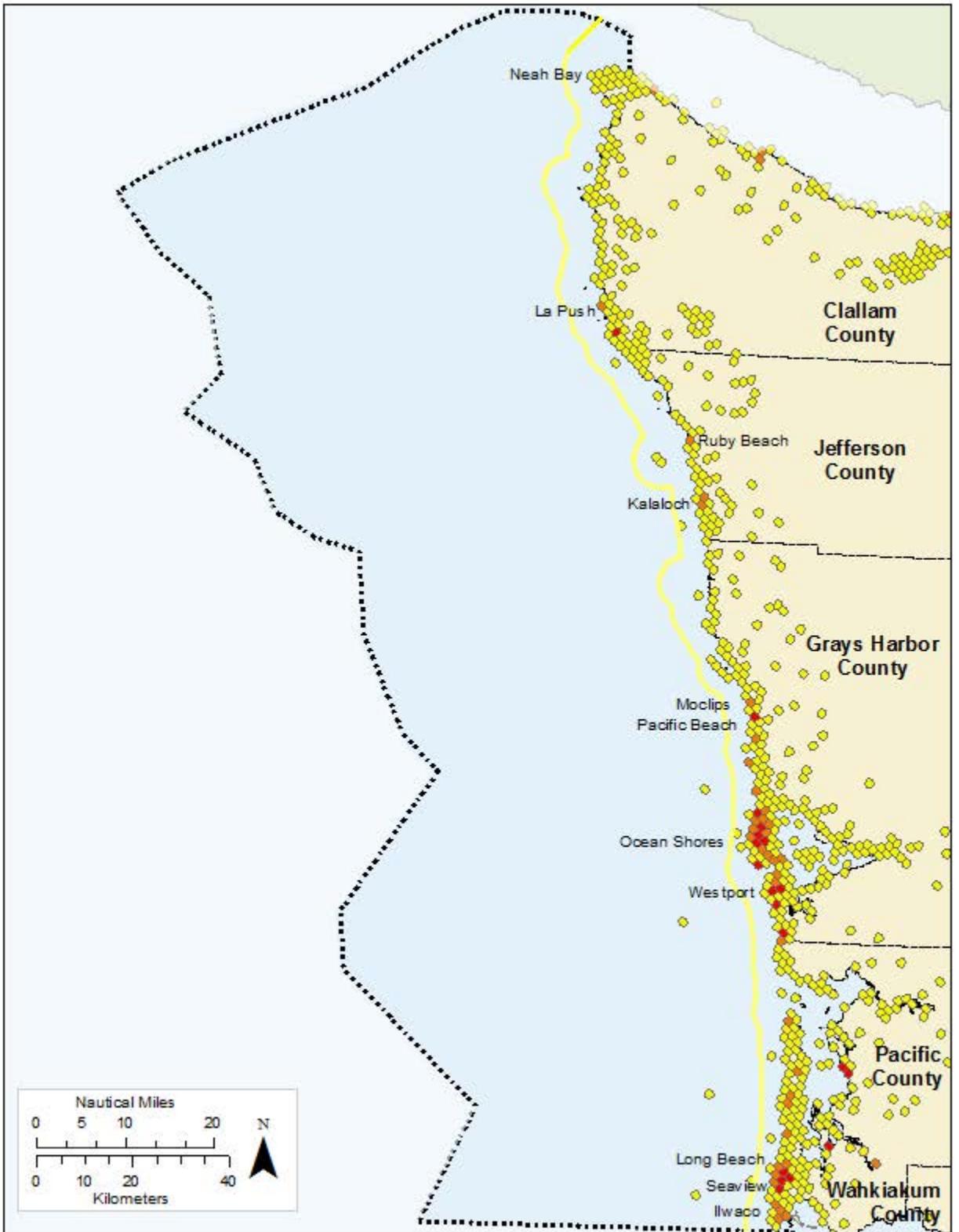
— WA State Boundary⁸





- Washington MSP Study Area⁷
- WA State Boundary⁸
- Aquaculture Districts²
- Oyster Reserves²
- Harvest Locations⁴
- Oyster Tracts²

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

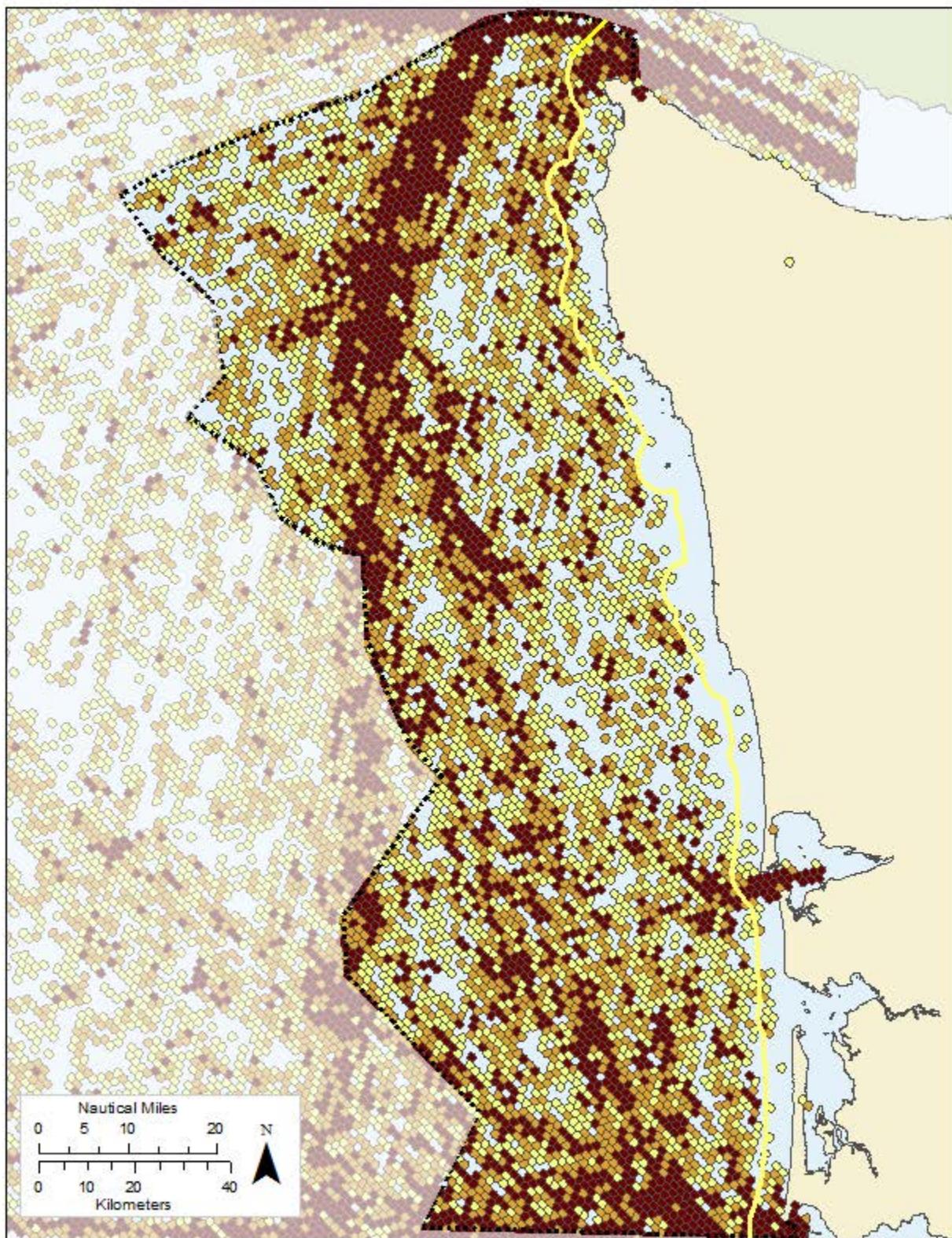


..... Washington MSP Study Area⁷
 Recreational Use Density²²

— WA State Boundary⁸



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



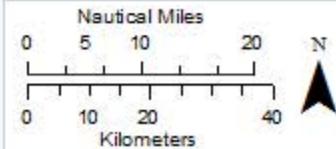
..... Washington MSP Study Area¹

— WA State Boundary²

Recreational Vessel Density³



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

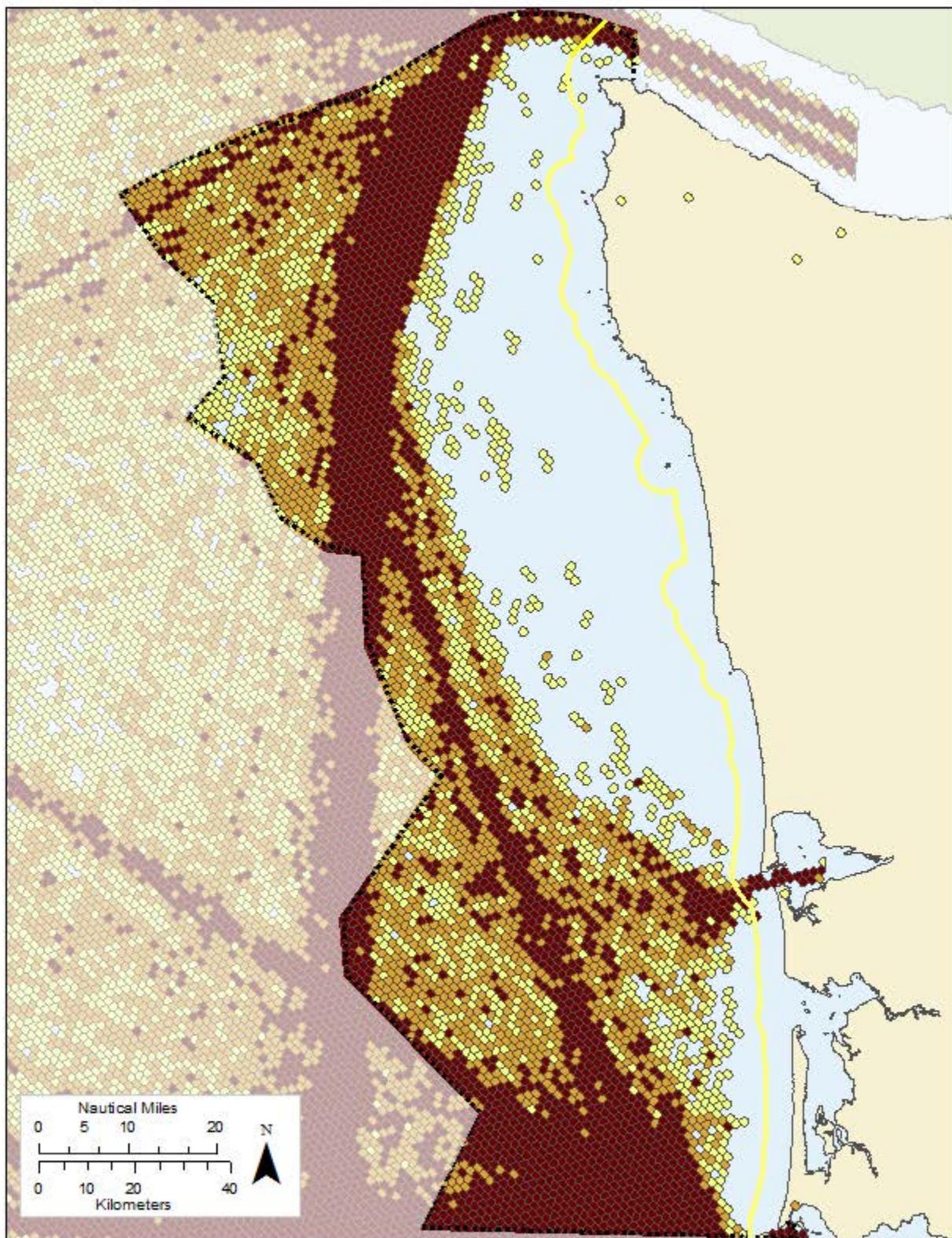


..... Washington MSP Study Area⁷

◆ Public Access²

— WA State Boundary⁸





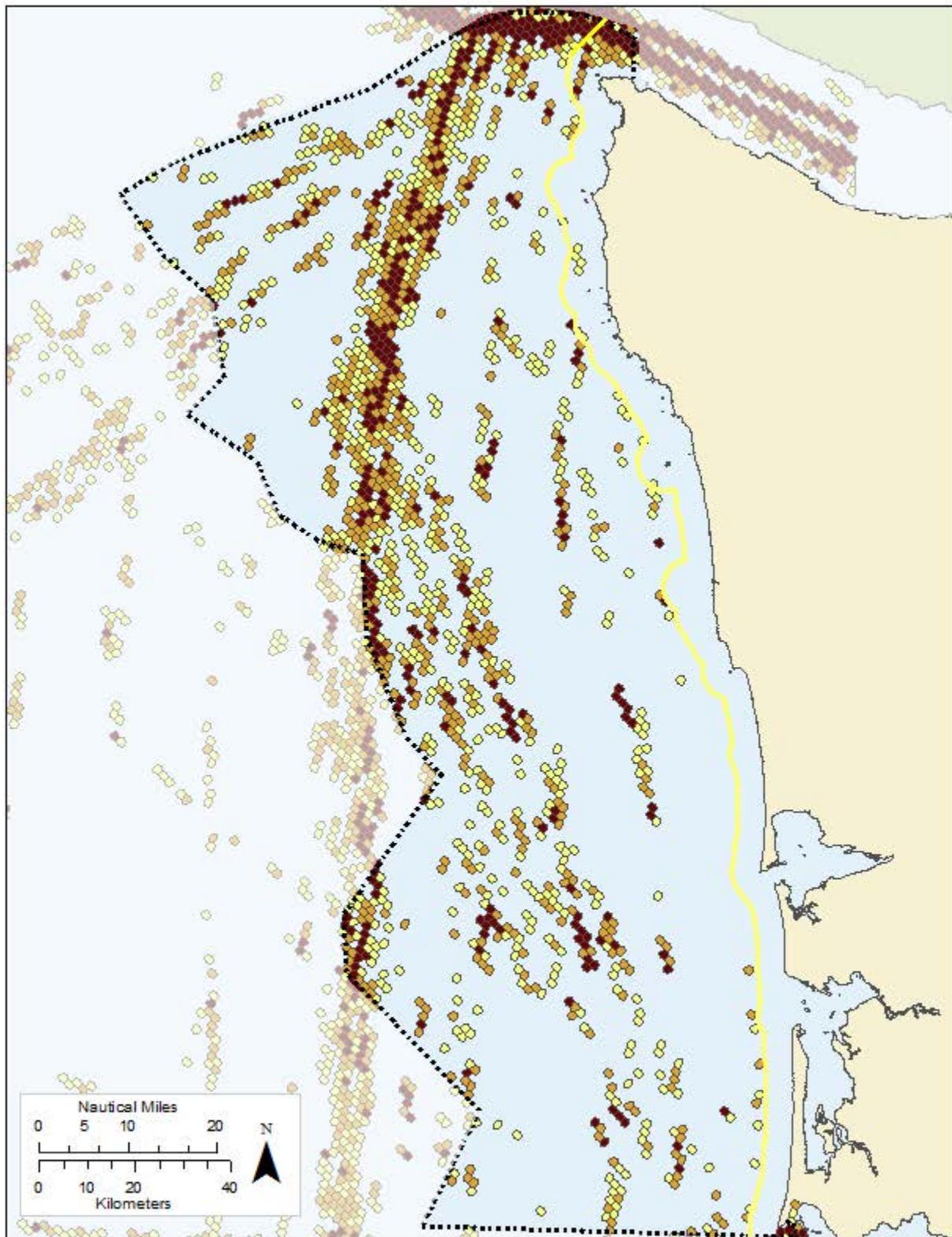
..... Washington MSP Study Area⁷

— WA State Boundary⁸

Cargo Vessel Density⁹



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



..... Washington MSP Study Area⁷

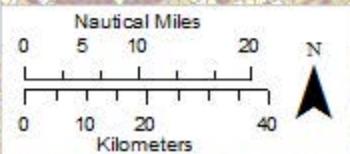
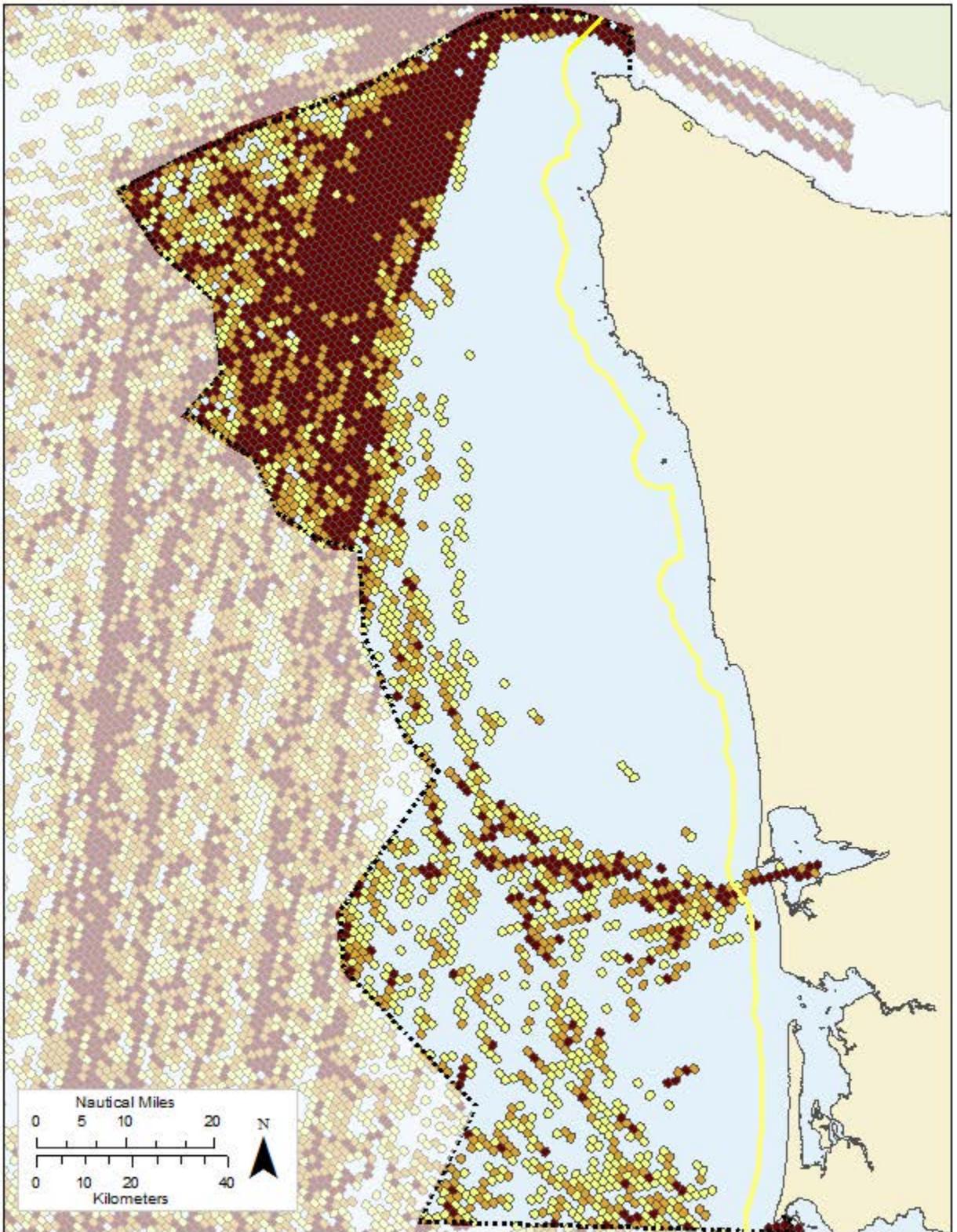
— WA State Boundary⁸

Passenger Vessel Density⁹



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 37: Tanker Vessel Density



..... Washington MSP Study Area⁷

— WA State Boundary⁸

Tanker Vessel Density⁹

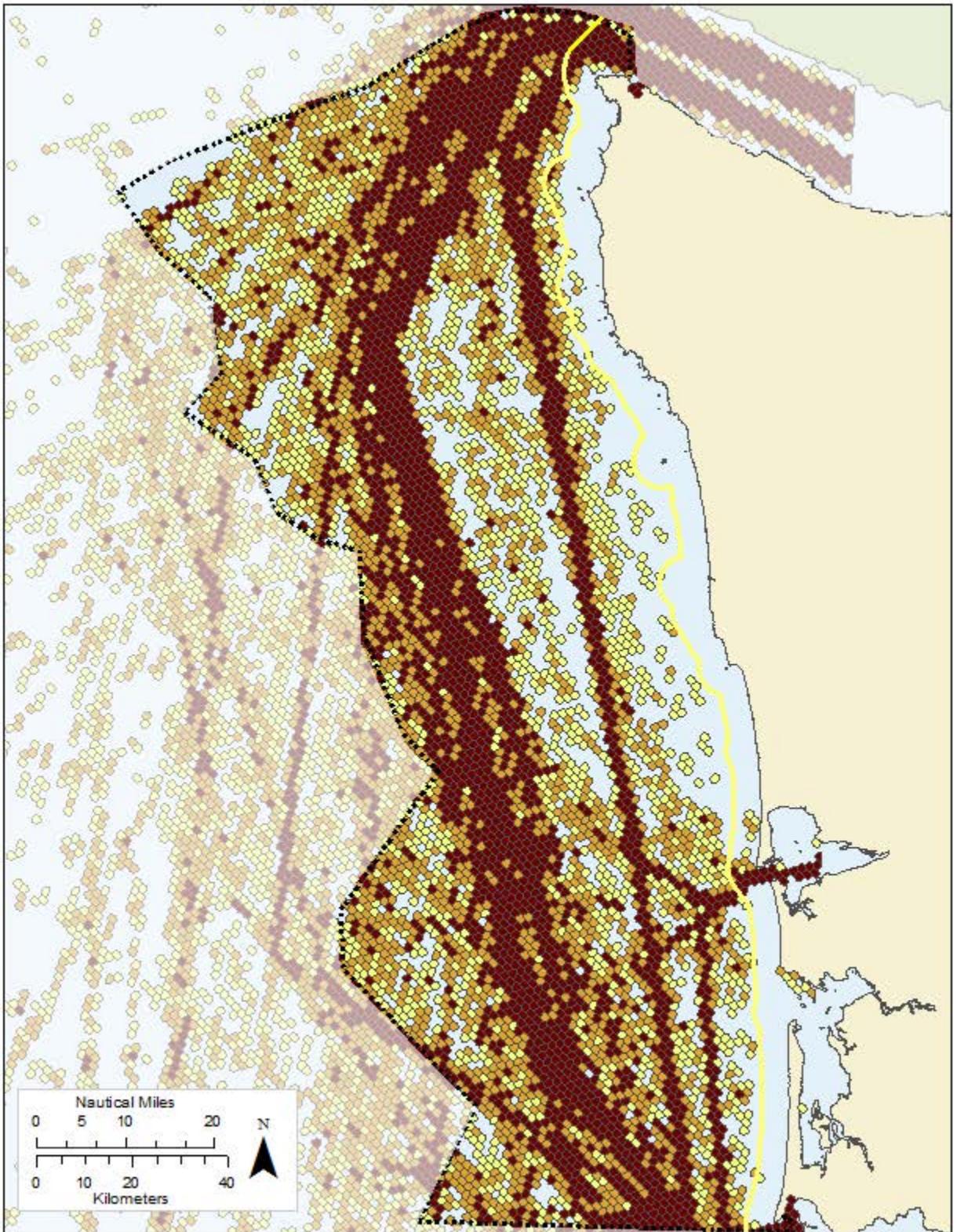


High

Low

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 38: Tug and Tow Vessel Density



..... Washington MSP Study Area⁷

— WA State Boundary⁸

Tug and Tow Vessel Density⁹

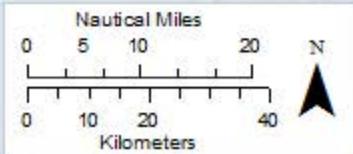
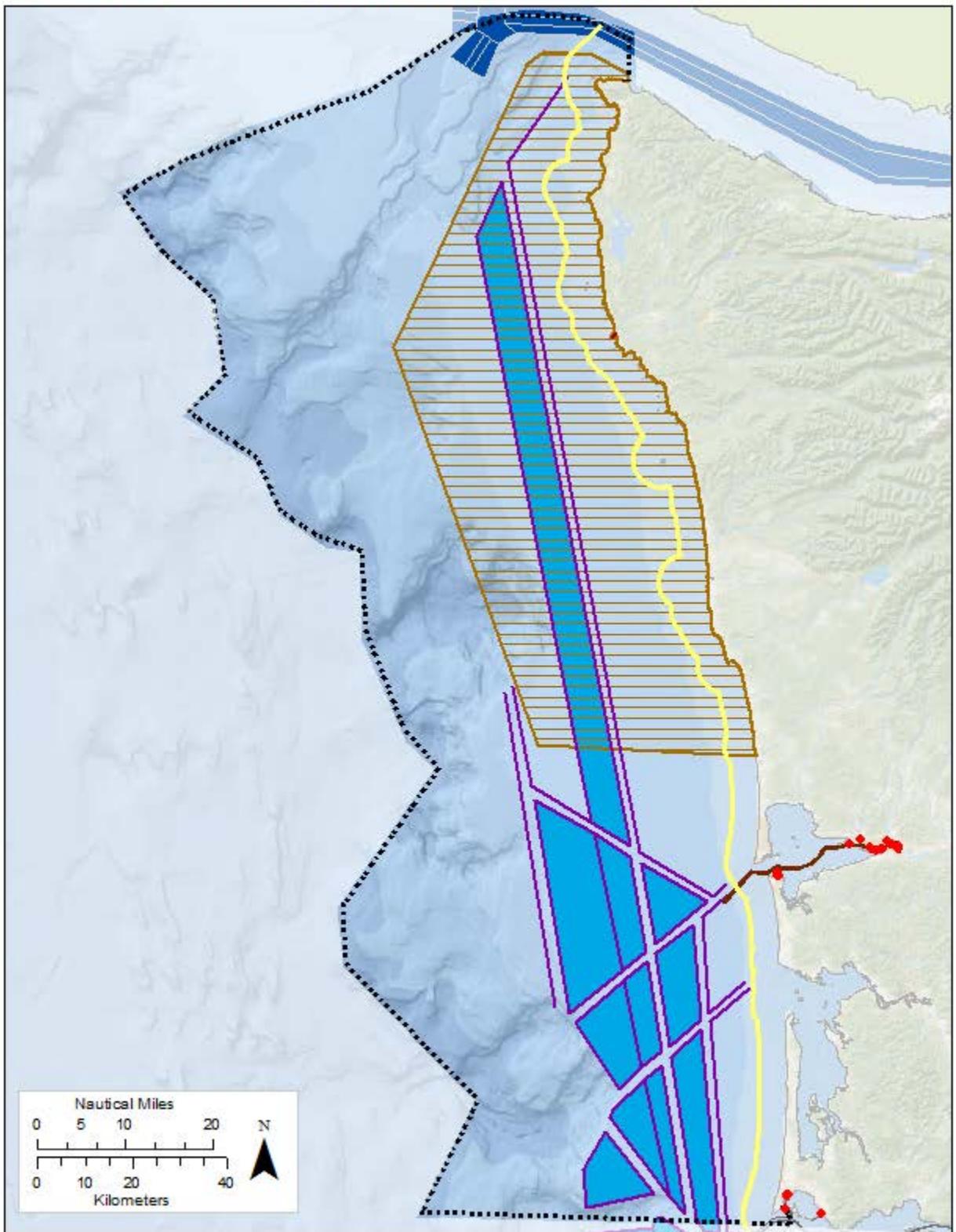


High

Low

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 39: Shipping Lanes, Federal Navigation Channels, and Navigation Agreement Lines

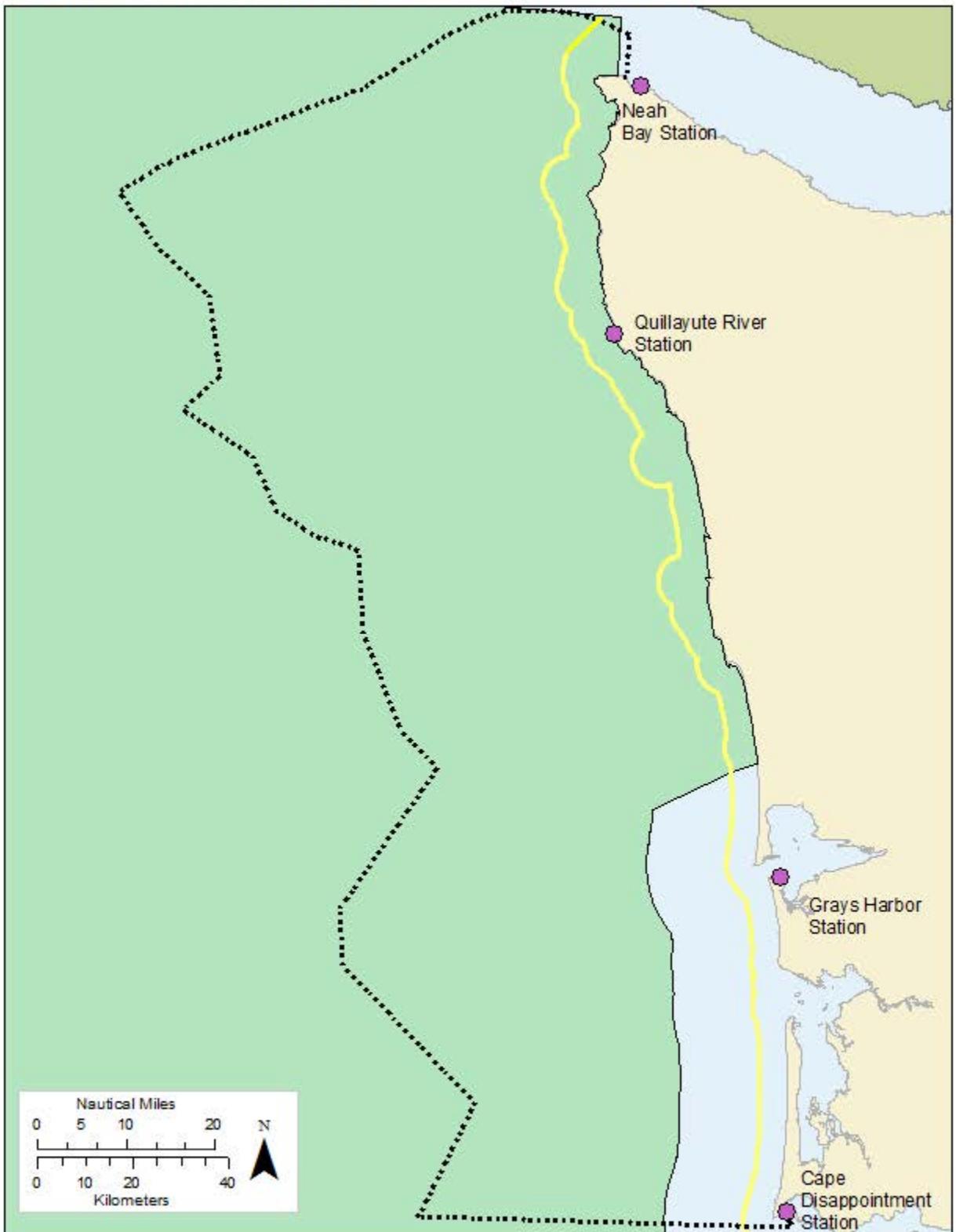
Marine Transportation, Navigation, and Infrastructure¹

- | | | |
|---|---|--|
|  Shipping Lanes ¹¹ |  Fishing Area ² |  WA MSP Study Area ⁷ |
|  Federal Navigation Channel ² |  ATBA ¹¹ |  WA State Boundary ¹¹ |
|  Towboat Lanes ² |  Ports ² | |



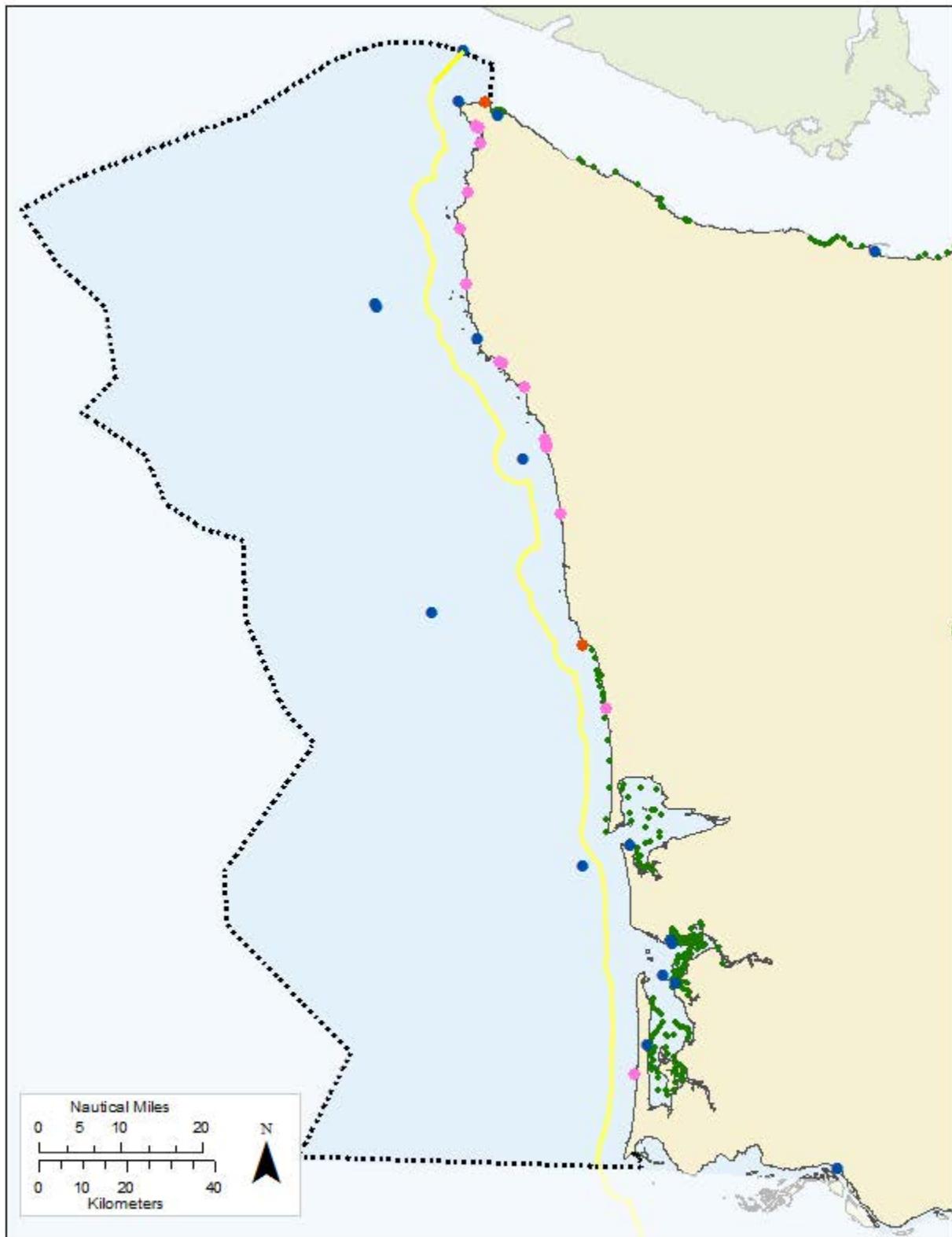
Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 40: Northwest Training Range Complex and Coast Guard Stations



- Northwest Training Range Complex¹²
- Washington MSP Study Area⁷
- Coast Guard Station¹⁴
- WA State Boundary⁸

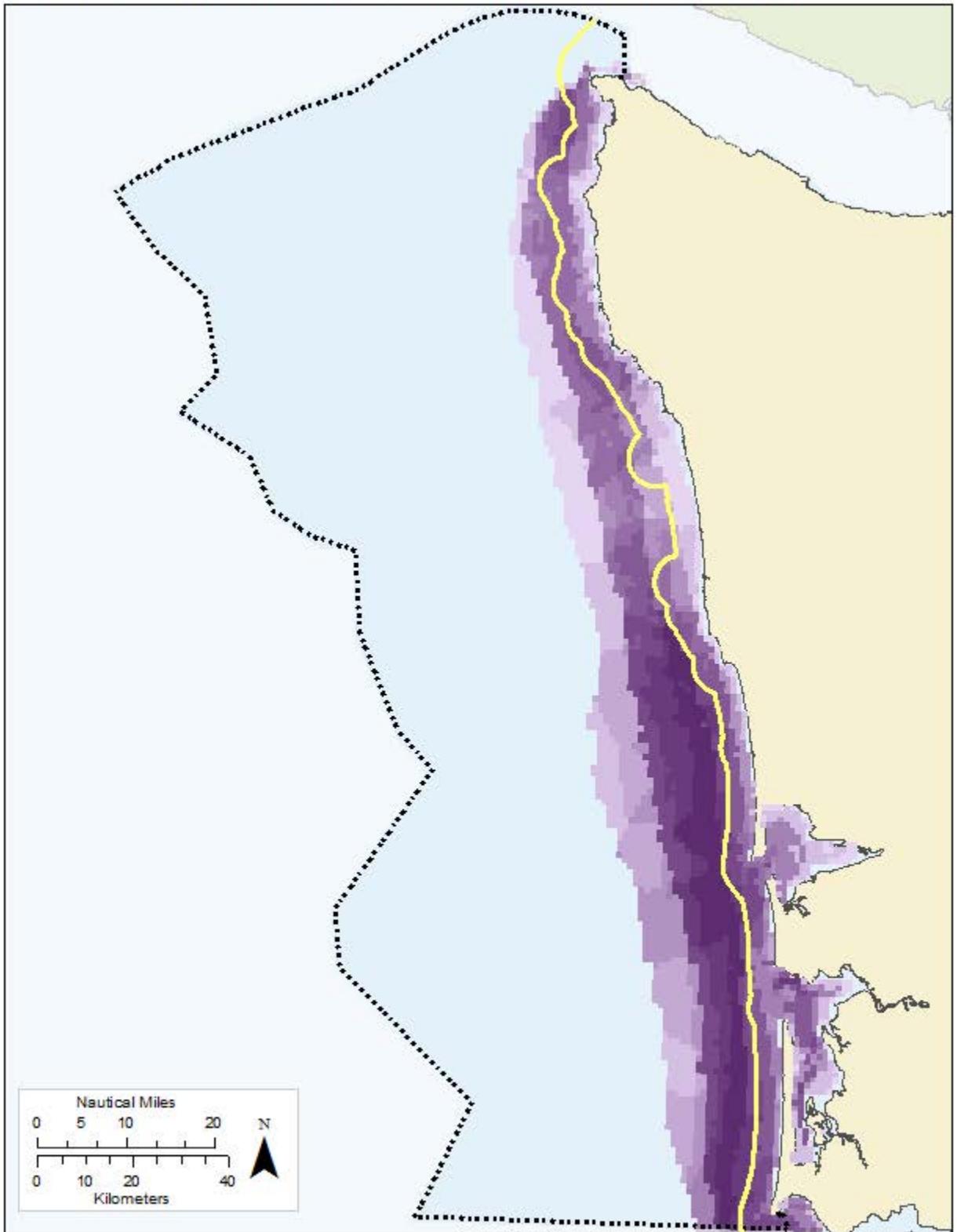
Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



- Water Quality Monitoring Stations⁴
 - Fixed Research Structures²²
- Long-term Monitoring Sites¹¹
 - Marine Debris Monitoring Stations¹¹
- WA MSP Study Area⁷
 - WA State Boundary¹¹

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 42: Renewable Energy Wind Turbine Suitability (Jacket-Tripod Foundation)



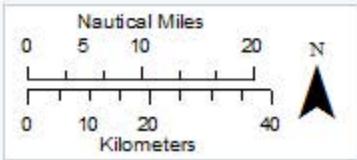
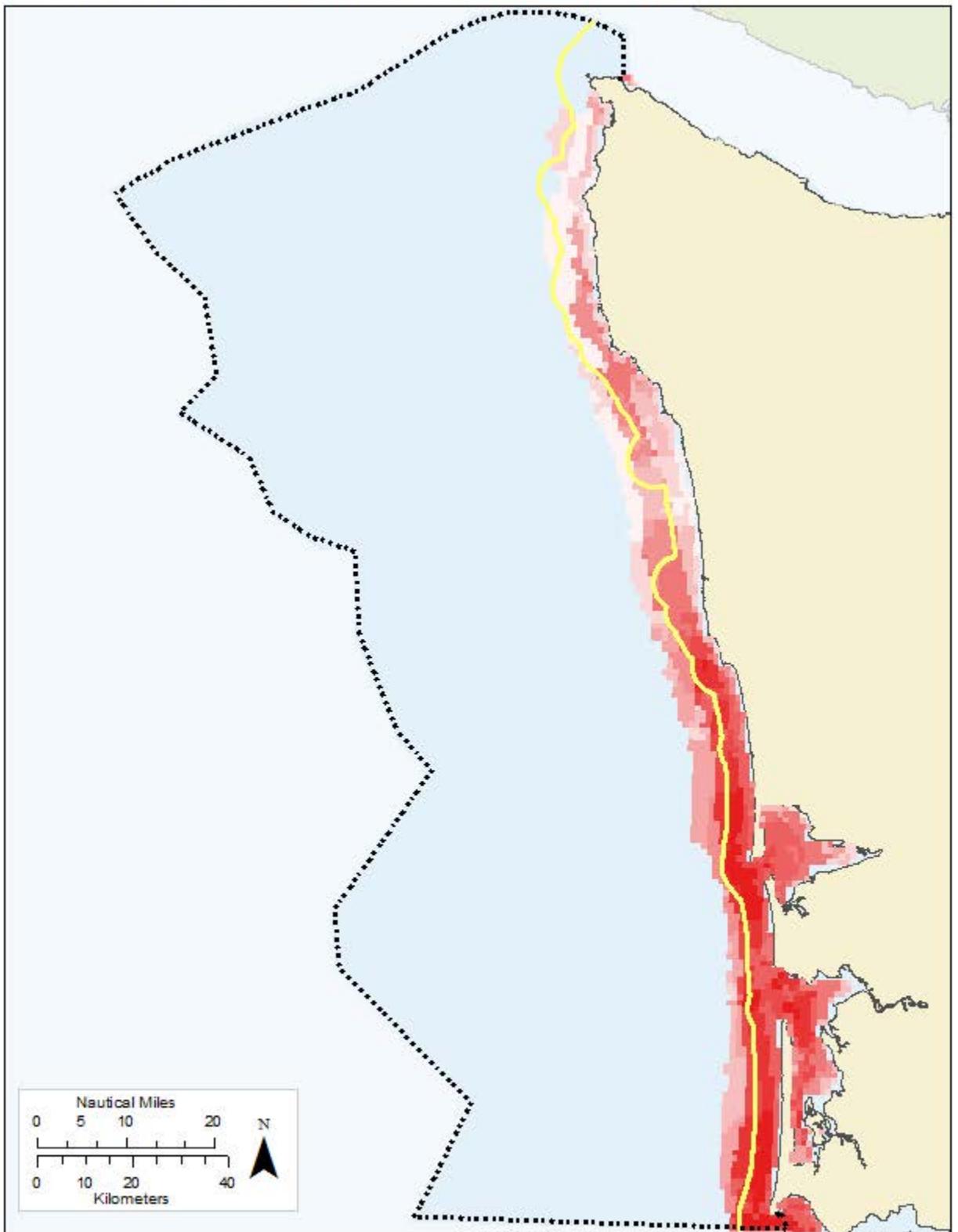
..... Washington MSP Study Area⁷ — WA State Boundary¹⁸

Relative Technical Suitability for Tripod Foundation Wind Technology¹⁹



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 43: Renewable Energy Wind Turbine Suitability (Monopile Foundation)



..... Washington MSP Study Area⁷

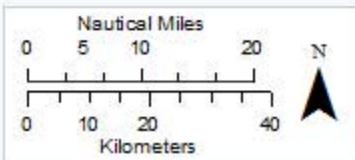
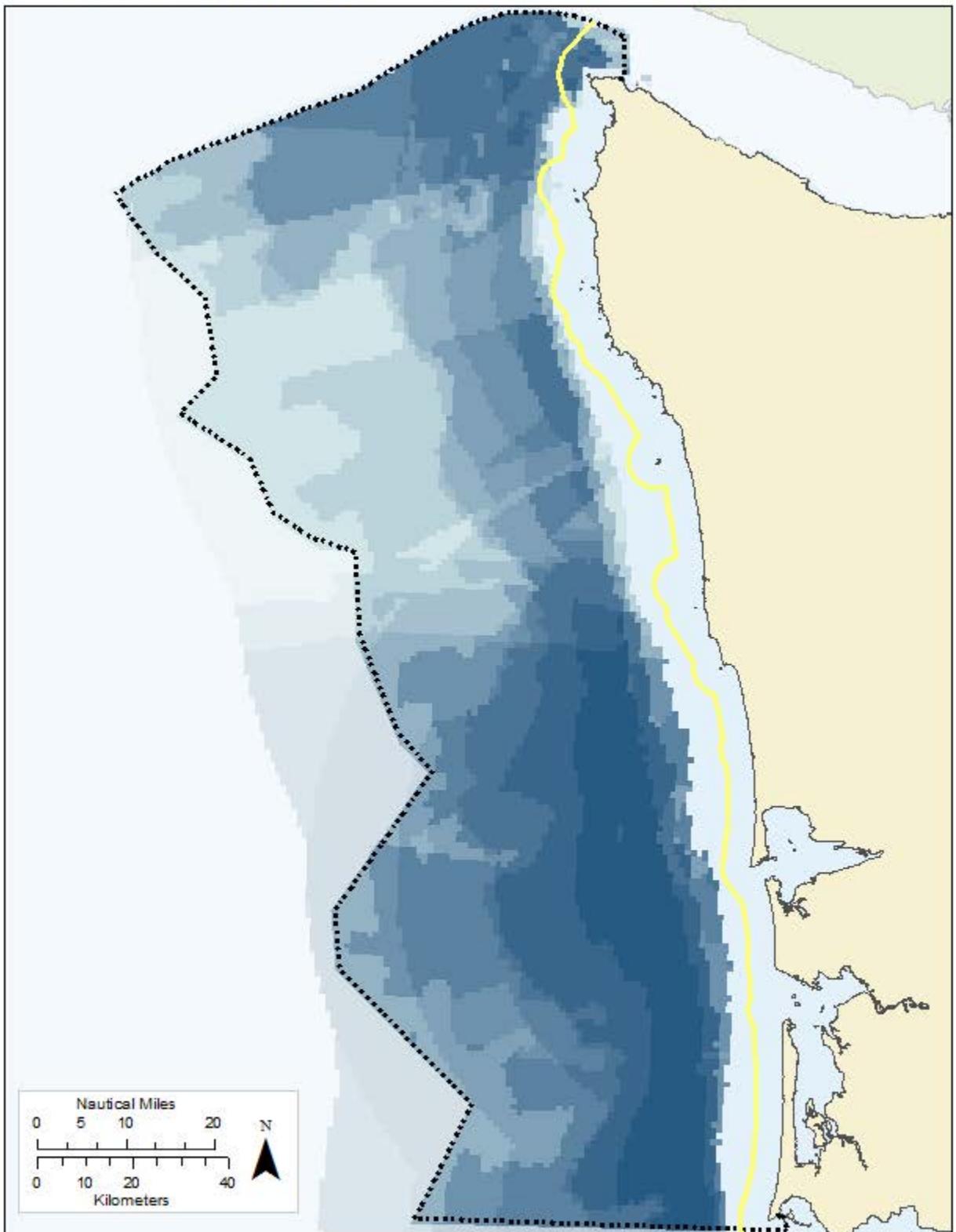
— WA State Boundary¹⁸

Relative Technical Suitability for Monopile Foundation Wind Technology¹⁹



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 44: Renewable Energy Wind Turbine Suitability (Floating Foundation)



..... Washington MSP Study Area¹

— WA State Boundary²

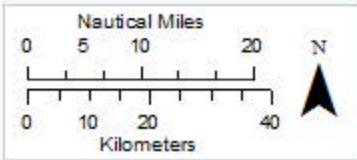
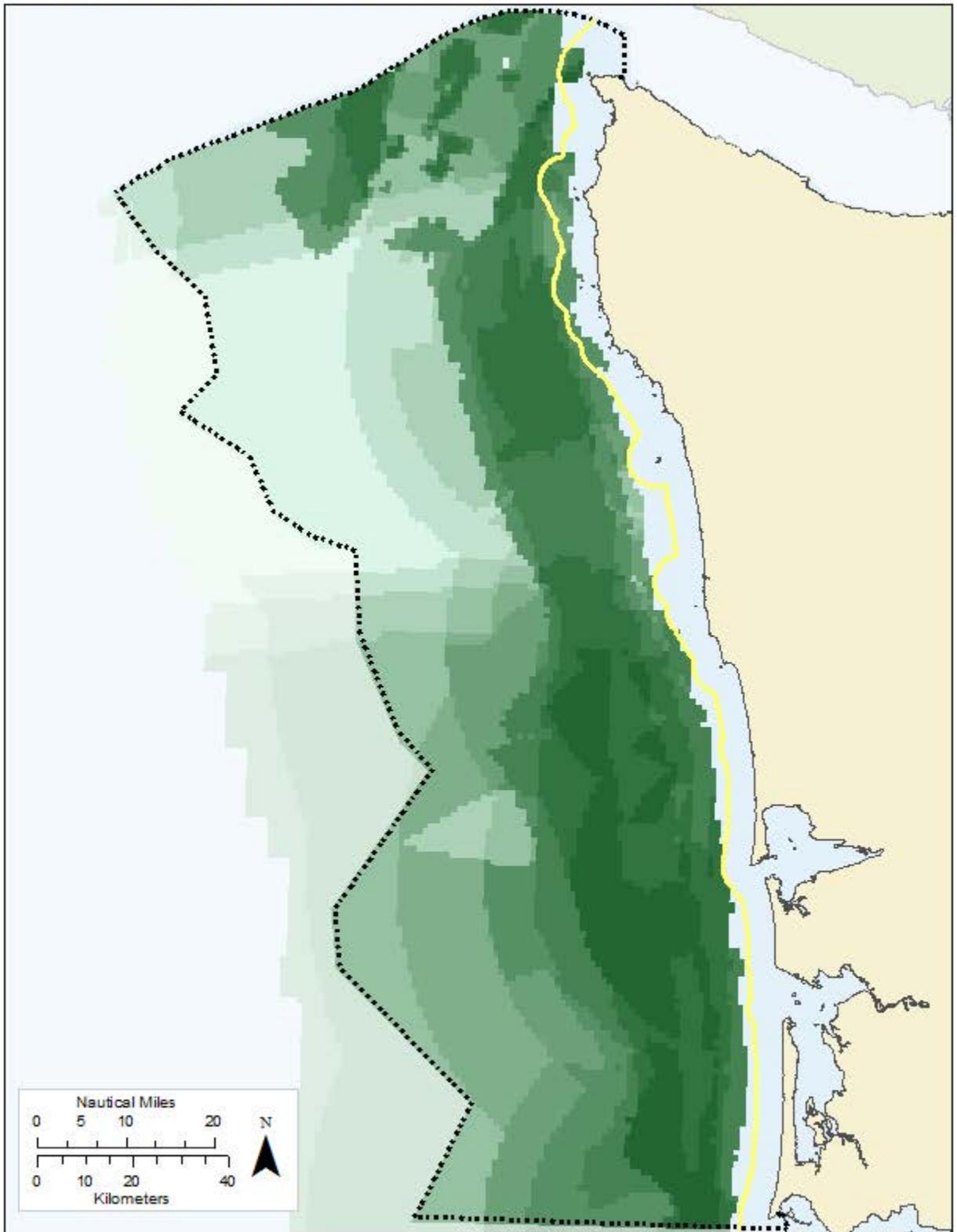
Relative Technical Suitability for Floating Foundation Wind Technology³



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Map 45: Renewable Energy Wave Device Suitability (Deepwater Energy Device)



..... Washington MSP Study Area¹

— WA State Boundary²

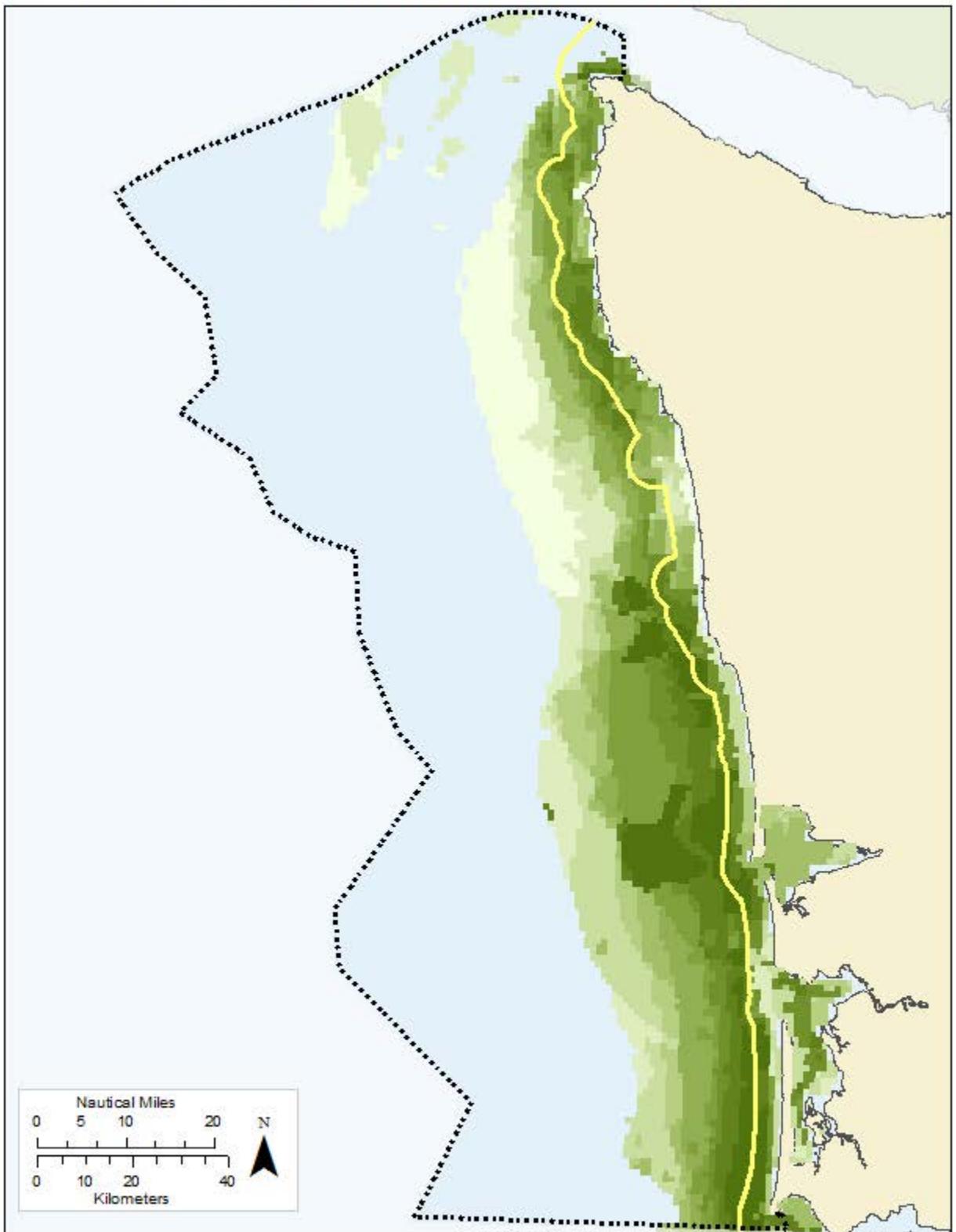
Relative Technical Suitability for Deepwater Wave Technology³



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Map 46: Renewable Energy Wave Device Suitability (Mid-Depth Energy Device)



..... Washington MSP Study Area¹

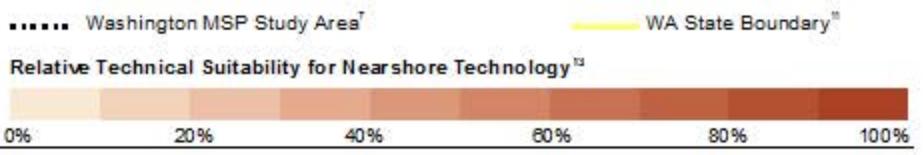
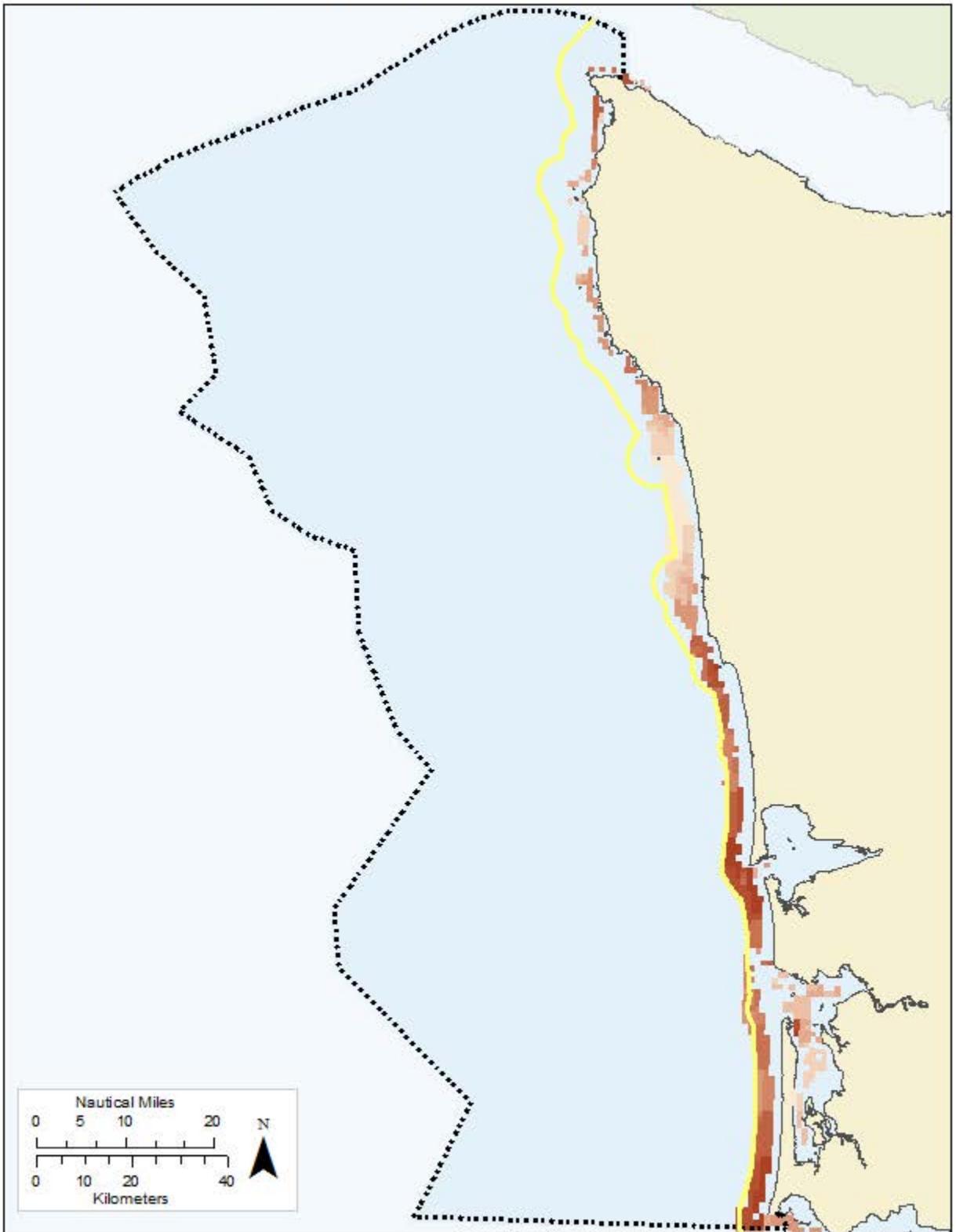
— WA State Boundary²

Relative Technical Suitability for Mid-Depth Wave Technology³



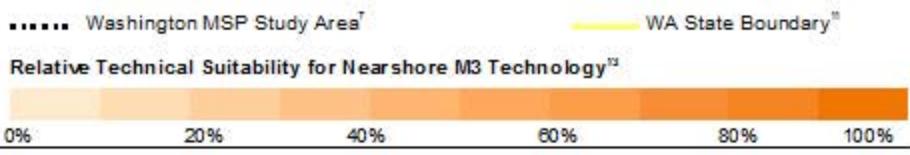
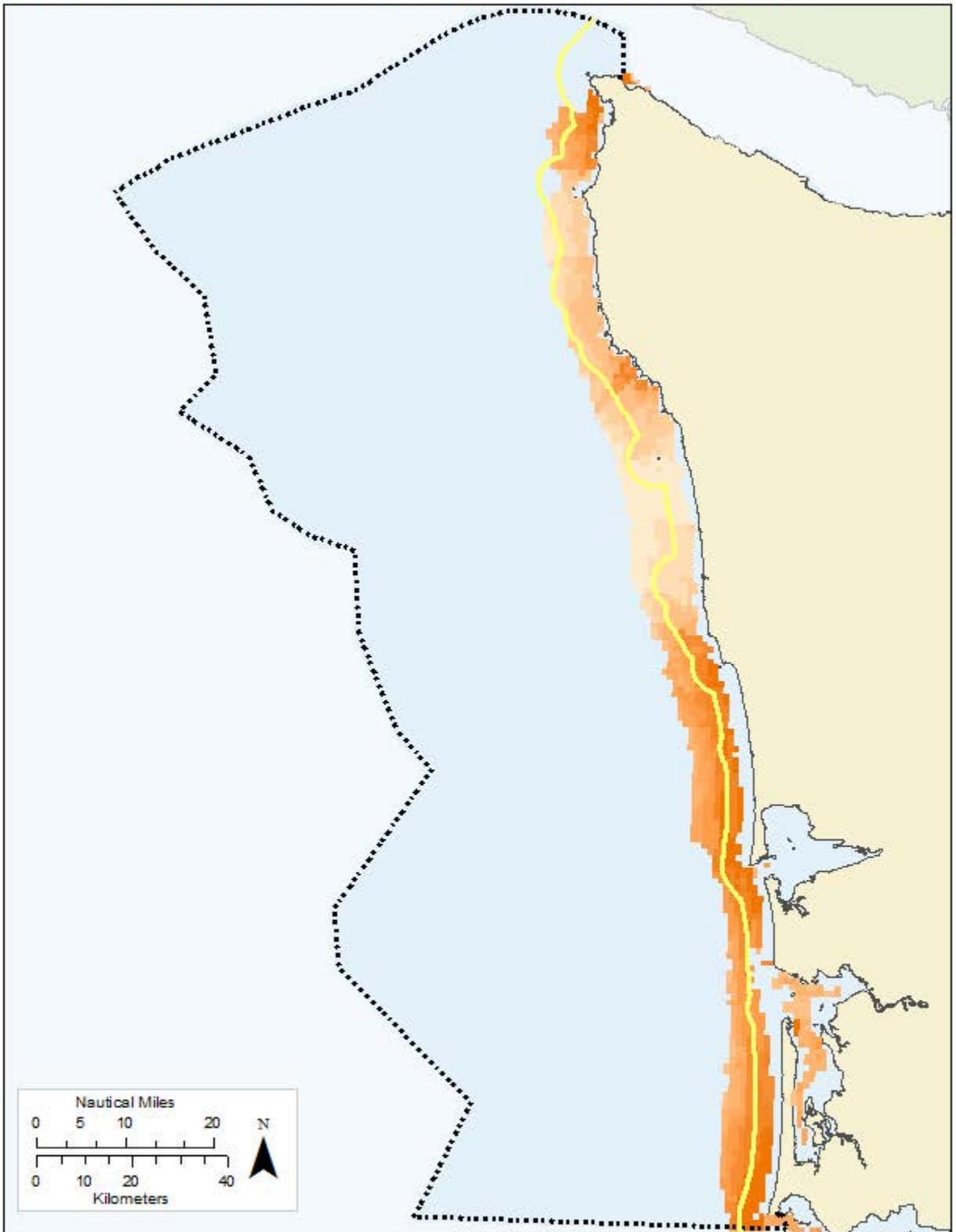
Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 47: Renewable Energy Wave Device Suitability (Nearshore Energy Device)



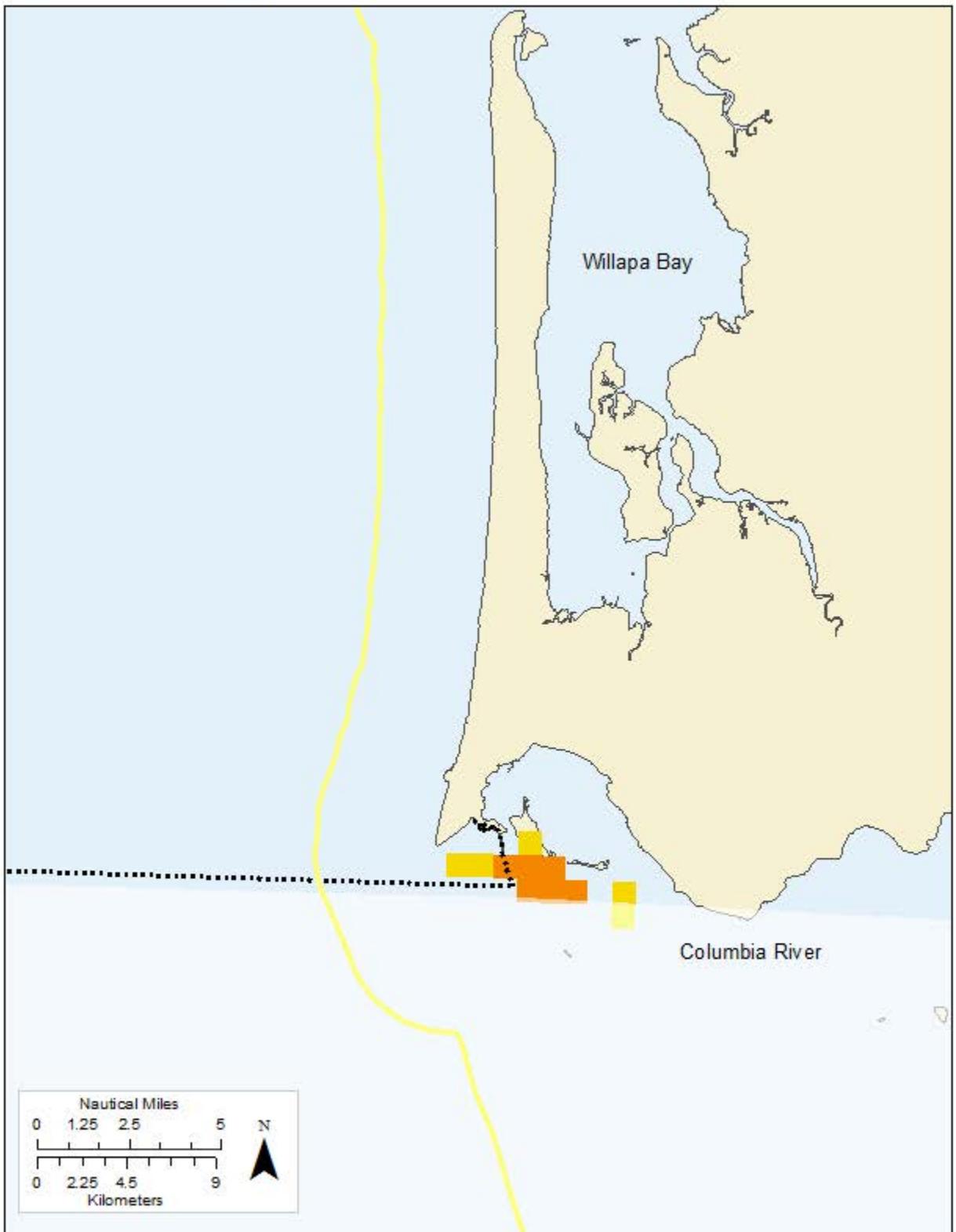
Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 48: Renewable Energy Wave Device Suitability (Nearshore M3 Energy Device)



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 49: Renewable Energy Tidal Turbine Suitability (Columbia River)



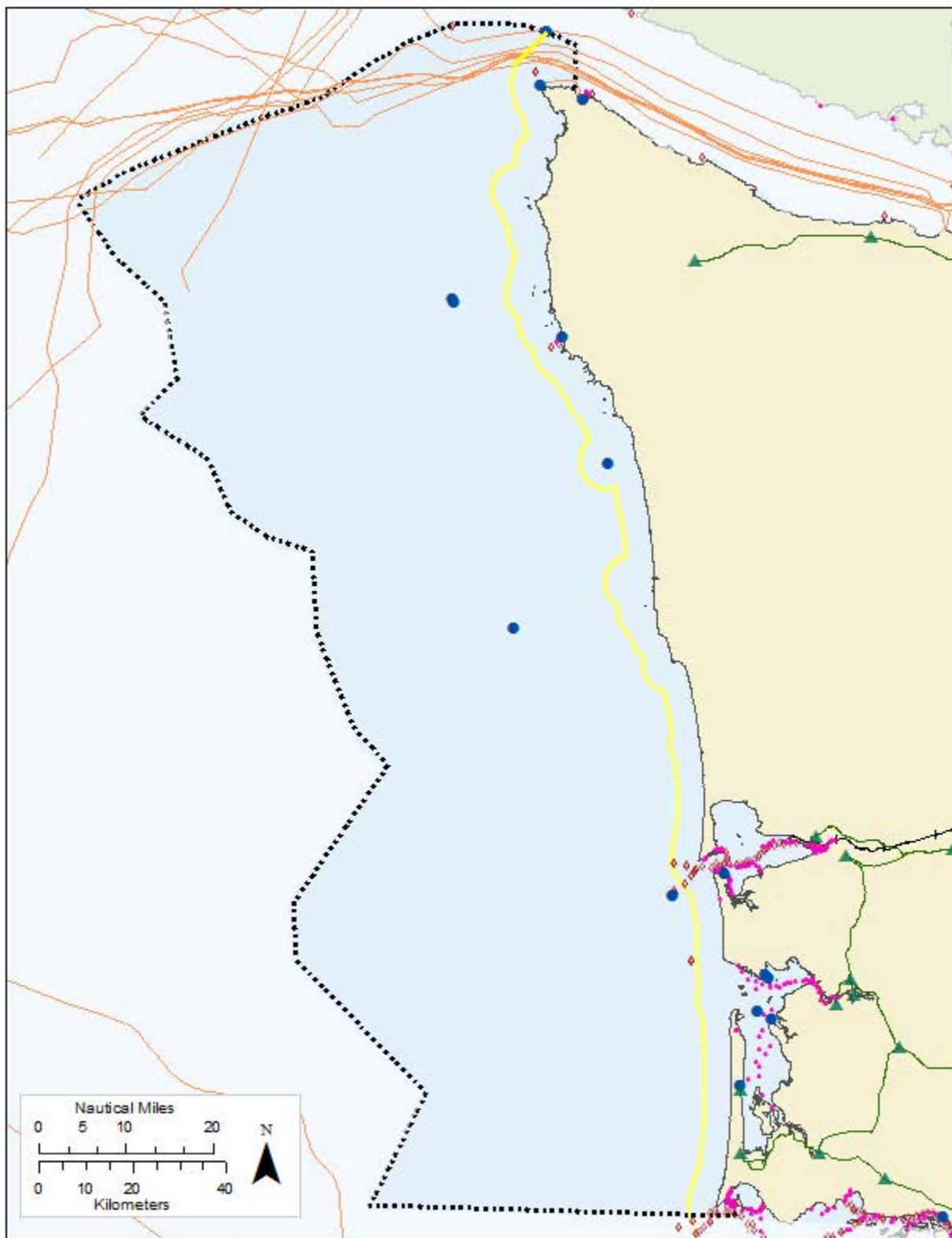
..... Washington MSP Study Area⁷

— WA State Boundary⁸

Relative Technical Suitability for Tidal Turbine Technology¹³

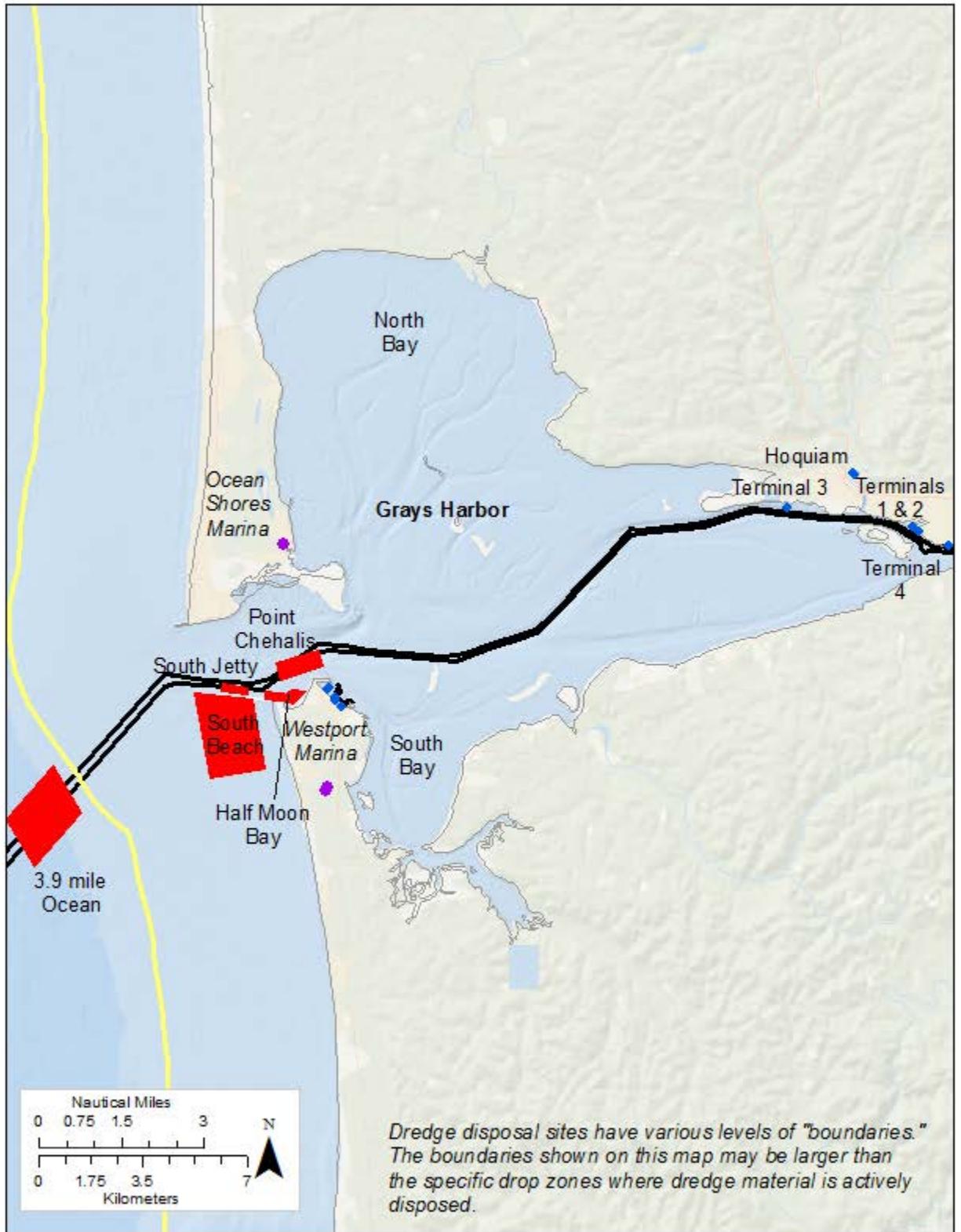


Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



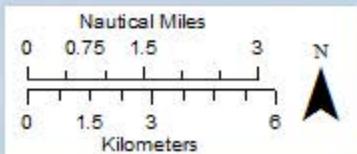
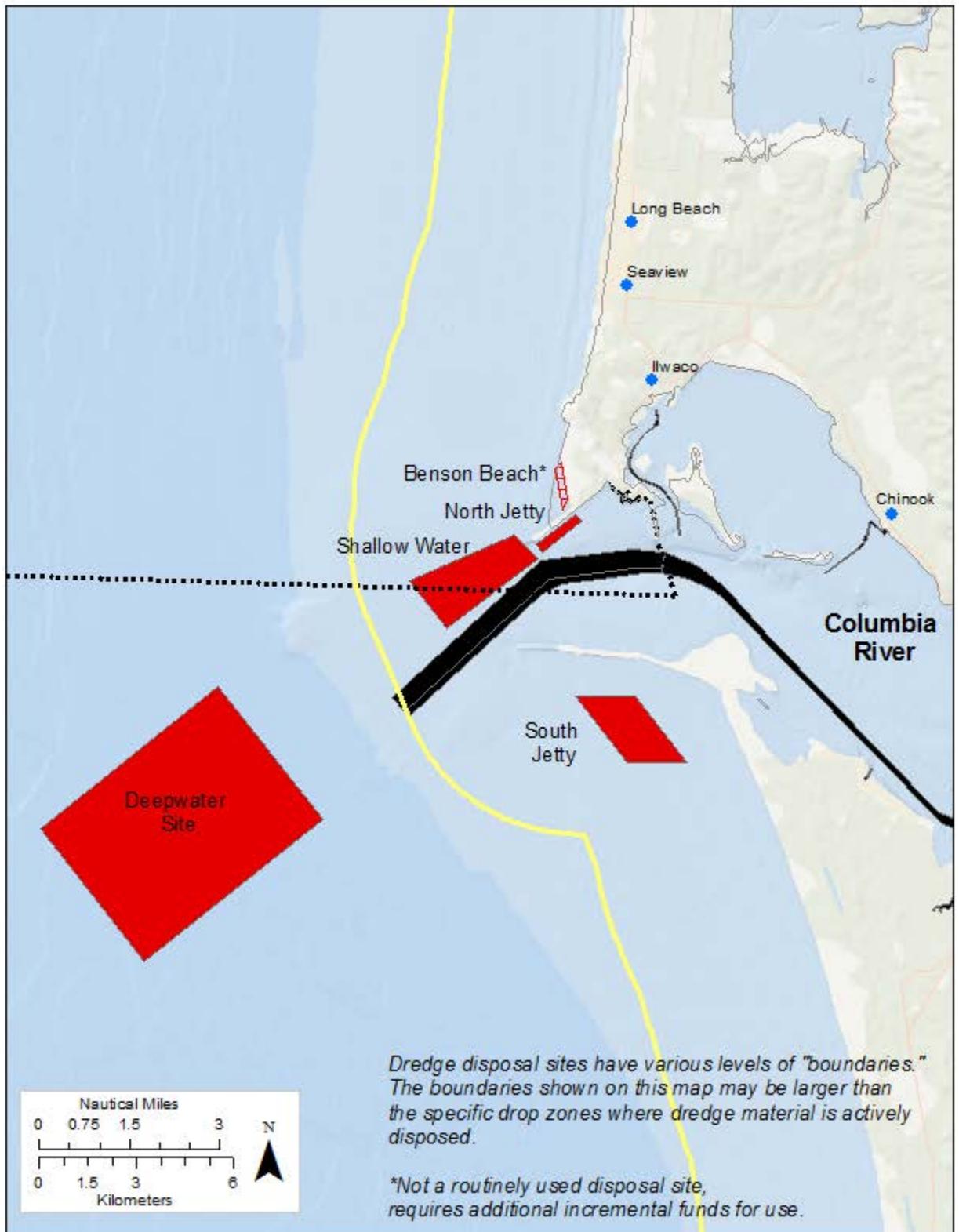
-  Transmission Lines and Substations¹⁹
-  Submarine Cables¹⁸
-  Fixed Research Structures²⁰
-  Rail Lines²
-  WA MSP Study Area⁷
-  WA State Boundary¹¹
-  Buoys¹⁸
-  Beacons¹⁸

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



- Disposal locations^{2,3,7}
- ◆ Ports²
- ◆ Marinas²
- Federal Navigation Channel²
- ⋯ Washington MSP Study Area⁷
- WA State Boundary⁸

Map 52: Columbia River Dredged Material Disposal, Federal Navigation Lanes, and Ports



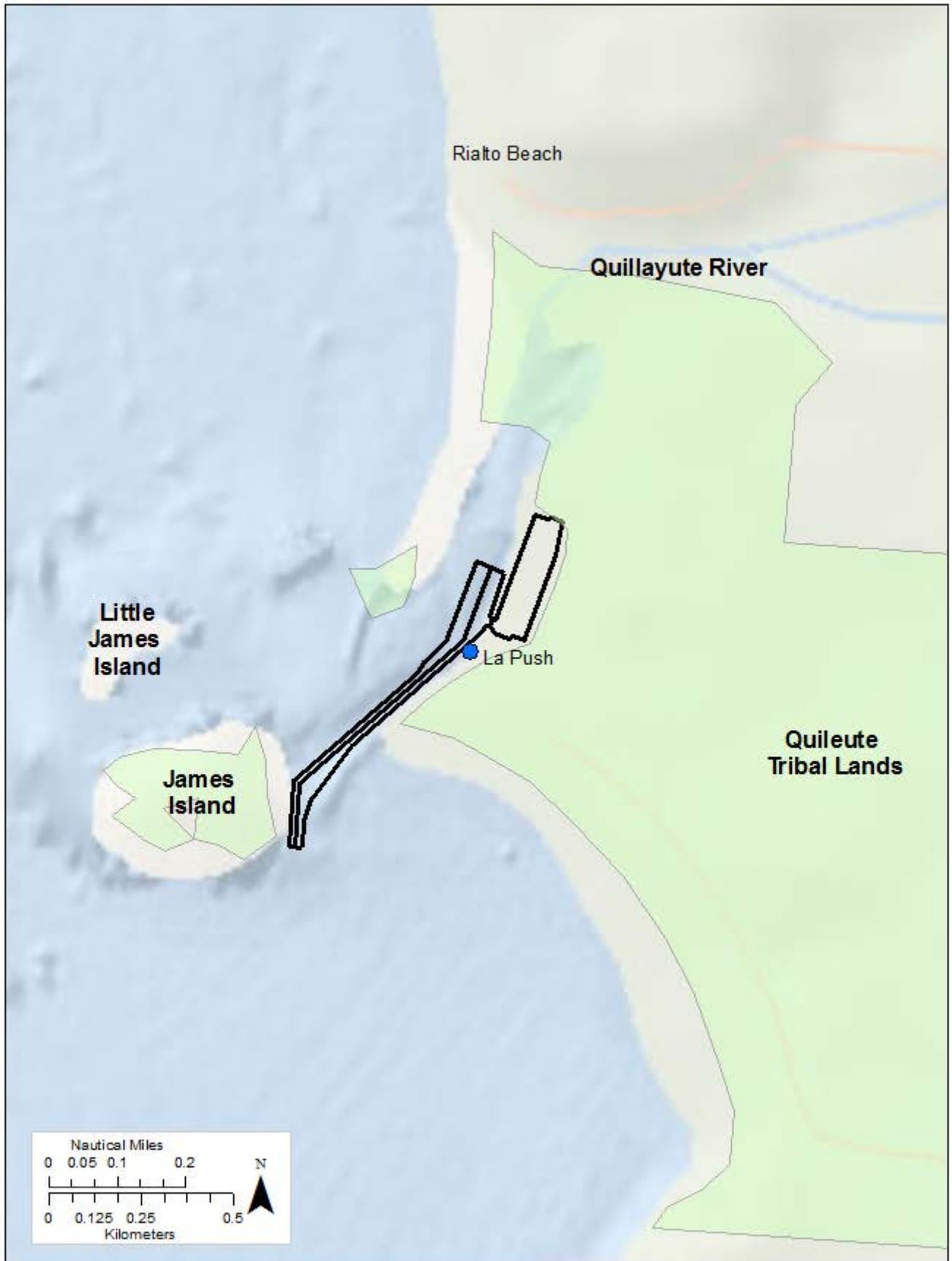
- Disposal locations ^{2, 3, 4}
- Federal Navigation Channel⁵
- Ports²²
- WA State Boundary²¹
- ⋯ Washington MSP Study Area⁷

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.

Map 53: Willapa Bay Disposal Sites, Beneficial Use Project, Ports and Marinas

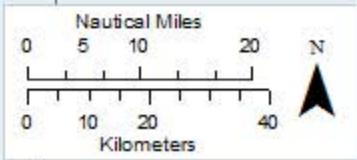
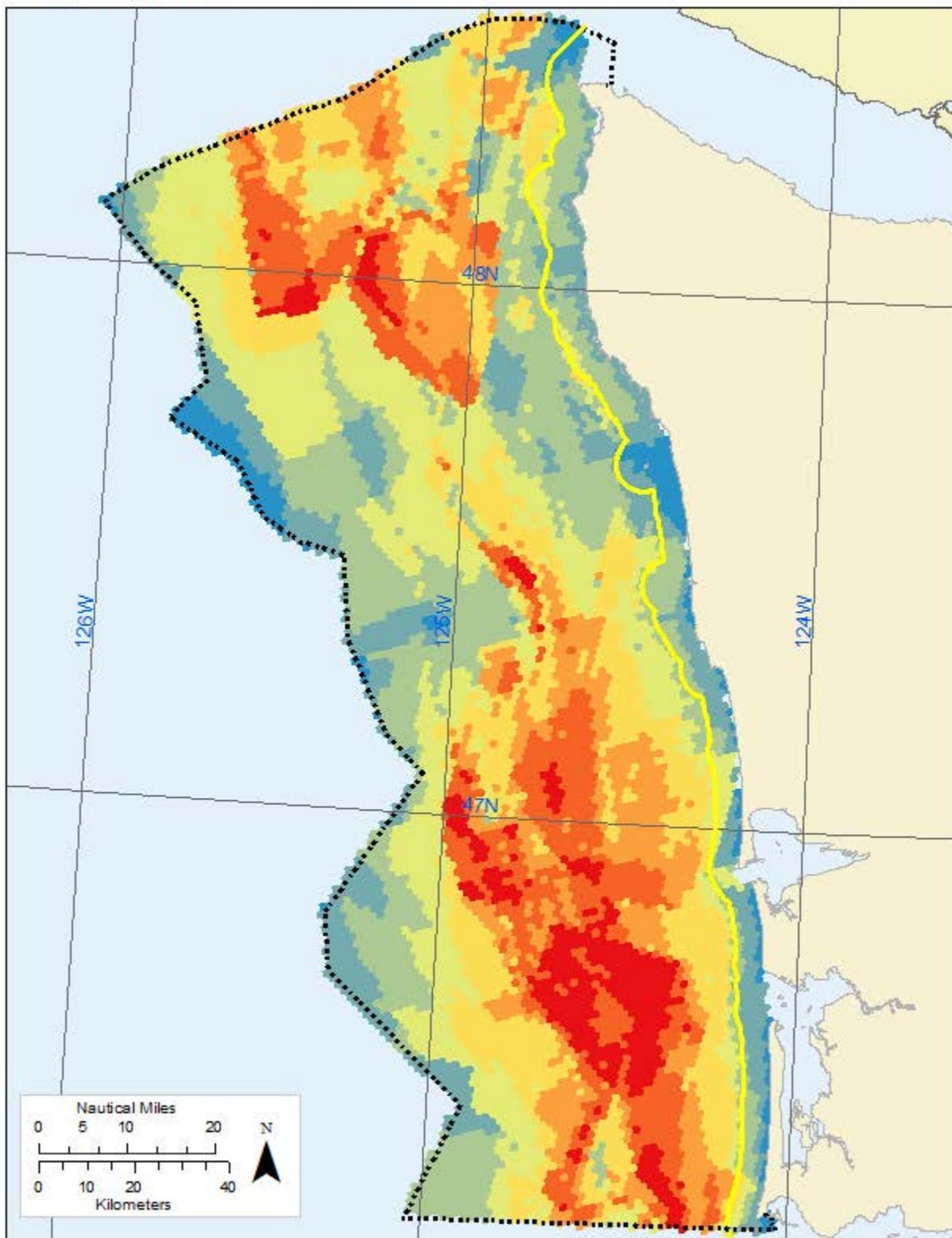


- Ports² -²
- Disposal Sites²
- Beneficial Use Project²
- Washinton MSP Study Area⁷
- WA State Boundary¹¹



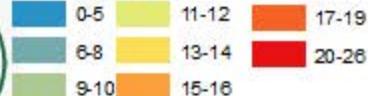
- Ports²²
- WA State Boundary¹⁸
- Federal Navigation Channel⁸
- Washington MSP Study Area⁷

Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



Commercial and Recreational

Fishing Intensity²³



*Sum of intensity scores from all individual fisheries maps, where:
 1 = Low intensity
 2 = Med intensity
 3 = High intensity

— WA State Boundary²⁴

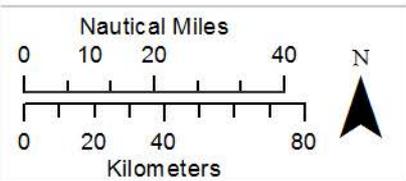
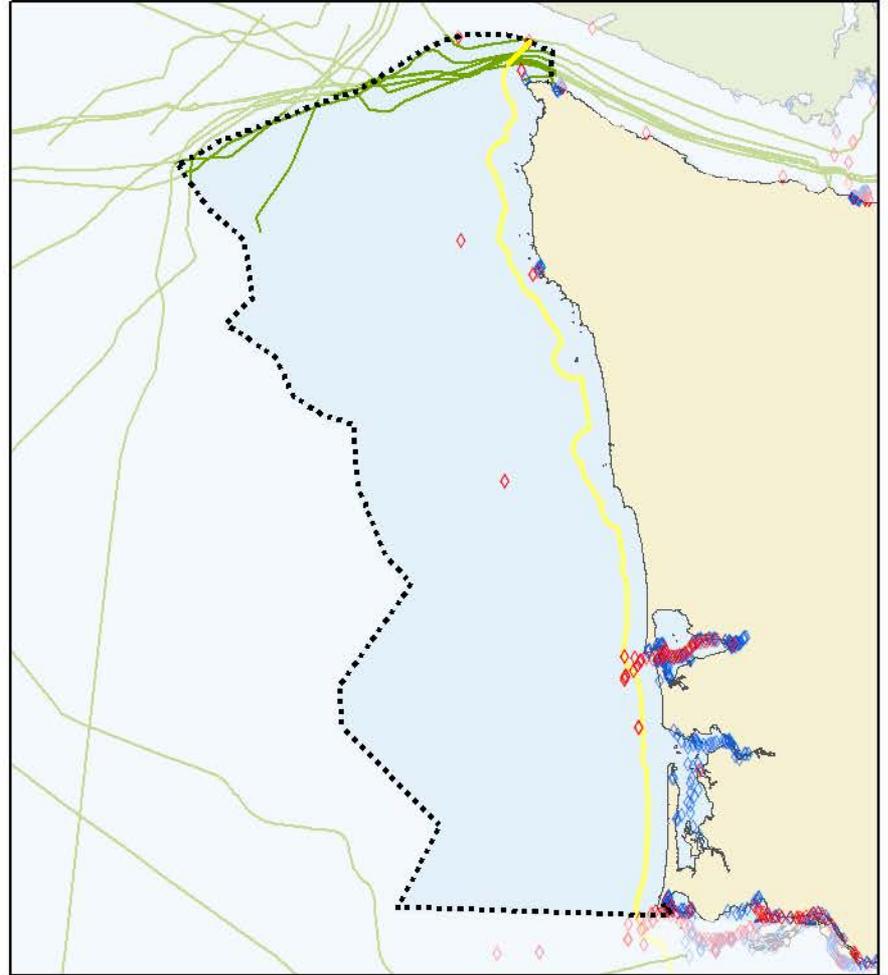
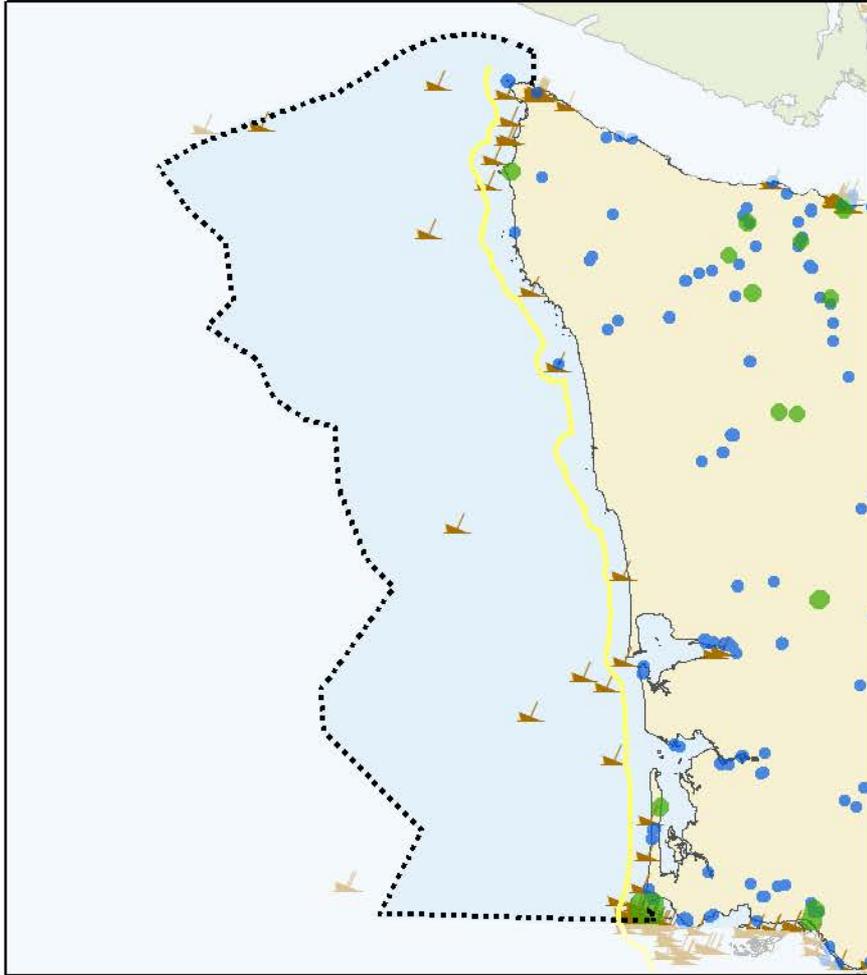
----- Washington MSP Study Area⁷

— World Latitude and Longitude Grids²⁵



Map 56: Draft Proposed Important, Sensitive, and Unique Areas: (1 of 4)
Historic Sites, Buoys, and Cables

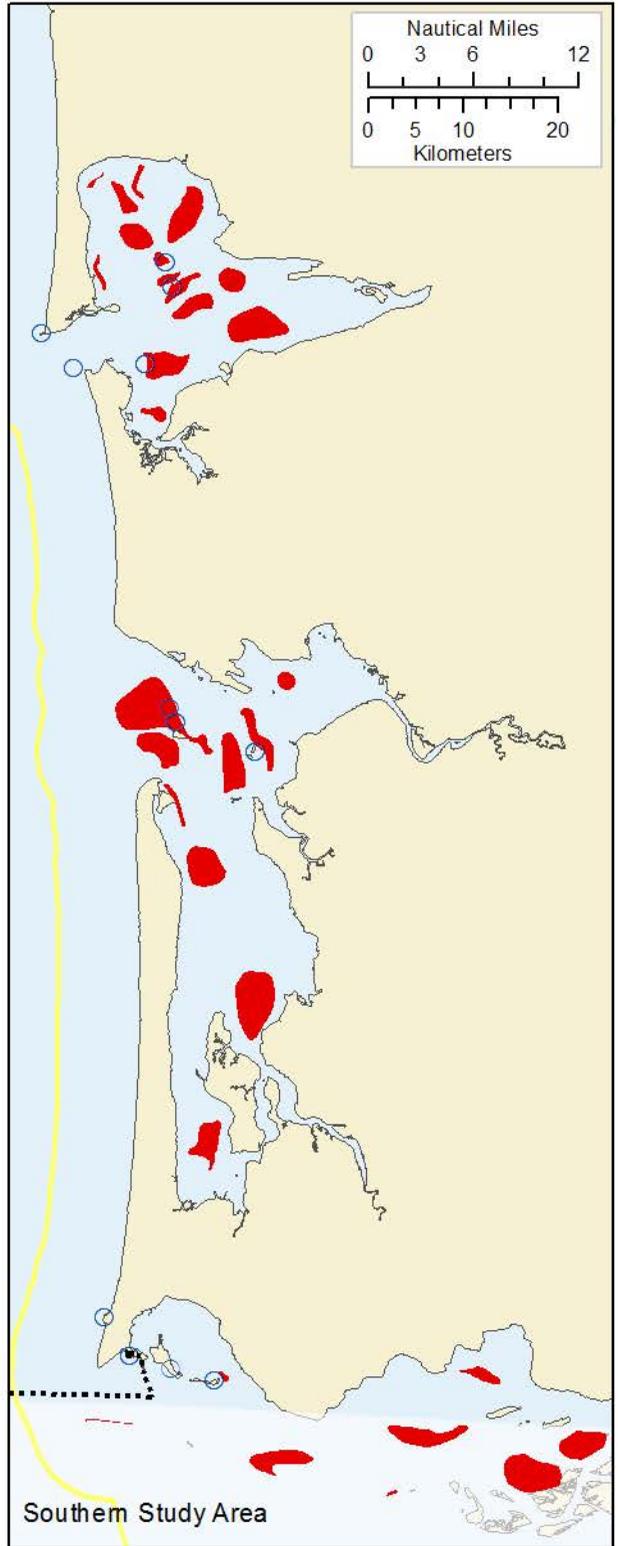
PRELIMINARY DRAFT



- Historic Registered Districts¹
- Historic Registered Properties¹
- Wrecks and Obstructions¹¹
- Washington MSP Study Area¹
- Washington State Boundary²
- Submarine Cables
- Buoys
- Beacons

**Map 57: Draft Proposed Important, Sensitive, and Unique Areas: (2 of 4)
Seal and Sea Lion Haulouts and Bird Colonies**

**PRELIMINARY
DRAFT**



Northern Study Area

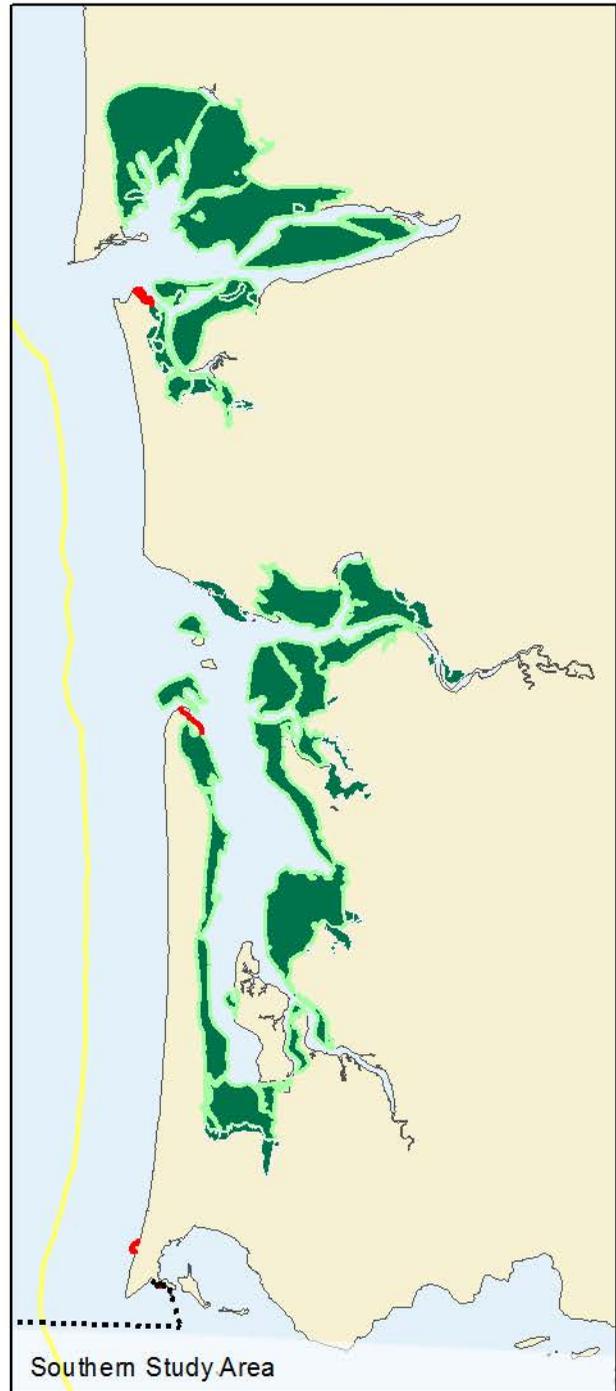
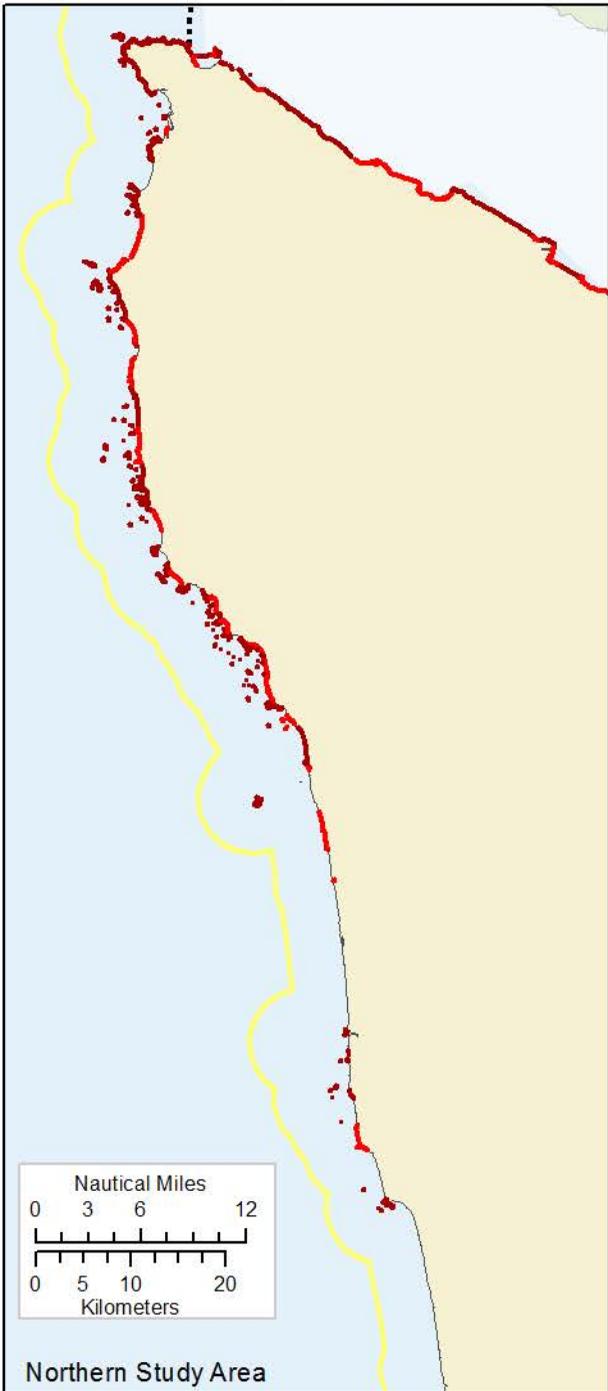
Southern Study Area



- Seabird Colonies³
- Pinniped Haulout Locations³
- Washington MSP Study Area¹
- Washington State Boundary²



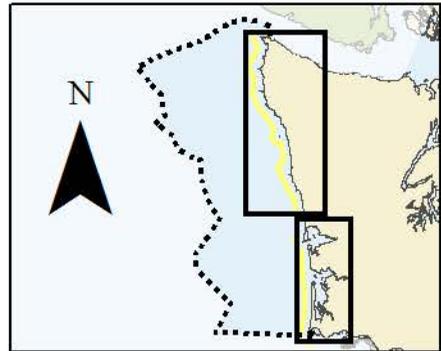
Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



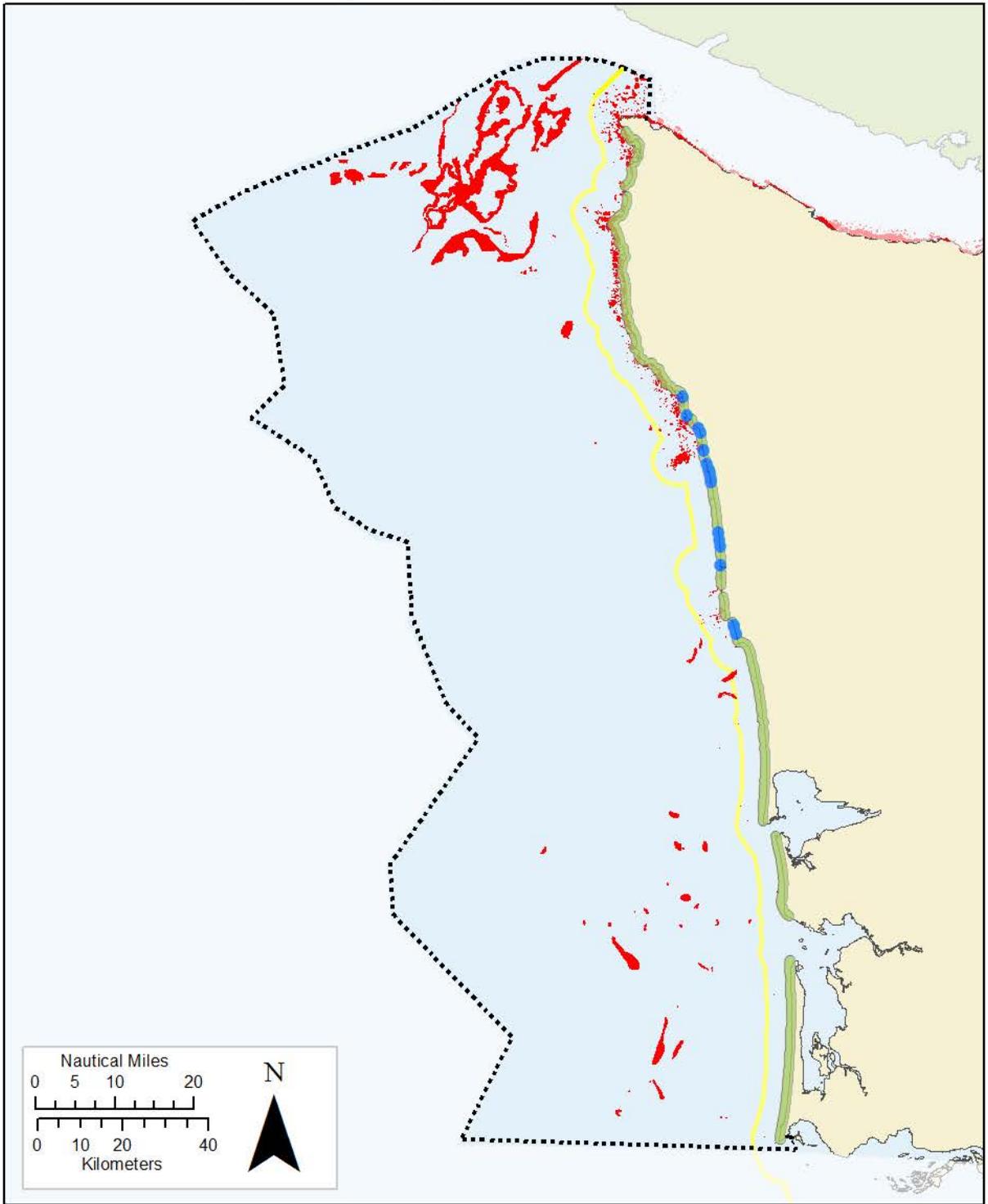
..... Washington MSP Study Area¹
 — Washington State Boundary²

Kelp
 — Continuous
 — Patchy

Eelgrass
 — Continuous
 — Patchy



Map coordinate system: North American Datum of 1983 (NAD83), Washington South State Plane Coordinate System, meters. Not to be used for legal purposes.



**Forage Fish Spawning
Survey Results³**

- Present
- Absent

- Washington MSP Study Area¹
- Washington State Boundary²
- Rocky Reefs (Modeled)²¹



Appendix B: WCMAC Recommendations

MSP POLICY RECOMMENDATIONS

Updated Nov. 9, 2016

Recommendations from the Washington Coastal Marine Advisory Council (WCMAC) are intended to support and reinforce statutory requirements, including but not limited to [The Ocean Resources Management Act \(RCW 43.143\)](#) and [The Marine Waters Planning and Management Act \(RCW 43.372\)](#)

Specific sections of the Marine Waters Planning and Management Act that guided the development of these recommendations include:

RCW 43.372.040 (4) (a-h):

- (4) The marine management plan must be developed and implemented in a manner that:
 - (a) Recognizes and respects existing uses and tribal treaty rights;
 - (b) Promotes protection and restoration of ecosystem processes to a level that will enable long-term sustainable production of ecosystem goods and services;
 - (c) Addresses potential impacts of climate change and sea level rise upon current and projected marine waters uses and shoreline and coastal impacts;
 - (d) Fosters and encourages sustainable uses that provide economic opportunity without significant adverse environmental impacts;
 - (e) Preserves and enhances public access;
 - (f) Protects and encourages working waterfronts and supports the infrastructure necessary to sustain marine industry, commercial shipping, shellfish aquaculture, and other water-dependent uses;
 - (g) Fosters public participation in decision making and significant involvement of communities adjacent to the state's marine waters; and
 - (h) Integrates existing management plans and authorities and makes recommendations for aligning plans to the extent practicable.

Specific sections of the Ocean Resources Management Act that guided the development of these recommendations include:

RCW 43.143.010

- (1) The purpose of this chapter is to articulate policies and establish guidelines for the exercise of state and local management authority over Washington's coastal waters, seabed, and shorelines.
- (2) There shall be no leasing of Washington's tidal or submerged lands extending from mean high tide seaward three miles along the Washington coast from Cape Flattery south to Cape Disappointment, nor in Grays Harbor, Willapa Bay, and the Columbia river downstream from the Longview bridge, for purposes of oil or gas exploration, development, or production.

- (3) When conflicts arise among uses and activities, priority shall be given to resource uses and activities that will not adversely impact renewable resources over uses which are likely to have an adverse impact on renewable resources.
- (4) It is the policy of the state of Washington to actively encourage the conservation of liquid fossil fuels, and to explore available methods of encouraging such conservation.
- (5) It is not currently the intent of the legislature to include recreational uses or currently existing commercial uses involving fishing or other renewable marine or ocean resources within the uses and activities which must meet the planning and review criteria set forth in RCW 43.143.030. It is not the intent of the legislature, however, to permanently exclude these uses from the requirements of RCW 43.143.030. If information becomes available which indicates that such uses should reasonably be covered by the requirements of RCW 43.143.030, the permitting government or agency may require compliance with those requirements, and appeals of that decision shall be handled through the established appeals procedure for that permit or approval.
- (6) The state shall participate in federal ocean and marine resource decisions to the fullest extent possible to ensure that the decisions are consistent with the state's policy concerning the use of those resources.

RCW 43.143.030

- (1) When the state of Washington and local governments develop plans for the management, conservation, use, or development of natural resources in Washington's coastal waters, the policies in RCW 43.143.010 shall guide the decision-making process.
- (2) Uses or activities that require federal, state, or local government permits or other approvals and that will adversely impact renewable resources, marine life, fishing, aquaculture, recreation, navigation, air or water quality, or other existing ocean or coastal uses, may be permitted only if the criteria below are met or exceeded:
 - (a) There is a demonstrated significant local, state, or national need for the proposed use or activity;
 - (b) There is no reasonable alternative to meet the public need for the proposed use or activity;
 - (c) There will be no likely long-term significant adverse impacts to coastal or marine resources or uses;
 - (d) All reasonable steps are taken to avoid and minimize adverse environmental impacts, with special protection provided for the marine life and resources of the Columbia river, Willapa Bay and Grays Harbor estuaries, and Olympic national park;
 - (e) All reasonable steps are taken to avoid and minimize adverse social and economic impacts, including impacts on aquaculture, recreation, tourism, navigation, air quality, and recreational, commercial, and tribal fishing;
 - (f) Compensation is provided to mitigate adverse impacts to coastal resources or uses;
 - (g) Plans and sufficient performance bonding are provided to ensure that the site will be rehabilitated after the use or activity is completed; and
 - (h) The use or activity complies with all applicable local, state, and federal laws and regulations.

1. Issues Related to All New Uses

1.1. Economic Recommendations

Problem Statement

New uses (including significant expansion of existing uses) may have acute and cumulative impacts on the local economy, both positive and negative. There is concern that some new uses could have short-term economic gains followed by long-term economic loss due to displacement of current uses by short-term projects (such as pilot projects or abandoned or failed projects). Additionally, a new use could result in national or global economic gain, but a significant economic loss at the local level. Local stakeholders and affected parties would like a clear understanding of the potential economic impacts of new uses, and a clear understanding of the interactions with existing uses, prior to the use being permitted.

Draft Recommendations

- 1.1.1. Prior to permitting new uses or expansions of existing uses which may cause impacts to either existing uses or to the local economy, an economic assessment should be completed. The purpose of this assessment is to provide agencies, the proponent, and stakeholders with information on economic impacts for consideration in conjunction with established review and permitting processes. When appropriate, the economic assessment should build on the baseline information of available economic and social studies¹.

¹ Baseline studies include but are not limited to:

- Taylor, M., Baker, J. R., Waters, E., Wegge, T. C., & Wellman, K. (2015). *Economic analysis to support marine spatial planning in Washington*. Prepared for the Washington Coastal Marine Advisory Council.
- Industrial Economics, Inc. (October 2014). *Marine Sector Analysis Reports: Aquaculture, Commercial and Recreational Fishing, and Recreation and Tourism*. Prepared for Washington Coastal Marine Advisory Council.
- BST Associates. (August 2014). *Washington Coast Marine Spatial Planning Assessment of Shipping Sector: Final Sector Assessment*. Prepared for Washington State Department of Natural Resources.
- Butler, K., Fryday, C., Gordon, M., Ho, Y., McKinney, S., Wallner, M., & Watts, E. (2013). *Washington's working coast: An analysis of the Washington Pacific coast marine resource-based economy* (Keystone Project). University of Washington Environmental Management Certificate Program.
- Radtke, H. (2011) *Washington State Commercial Fishing Industry Total Economic Contribution*. Prepared for Seattle Marine Business Coalition.
- Martin Associates (October 2014) *The 2013 Economic Impact of the Port of Grays Harbor*. Prepared for the Port of Grays Harbor.
- Resource Dimensions (2015) *Economic Impacts of Crude Oil Transport on the Quinault Indian Nation and the Local Economy*.
- National Marine Fisheries Service (2013). *Fisheries of the United States 2012*. Office of Science and Technology, Fisheries Statistics Division. Alan Lowther, editor.
- Point 97 and the Surfrider Foundation. (May 2015). *An Economic and Spatial Baseline of Coastal Recreation in Washington*. Prepared for Washington Department of Natural Resources.

The assessment should include:

a) Process

- Early stakeholder notice, including a detailed description of the project proposal.
- A designated time period for review and comment that provides time for stakeholder input at key stages throughout the assessment.
- A clear timeframe for response to comments.
- Independent third party expert review of the assessment and the stakeholder comments. The project proponent will be given an opportunity to review and respond to the assessment, stakeholder comments, and the independent review.

b) Content

- An assessment of the short-term and long-term economic costs and benefits to the affected community, including social costs and benefits. The assessment should specifically address the social costs to vulnerable ocean users, and the potential impacts on taxpayers (and, if appropriate, ratepayers). The determination of costs and benefits should not be completed without input from local stakeholders and affected parties.
- As appropriate, an assessment of the costs and benefits to the larger economy (state, national, global).
- An assessment of various scenarios which include the full project footprint, and scenarios where the new use fails and is abandoned or decommissioned.
- A discussion of how the project complies with all legal requirements, including but not limited to RCW 43.143.030 (e): *All reasonable steps are taken to avoid and minimize adverse social and economic impacts, including impacts on aquaculture, recreation, tourism, navigation, air quality, and recreational, commercial, and tribal fishing;*

1.2. Infrastructure and Technology Recommendations

Problem Statement

New ocean² infrastructure presents many concerns to coastal communities, ranging from loss of views and aesthetics to safety concerns.

New infrastructure may pose an increased risk to the navigational safety of all vessel types and sizes. Impacts may be both direct impacts (including but not limited to collision, damage to or loss of fishing gear, and reduction or elimination of existing fishing operations and maritime commerce) and indirect impacts (such as impacts from changes in ocean conditions or traffic patterns). New uses that disturb the seafloor could harm or bury cultural or historic resources, habitat for marine species, and fishing

² The terms “ocean” and “offshore” throughout this document include estuaries

grounds. New uses could also create hazardous ocean conditions that endanger existing uses and infrastructure.

Some types of fishing gear are "mobile" some are "fixed". On the Washington Coast even "fixed gear" (especially crab pots) moves during storm events. New infrastructure in the ocean presents an increased risk for entangling fishing gear. Gear entanglement results in lost and derelict gear, negative impacts on fishing opportunities and economies, and unintended mortality or harm to marine life.

Harsh coastal conditions on the Washington Coast, including storms and tsunamis, may harm or destroy infrastructure. If a structure becomes obsolete, is destroyed, or is abandoned, there are concerns about the ongoing impacts of leaving unmaintained structures in place, the impacts of the removal process, associated debris, and footprint scars.

Draft Recommendations

1.2.1. Navigational Safety

WCMAC recommends that a vessel traffic risk assessment or a risk-based modelling analysis be presented or prepared prior to permitting to evaluate navigational safety. WCMAC recommends that permitting agencies deny permits that have an adverse impact on navigational safety.

1.2.2. Dredge Disposal and Wave Amplification

WCMAC recommends implementation of recommendations established by the updated Mouth of the Columbia River Regional Sediment Management Plan and local Shoreline Master Programs that address navigation safety and dredge disposal. WCMAC recommends that dredge disposal should be sited in areas where the disposal will provide beneficial use to the greatest extent possible.

1.2.3. Historic and Cultural Resources

WCMAC recommends that, for new uses that will impact the ocean floor, a high-resolution seafloor archeological assessment be conducted prior to permitting, and that the project be sited and mitigated to avoid and preserve historic and cultural resources.

1.2.4. Coastal Erosion and Sea-Level Rise

WCMAC recommends that state agencies continue to monitor erosion and sea-level rise on the Washington coast. The effects of projected coastal erosion, future sea-level rise, and other climate change impacts should be evaluated to determine the long-term suitability of a proposed new use prior to permitting.

1.2.5. Aesthetics

WCMAC recommends that the environmental review process require conceptual site drawings of visual impacts and assess the effect new infrastructure will have on views, aesthetics, and public access.

1.2.6. Structure Survivability

WCMAC recommends that a survivability assessment be required for all new ocean structures. Permit conditions should include requirements that comply with RCW 43.143.030(2)(g): *Plans and sufficient performance bonding are provided to ensure that the site will be rehabilitated after the use or activity is completed.*

1.2.7. Entangled Fishing Gear

WCMAC recommends that prior to permitting a new applicant include an assessment of the potential for gear entanglement and, if permitted, require a plan for monitoring for entangled fishing gear or other debris, including a plan to mitigate impacts.³

1.2.8. New Structures

WCMAC recommends that, at a minimum, proposals for any new structures (including the creation of artificial reefs) consider the information in the Marine Spatial Plan, follow the MSP recommendations, and comply with the criteria described in RCW 43.143.030(2).

1.3. Ecological Recommendations

Problem Statement

New uses raise ecological concerns, including impacts to species and habitats; changes to migration routes and physical processes; degradation of water quality; impacts to the food web; and introduction of invasive species. In addition, offshore uses are often supported by on-shore infrastructure, and it is important to understand and assess the positive and negative impacts of changes to infrastructure on local coastal communities.

Draft Recommendations

1.3.1. WCMAC recommends that, prior to permitting new uses or expansions of existing uses, an environmental assessment should be completed. Environmental assessments required under SEPA or NEPA should thoroughly address:

- Degradation of sensitive and important habitat for representative important species, including, but not limited to, ESA listed and commercially, recreationally and ecologically valuable species.
- Potential for direct injury or harm to species, including ESA listed and commercially valuable species (e.g. strikes, entanglement, etc.), or indirect injury related to

³ Revised at the 11/9/16 WCMAC meeting.

exposure to noise, light, vibration, electromagnetic fields or other related stressors associated with the new use.

- Alteration or impairment of existing animal migration routes.
- Degradation of water quality (chemicals, petroleum products, nutrients, oxygen, temperature, acidification, etc.).
- Changes in physical processes, including, but not limited to, currents and waves, sediment processes, coastal erosion and accretion, electromagnetic fields, acoustics and wave amplification.
- Unintended impacts, including, but not limited to, impacts to the food chain, changes to physical processes, introduction of disease or genetic pollution, and access to existing resources.
- Inadvertent introduction of invasive species, organisms, etc.
- Comparison of alternatives and best-available technologies, if appropriate.
- Evaluation of impacts and demands on existing infrastructure, both on and offshore.

If environmental review is not required by SEPA or NEPA, WCMAC recommends that state and local agencies ensure that these concerns are addressed by applicants for new uses.

1.3.2. WCMAC recommends that all environmental assessments include a process for stakeholder input, including scoping, review of draft assessments, and a period for public comment. Agencies should establish adequate time for notice and public comment based on the complexity of the project.

1.3.3. WCMAC recommends applicants be held liable for damages and provide mitigation of adverse impacts to coastal resources, coastal uses, or both, consistent with existing law.

1.3.4. For projects that pose risk for invasive species introduction, WCMAC recommends applicants be required to provide a risk assessment for potential invasive species impacts and, if permitted, be required to prepare a prevention, monitoring and control plan.⁴

2. Additional Issues Related to Specific New Uses

2.1. OFFSHORE AQUACULTURE ISSUES

Problem Statement

Offshore aquaculture presents unique concerns. The infrastructure and activities from offshore aquaculture could harm other species, particularly predators such as pinnipeds, cetaceans, and sharks. The infrastructure could also alter habitat and food sources for marine species. Offshore aquaculture may introduce new species, genetic mixing, and diseases into the environment, potentially harming existing populations and ecosystems. Fin-fish aquaculture could have economic, ecological and spatial

⁴ Revised at the 11/9/16 WCMAC meeting.

impacts on existing fishing, and there is currently no feasible recovery method for escaped fin-fish from net-pen aquaculture.

Draft Recommendations

- 2.1.1. WCMAC recommends that applicants for offshore aquaculture prepare prevention, monitoring and response plans that address escapement, disease, and nutrient pollution.
- 2.1.2. WCMAC recommends that applicants for offshore aquaculture avoid and minimize impacts to pinnipeds, cetaceans, sharks and other species through facility design, siting and operation.
- 2.1.3. WCMAC recommends that agencies deny permits for offshore aquaculture facilities with species that pose a significant risk of introducing disease, impairing fish health, or potentially introducing genetic pollution into the area, in accordance with WAC 276.76.100: *A permit may be denied based on the determination by the director of significant genetic, ecological or fish health risks of the proposed fish rearing program on naturally occurring fish and wildlife, their habitat or other existing fish rearing programs.*
- 2.1.4. WCMAC recommends that pesticide controls should undergo risk assessment before their use is allowed.

3. Additional Issues Related to Protecting and Preserving Existing Sustainable Uses

Problem Statement

New uses could irrevocably change coastal communities. While some new uses may bring positive changes, there are concerns that new uses could also harm communities in ways that are difficult to repair. There is a concern that harmful changes are likely to occur without adequate stakeholder involvement and input during all aspects of the decision-making process for new development.

The Washington coast is the shortest coast line of the three Pacific Coast states⁵, and has unique limitations on usage, including the Olympic National Park, the Coastal Islands National Wildlife Refuges,

⁵ Washington's Pacific Coastline is 157 miles, Oregon's is 296, and California's is 840. Source: NOAA Office for Coastal Management, General Coastline and Shoreline Mileage of the United States.

The coast of Willapa Bay is 129 miles and the coast of Grays Harbor is 89 miles. Source: T. Swanson. February 2001. "Managing Washington's Coast: Washington's Coastal Zone Management Program." Washington State Department of Ecology, publication 00-06-029. Olympia, WA.

The Marine Spatial Planning study area covers approximately 375 miles of Washington's marine and estuarine shoreline.

the Olympic Coast National Marine Sanctuary, areas of tribal sovereignty and off-shore treaty rights, restrictions by the US military, and severe weather. Ocean space is limited and already hosts multiple uses. Additional spatial displacement along the Washington coast could place an undue burden on existing uses, including fishing. New uses could preempt existing fishing space, resulting in smaller fishing areas. Smaller fishing areas may lead to overcrowded and dangerous fishing activities as well as reduced catch and negative socio-economic impacts.

There is concern that new uses could degrade or alter existing sustainable uses in the marine waters, including fisheries and aquaculture, in a variety of ways (impairment of estuary functions, degradation of water quality, impacts to fish and wildlife habitat, etc.). This could result in reduced harvest or reduced profitability for existing uses. New uses could also degrade recreational opportunities, public access, and aesthetics.

Draft Recommendations

- 3.1.1. WCMAC recommends public and stakeholder involvement in all aspects of project development and review, including:
 - working collaboratively with stakeholders, including but not limited to fishing, aquaculture, maritime commerce, conservation, tourism and recreation interests;
 - providing timely and effective notice; and
 - initiating both formal and informal pre-application discussions between stakeholders and applicants.
- 3.1.2. WCMAC recommends a project review process that includes existing uses, appropriate agencies, and project proponents. The process should involve established fishing advisory groups, and should identify potential adverse impacts on commercial and recreational fisheries and opportunities to avoid, reduce, or mitigate impacts. Fishing advisory boards comprised of representatives of the affected fisheries could also be created for specific projects or sites.
- 3.1.3. WCMAC recommends that project proponents use WCMAC as a forum for early notification and discussion of potential proposals, including impacts to habitat, impacts on existing uses, project location and maximum size, etc.
- 3.1.4. WCMAC recommends that through the permitting and review process, applicants prepare site specific impact assessments addressing impacts to current uses, including, but not limited to, fishing, recreation, and aquaculture. The assessment should also describe how the project will comply with local Shoreline Master Programs.

- 3.1.5. WCMAC recommends that cumulative impacts⁶, environmental baseline and variability, and potential tipping points for harm to existing uses be considered when applying the planning and project review criteria required by RCW 43.143.030.⁷

4. Adaptive Management and Data Gathering

Problem Statement

As conditions change or as new information is gathered, it is important to update baseline information, apply adaptive management, and update the MSP.

- 4.1.1. WCMAC recommends that state agencies identify a systematic process to update existing datasets, gather new data to keep baseline information current, and fill data gaps.
- 4.1.2. WCMAC recommends that, based on new information or changing conditions, state agencies identify areas of the MSP's recommendations where changes may be needed, and recommend changes to the MSP or to existing implementation activities.
- 4.1.3. WCMAC recommends that project applicants be required to use up-to-date data that is adequate to evaluate the project and its potential effects. If new data gathering is required, it should be done at the applicants' expense. When it exists, data should include multiple years and multiple seasons within those years.⁸

⁶ The following definitions, taken from the National Environmental Policy Act (NEPA) are recommended for the MSP:

"Cumulative impact" is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

"Effects" or "impacts" include:

- (a) Direct effects, which are caused by the action and occur at the same time and place.
- (b) Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems.

Effects and impacts as used in these regulations are synonymous. Effects includes ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance the agency believes that the effect will be beneficial.

⁷ This recommendation was adopted at the 11/9/16 WMCAC meeting.

⁸ This recommendation was adopted at the 9/28/16 WCMAC meeting.

NOTES:

1. A definitions section will be added to the MSP to define key terms in these recommendations.
2. Cross-references to relevant sections of the full MSP will be added as appropriate (e.g. references to Olympic National Park, the Coastal Islands National Wildlife Refuges, the Olympic Coast National Marine Sanctuary, etc.)
3. Staff will research the miles of shoreline for WA, OR and CA and add a footnote with these numbers the problem statement in section 3.

DRAFT

Appendix C: Data Sources, Methods and Gaps

Existing data summaries provide a general overview of data sources, methods and gaps, which will be expanded upon in the formal draft. In addition, Part 3 – Spatial Analyses of the preliminary draft provides a summary of the data and methods for the following analyses: Ecological modeling of seabirds and marine mammals, Ecologically Important Areas (EIA) analysis and the Use Analysis.

DATA SUMMARY: AQUACULTURE

Marine spatial planning (MSP) is a process for gathering information on coastal and ocean activities and environments, providing recommendations for siting new ocean uses, creating a process for coordinating across all levels of government, and ensuring stakeholder input on new ocean uses in a comprehensive plan.

For more detailed information on the planning process in Washington, specific data, or projects, or to use the interactive MSP spatial data viewer, please visit the Marine Spatial Planning website at www.msp.wa.gov. Links are also provided to some project reports or data sources below.

AQUACULTURE:

The following data provides information related to aquaculture activities within the study area. Currently, these operations consist of shellfish aquaculture located primarily within the Willapa Bay and Grays Harbor estuaries. For more detail on aquaculture in the study area, please refer to Section 2.5 of the Marine Spatial Plan.

MAJOR DATA SOURCES:

Information relevant to aquaculture in the study area was provided by:

- [Washington Department of Fish and Wildlife](#): Aquaculture districts
- [Washington Department of Health](#): Commercial shellfish growing areas, harvest sites, and water quality monitoring stations
- [Washington Department of Natural Resources](#): Oyster reserves and oyster tracts
- [Washington Department of Ecology](#): Seafood processors and location of marinas
- US Army Corps of Engineers: Location of ports
- [Industrial Economics](#) and [Cascade Economics](#): Economic analyses of marine sectors including shellfish aquaculture

PRODUCTS AND METHODS:

Spatial data for harvest areas: Maps of commercial growing areas, harvest sites, and aquaculture districts were provided by the state agencies that regulate or manage aquaculture areas and operations.

Seafood processors: A list of seafood processors was compiled using two Department of Ecology databases. The Facility/Site Database and the water quality Permit and Reporting Information System (PARIS) contain publically available information on facilities which hold state permits for industrial or stormwater discharges. Searches were performed to identify the location of facilities conducting operations related to various types of seafood processing.

Economics: Cascade Economics conducted an analysis of Washington's coastal economies, completed in 2015. This report provides economic profiles of several marine sectors including aquaculture. Analysis of the aquaculture industry was based in part on a report produced by Industrial Economics in 2014, which incorporated information including harvest and shellfish farm data from the Washington Department of Fish and Wildlife (WDFW) and licensing data from the Department of Health. Cascade's analysis also includes results of a survey and interviews regarding coastal shellfish processing and distribution. The final report assesses the economic contributions of aquaculture, and provides a qualitative analysis of the potential impacts of new coastal uses on the aquaculture industry.

REMAINING DATA GAPS AND CHALLENGES:

Seafood processing: The state does not maintain a comprehensive spatial dataset of seafood processing facilities. The data described here identifies facilities involved in processing which have been issued more general stormwater or industrial discharge permits by the Department of Ecology. As a result, the records from these databases may not include all relevant facilities in the study area.

Tribal shellfish data: Data sources described here do not include tribal shellfish aquaculture activities.

Data used for economic studies: Some datasets used in economic studies, including information from WDFW regarding shellfish farm acreage and harvest volume, have known reporting limitations and are considered to some extent incomplete and inaccurate. This makes assessing the amount of aquaculture actively occurring in the study area difficult. For this and other reasons addressed in more detail in final reports, data on total harvest value is limited and potentially underrepresented. Additionally, some other datasets used in economic and sector analyses were only available at statewide or local scale, rather than at the county or planning area scale.

Offshore aquaculture suitability: General information is provided in the Marine Spatial Plan regarding conditions that tend to be suitable for various types of offshore aquaculture, including water depth and access to shore facilities. However, limited information is available on more specific attributes that pertain to detailed site suitability for offshore aquaculture. As a result, no detailed analysis has been done to identify where in the study area these types of activities might be proposed in the future.

DATA SUMMARY: FISHERIES

Marine spatial planning (MSP) is a process for gathering information on coastal and ocean activities and environments, providing recommendations for siting new ocean uses, creating a process for coordinating across all levels of government, and ensuring stakeholder input on new ocean uses in a comprehensive plan.

For more detailed information on the planning process in Washington, specific data or projects, or to use the interactive MSP spatial data viewer, please visit the Marine Spatial Planning website at www.msp.wa.gov. Links are also provided to some project reports or data sources below.

RECREATIONAL AND COMMERCIAL FISHERIES:

The following data provides information related to commercial and recreational fishing activity within the study area. For a description of the fisheries occurring in and important to the communities of the MSP study area, please refer to Chapter 2.4 of the Marine Spatial Plan. More details about the fisheries maps will also be provided in a separate report, yet to be completed.

MAJOR DATA SOURCES:

Maps for the following non-tribal fisheries were created by the [Washington Department of Fish and Wildlife](#), using logbook data, industry interviews, and other information:

- Commercial fisheries: Albacore Tuna, Dungeness Crab, Sablefish (fixed gear), groundfish (bottom trawl), Pacific Whiting, Pink Shrimp, salmon (troll), and Pacific Sardine
- Recreational fisheries: Salmon, Pacific Halibut, bottomfish, Lingcod, and Albacore Tuna

Additional relevant information was acquired from:

- [Washington Department of Health](#): Location of recreational shellfish beaches
- [National Park Service](#): Location of hardshell clam beaches in Olympic National Park
- [Industrial Economics](#) and [Cascade Economics](#): Economic analyses of marine sectors including tribal and non-tribal fisheries, based on catch and effort statistics from WDFW and NOAA, permit records, and other sources
- [NOAA Fisheries](#): Location of combined Usual and Accustomed areas for the four coastal treaty tribes
- [Washington Sea Grant](#): Location of towboat lanes established by crab fishermen and the tugboat and towboat industry in order to limit interactions between towing vessels and fishing gear.

PRODUCTS AND METHODS:

Maps of fishing activity: Fishing maps were created using a combination of fishery logbook data and industry interviews. More detail on WDFW's methods for compiling fishing intensity maps is provided on the following page.

Seafood processors: A list of seafood processors was compiled using two Department of Ecology databases. The Facility/Site Database and the water quality Permit and Reporting Information System (PARIS) contain publically available information on facilities which hold state permits for industrial or stormwater discharges. Searches were performed to identify the location of facilities conducting operations related to various types of seafood processing.

Economics: Industrial Economics provided a sector analysis for non-tribal commercial and recreational fishing in Washington, which gives an overview of the current status of these sectors and significant issues facing them. Cascade Economics conducted an analysis that provides economic profiles of Washington's tribal and non-tribal coastal communities and several marine sectors including fisheries and associated industries. The authors used landing and survey data from WDFW and NOAA, as well information on international markets, environmental conditions, and more to assess current trends and the potential for impacts on fishing sectors from future new uses. Additional sources of economic information are referenced in Chapter 2.4 of the Marine Spatial Plan.

REMAINING DATA GAPS AND CHALLENGES:

Fishing activity: Logbook records are not available for every fishery. Available records may only cover a short time frame, be subject to inaccurate reporting, be reported at an imprecise spatial resolution, or have other limitations. In addition to uncertainty associated with data, fisheries are inherently variable. Changes in regulations, economic conditions, the marine environment, and other factors all affect the location and amount of fishing effort each year. The footprint of a fishery and the relative intensity of fishing within in it should be expected to vary from year to year.

Tribal fisheries: While information on tribal fishing activity and its economic value is provided both in the Cascade Economics study and the Marine Spatial Plan, spatial data regarding tribal fishing intensity was not available nor included in these fisheries maps. Chapter 2.4 provides an overview of tribal fishing activities.

Seafood processing: The state does not maintain a comprehensive spatial dataset of seafood processing facilities. The data described here identifies facilities involved in processing which have been issued more general stormwater or industrial discharge permits by the Department of Ecology. As a result, the records from these databases may not include all relevant facilities in the study area. Additionally, the Cascade Economics report addresses the economic impacts of seafood processing, but does not include secondary processing operations or non-local distribution or retailing.

Economic data: In some cases the data used in economic analysis had confidentiality restrictions. Some datasets were also only available at a scale that can be difficult to apply to the planning area, specific communities, or segments of the commercial or recreational fishing sectors.

ADDITIONAL DETAIL ON FISHERIES MAPPING METHODS:

Fisheries use maps were developed by WDFW to summarize available information on areas of high importance to fisheries as required by RCW 43.372.040(6)(c). The primary purpose of the maps is to identify the footprint of each fishery (where fishing has occurred or has the potential to occur).

The secondary goal is to characterize the relative level of activity within each fishery's footprint using intensity rankings. Rankings cannot be used to compare the intensity of one fishery to another, as a "high" intensity area in one fishery may have seen less overall activity than a "low" or "medium" from another, larger fishery.

Maps were based on fishery-dependent data (i.e. logbook or observer records), the professional expertise and judgment of fishery managers and participants, or a combination of the two. WDFW used one of three general approaches for maps, depending on the information available for each fishery:

1. **Maps based on fishery-dependent data and percentile rankings:** Each hexagon was evaluated for units of fishing effort (i.e. number of set or tows per hexagon) and all hexagons within the fishery's footprint were ranked as:
 - a. "High"- Top 25% of hexagons
 - b. "Medium"- Middle 50% of hexagons
 - c. "Low"- Bottom 25% of hexagons
2. **Maps based on logbook data with criteria-based intensity definitions:** Due to limited location and effort data presented in logbooks, each hexagon was evaluated based on available effort data and other criteria that correlates with high activity in that particular fishery (e.g. depth, distance from shore).
3. **Maps based on interviews with fishery participants and managers:** Some fisheries have no logbook or observer data that can be used to evaluate effort level. Therefore, WDFW consulted with fishery participants and managers to determine intensity levels and footprints of select fisheries.

In addition to the data gaps and limitations described on the previous page, WDFW emphasizes that these maps cannot address the impact or conflict that would occur from new uses in these areas. Assessment of conflict and impact would require careful study and examination of all available information on a case by case basis.

DATA SUMMARY: RECREATION AND TOURISM

Marine spatial planning (MSP) is a process for gathering information on coastal and ocean activities and environments, providing recommendations for siting new ocean uses, creating a process for coordinating across all levels of government, and ensuring stakeholder input on new ocean uses in a comprehensive plan.

For more detailed information on the planning process in Washington, specific data, or projects, or to use the interactive MSP spatial data viewer, please visit the Marine Spatial Planning website at www.msp.wa.gov. Links are also provided to some project reports or data sources below.

RECREATION AND TOURISM:

The following data provides information related to recreational and tourism activities within the study area. This information is described in more detail in Chapter 2.6 of the Marine Spatial Plan. Note that recreational fishing data is described in the fisheries data summary and Chapter 2.4.

MAJOR DATA SOURCES:

[The Surfrider Foundation](#)'s Washington Ocean and Coastal Recreation Study provided data describing:

- The economic impacts of recreational activities on Washington's coast
- The geographic distribution and intensity of recreational uses in four categories:
 - **Diving activities:** SCUBA diving and free diving/snorkeling
 - **Shore-based activities:** Beachcombing, beach going, beach driving, biking & hiking, camping, hang gliding & parasailing, horseback riding, sea-life collecting & harvesting, tide pooling
 - **Surface water activities:** Boating & sailing, kayaking, kiteboarding, skimboarding, surfing, windsurfing, swimming & body surfing
 - **Wildlife viewing and sightseeing activities:** Photography, sightseeing, scenic drives, and wildlife viewing from boats or from shore

Additional data provided by:

- [Industrial Economics](#) and [Cascade Economics](#): Economic analyses of marine sectors including tourism and recreation
- [Washington Department of Ecology](#): Public shoreline access locations
- [National Park Service](#): Location of Olympic National Park boundaries
- [Washington Department of Natural Resources](#): Location of Seashore Conservation Areas
- [National Oceanic and Atmospheric Administration](#): Location of Olympic Coast National Marine Sanctuary boundaries and spatial data on recreational vessel transit
- [US Fish and Wildlife Service](#): Location of National Wildlife Refuges

PRODUCTS AND METHODS:

Recreation data: To provide baseline data on the extent, intensity and economic impacts of recreation and tourism in coastal Washington, the Surfrider Foundation, in collaboration with Point 97, conducted an online survey which asked respondents to map locations where they had participated in recreational activities within the study area, and to provide information on expenditures associated with trips to coastal Washington. Two sampling approaches were used, the first of which acquired data from a random sample representing all Washington residents. The second approach was an opt-in survey that allowed anyone to participate, with the goal of reaching a more targeted group of coastal users. This method helped provide a complete picture of activities occurring in the study area, including some activities which are important to the region and its economy but have a smaller number of users that may not have been represented using only statewide random sampling.

Spatial and statistical analyses were used to display activity results as “heat maps” showing areas of highest intensity for individual uses and groups of uses. Surfrider also provided a map showing overall use intensity based on the results, and a final report describing important trends, popular uses, and estimations of the economic value of recreation and tourism to the coast.

Economics: The sector analysis by Industrial Economics provides an overview of other available information on recreation and tourism in Washington State and the study area. Cascade Economics also conducted an analysis of Washington’s coastal economies, using Surfrider’s results as well as other economic data and studies. Cascade’s final report assesses the importance of these sectors to three regions, individual communities, and the state as a whole, and discussed likely impacts to tourism and recreation from potential new uses.

Recreational vessel transit: The Olympic Coast National Marine Sanctuary (OCNMS) mapped recreational vessel traffic using similar data and methods to those described for other shipping layers (please see shipping data summary). Recreational vessel data includes personal craft like sailboats, motorboats, and small personal fishing vessels when they are using the study area for purposes other than fishing.

REMAINING DATA GAPS AND CHALLENGES:

Recreational Activity and Vessel Mapping: For the recreation study, over 17,000 data points were entered by respondents using an online mapping application. All points were included in the final analysis because even if a few individual points were associated with minor user input errors, they provide valuable information about overall trip expenditures and the total numbers of users participating in each activity.

Vessel density analyses by OCNMS were primarily based on Automated Identification System (AIS) data, which is not available for all small vessels. OCNMS consulted multiple sources to identify and track recreational ship transits in the study area, but some small vessels may not be represented in this data.

Economics: As noted in Cascade’s report, the full economic impacts of some expenditures by out-of-state visitors (and thus the related employment and labor implications) are difficult to accurately assess and are not included in their analysis. Surfrider results only include expenditure and activity information for Washington State residents, and additional surveys would be necessary to provide comparable information for those visitors coming to the area that are from out of state.

DATA SUMMARY

ECOLOGY: BIOLOGICAL DATA

Marine spatial planning (MSP) is a process for gathering information on coastal and ocean activities and environments, providing recommendations for siting new ocean uses, creating a process for coordinating across all levels of government, and ensuring stakeholder input on new ocean uses in a comprehensive plan. For more detailed information on the planning process in Washington, specific data, or projects, or to use the interactive MSP spatial data viewer, please visit the Marine Spatial Planning website at www.msp.wa.gov. Links are also provided below to some relevant reports or sources.

ECOLOGY

The Marine Spatial Plan provides information about the physical, biological, chemical, and geological characteristics of the study area. Some information was acquired from existing programs or studies, while other data was collected or analyzed specifically for MSP purposes. This document provides a summary of some key data sources, but more information on the many ecological data sources consulted is provided in Sections 2.1, 3.1, and 3.2 of the Marine Spatial Plan.

MAJOR DATA SOURCES

[The Washington Department of Fish and Wildlife](#) performed an analysis of Ecologically Important Areas for:

- **Birds:** Snowy Plover, Streaked Horned Lark, Black-footed Albatross, Northern Fulmar, Sooty Shearwater, Common Murre, Tufted Puffin, Pink Footed Shearwater, Marbled Murrelet, seabird colonies, and nearshore seabird encounters
- **Marine Mammals:** Seal and sea lion haulouts, Dall's Porpoise, Gray Whale, Harbor Porpoise, Harbor Seal, Humpback Whale, sea otters, and Steller Sea Lion
- **Fish and Invertebrates:** Razor clams, Dungeness Crab, Darkblotched Rockfish, Dover Sole, Greenspotted Rockfish, Longspine Thornyhead, Pacific Ocean Perch, Petrale Sole, Sablefish, Shortspine Thornyhead, Yelloweye Rockfish, Pacific Whiting, Pink Shrimp, deep sea coral, and forage fish spawning areas
- **Habitats:** Rocky reefs and kelp

Additional information relevant to the ecology of the study area was provided by:

- [Washington Department of Natural Resources](#): Maps of shoreline biology and habitat including kelp, seagrass, and salt marshes
- [Washington Department of Fish and Wildlife](#): Forage fish survey results and the location of seabird colonies, marine mammal haulouts, and Northern Sea Otter concentration areas
- [NOAA's National Centers for Coastal Ocean Science \(NCCOS\)](#): Predictive models showing expected relative abundance for eight species of birds and six species of marine mammals
- [National Oceanic and Atmospheric Administration \(NOAA\)](#): Maps of [critical](#) and [essential habitat](#) for several fish species and information supporting the evaluation and selection of [ecosystem indicators](#) for the study area

SELECTED PRODUCTS AND METHODS:

Ecologically Important Areas (EIA): The Washington Department of Fish and Wildlife (WDFW) compiled maps that aimed to identify regions of relatively greater ecological importance in the study area, as represented by available data on the distribution of selected species and habitats. Input data for this analysis varied widely in format and scope, but included information from fisheries records, fish and wildlife surveys, and predictive models. Data was acquired both from WDFW projects and monitoring programs, and from various external federal, state, and academic sources. Estuaries were not included in analysis due to data availability and resolution issues, but the Marine Spatial Plan recognizes that they are known to be of high ecological importance. For each species and habitat, WDFW used a quantile approach to assign a relative importance score to each 1-square mile hexagon within the planning area. These scores allowed analysts to compare results across species, and to combine multiple data layers into “hotspot” maps. Hotspots show areas that are expected to be relatively more important to a greater number of species or groups. Please see Section 3.2 of the Marine Spatial Plan for more information about the methods and results of the EIA analyses.

Relative Abundance Models for Mammals and Birds: NCCOS synthesized data from 11 existing survey programs and a wide variety of ecological datasets. The results of this analysis were a series of statistical models and maps showing areas where relatively higher abundances of each species would be expected, based on field observations and relevant environmental predictor variables. Model outputs were incorporated into the EIA analysis described above. Please see Section 3.1 of the Marine Spatial Plan for more detail on the source data and models.

Ecosystem Indicators: With input from a wide range of scientists, NOAA’s Northwest Fisheries Science Center (NWFSC) developed a conceptual model for describing key ecological components of the study area and identified a list of potential ecological indicators to support Marine Spatial Planning in Washington. This project described physical drivers, habitats, human pressures, and biological factors that are important to characterizing ecology in the study area. Based on this information, a review of scientific information on indicators, initial input from scientists and managers on criteria, and other sources, NWFSC developed an initial list of potential indicators that may provide measures of the health and status of Washington’s coastal waters. NWFSC also produced a status and trends report for these potential ecological indicators, where data was available to report on those indicators.

REMAINING DATA GAPS AND CHALLENGES:

Ecologically Important Areas and Relative Abundance Models: Because of the complexity of the analyses conducted by WDFW and NCCOS and the number and diversity of datasets used to represent different species and habitats, there are various limitations and uncertainties associated with their data and results. The EIA maps provide a way to summarize available data on some key biological aspects of the study area, and show broad trends in species and habitat distribution throughout the region. However, these maps cannot fully account for other important factors such as ecological interactions or differences in ecological hotspots over different seasons and time scales. For both analyses, each input dataset is also associated with its own challenges depending on data coverage and collection methods, and insufficient data was available to include some important species, including some which are endangered or threatened. All analysis outputs must be carefully assessed alongside other available information, including the evaluations of uncertainty provided by both studies. Please see Section 3.2 of the Marine Spatial Plan for a further discussion of NCCOS and EIA data gaps and limitations.

Ecological Indicators: The work by NWFSC provides a starting point for identifying helpful and scientifically-sound ecological indicators. The indicators suggested in the final report are only an initial list, which still must be further assessed and refined into a shorter list to maximize their usefulness.

DATA SUMMARY

ECOLOGY: SEAFLOOR AND OCEANOGRAPHIC DATA

Marine spatial planning (MSP) is a process for gathering information on coastal and ocean activities and environments, providing recommendations for siting new ocean uses, creating a process for coordinating across all levels of government, and ensuring stakeholder input on new ocean uses in a comprehensive plan. For more detailed information on the planning process in Washington, specific data, or projects, or to use the interactive MSP spatial data viewer, please visit the Marine Spatial Planning website at www.msp.wa.gov. Links are also provided below to some relevant reports or sources.

ECOLOGY

The Marine Spatial Plan provides information about the physical, biological, chemical, and geological characteristics of the study area. Some information was acquired from existing programs or studies, while other data was collected or analyzed specifically for MSP purposes. This document provides a summary of key data sources, but more information on the many ecological data sources consulted is provided in Sections 2.1, 3.1, and 3.2 of the Marine Spatial Plan.

MAJOR DATA SOURCES

Information relevant to seafloor mapping and other oceanographic data was provided by:

- [NOAA's National Centers for Coastal Ocean Science \(NCCOS\)](#): An evaluation of available seafloor mapping data and identification of priorities for future mapping projects
- [The Nature Conservancy](#): Models and data describing benthic substrate and bathymetry
- [Olympic Coast National Marine Sanctuary](#) and [Oregon State University](#): Seafloor mapping data and a seafloor atlas for Washington's outer coast
- [Washington Department of Ecology](#) and the US Geological Survey: Shallow water bathymetric, sediment, and topographic surveys
- [National Oceanic and Atmospheric Administration \(NOAA\)](#): The location of dominant coastal geology features
- [The University of Washington](#): Oceanographic data relevant to primary productivity, oxygen levels, and other physical and chemical properties of the study area

SELECTED PRODUCTS AND METHODS:

Seafloor Data Prioritization: NCCOS conducted an evaluation of available seafloor data, and led a participatory process designed to identify priorities for future seafloor mapping efforts. This effort included two workshops with representatives from federal and state agencies and coastal tribes, where participants provided their perspective on the potential for future mapping efforts to assist with fulfilling their management and planning goals. The process resulted in the creation of an interactive data viewer and prioritization tool, and the collaborative identification of several areas most frequently selected by participants as a high priority.

Synthesis of Seafloor Data: The Olympic Coast National Marine Sanctuary collaborated with the Active Tectonics and Seafloor Mapping Lab at Oregon State University to compile and standardize existing seafloor mapping survey data. This involved synthesizing sidescan and multibeam sonar data collected between 2000 and 2013, and producing an online Seafloor Atlas.

Shallow Water Surveys: The Washington Department of Ecology's Coastal Monitoring and Analysis Program (CMAP) conducted surveys of shallow coastal areas along Washington's coast. CMAP collected data using multibeam bathymetric, single beam bathymetric, and topographic LiDAR surveys. CMAP also collected data on beach profiles and geomorphology, and collaborated on the installation of a network of geodetic controls to support the ongoing study of shoreline characteristics. Partners for these projects included the U.S. Geological Survey, Oregon State University, the Quinault and Quileute Indian Nations, and the National Park Service.

Synthesis of Water Property Data: Oceanographers at the University of Washington compiled maps of the study area describing properties including temperature, salinity, water currents, chlorophyll content, and oxygen content. These maps and other final products were based on data collected by the University over several decades. Researchers synthesized existing data and models, and converted them to formats compatible with other information being used in the MSP process. Seasonal variability in this ocean observation data was also considered and incorporated into the maps.

REMAINING DATA GAPS AND CHALLENGES:

Seafloor Mapping: Collecting bathymetric and other seafloor data is often logistically challenging and costly. In some cases, modeling approaches can provide indications of where certain seafloor features or sediment types are likely to be located based on various environmental factors and known features. However, the usefulness of this kind of data can be limited without studies that can ground-truth models using mapping technology in the field.

The seafloor data prioritization process led by NCCOS identified areas that may prove particularly valuable for both Marine Spatial Planning and other ongoing efforts to understand the physical characteristics of Washington's coastal and marine waters. These locations do not represent the only oceanographic and bathymetric data gaps in the study area. They give an indication of areas that have shared management priorities for filling data gaps and, therefore, where future mapping efforts could maximize their benefit for multiple purposes and groups.

DATA SUMMARY: SHIPPING

Marine spatial planning (MSP) is a process for gathering information on coastal and ocean activities and environments, providing recommendations for siting new ocean uses, creating a process for coordinating across all levels of government, and ensuring stakeholder input on new ocean uses in a comprehensive plan.

For more detailed information on the planning process in Washington, specific data, or projects, or to use the interactive MSP spatial data viewer, please visit the Marine Spatial Planning website at www.msp.wa.gov. Links are also provided to some project reports or data sources below.

SHIPPING:

The following data used in the Marine Spatial Plan provides information related to the transit of commercial waterborne cargo to, from, and through the study area, including navigational information relevant to the shipping industry. More information on marine transportation, navigation, and infrastructure is available in Section 2.7 of the Marine Spatial Plan.

MAJOR DATA SOURCES:

Shipping data for the study area provided by:

- [Olympic Coast National Marine Sanctuary](#): Density of shipping vessel transits in the study area
- [BST Associates](#): Vessel transit trends and forecasts for the Pacific Northwest
- [Cascade Economics](#): Economic analyses of marine sectors including shipping

Navigational data relevant to shipping was acquired from:

- [National Oceanic and Atmospheric Administration](#): Location of shipping lanes, Area to be Avoided (ATBA), buoys, beacons, and other aids to navigation
- [US Army Corps of Engineers](#): Location of federal navigation channels and ports
- [National Waterways Network at the Bureau of Transportation Statistics](#): Location of commercially navigable deep draft waterways
- [Washington Sea Grant](#): Location of towboat lanes established by crab fishermen and tugboat and towboat industry in order to limit interactions between towing vessels and fishing gear.

PRODUCTS AND METHODS:

Shipping activity maps: The Olympic Coast National Marine Sanctuary (OCNMS) compiled and processed spatial data on shipping activity. This information represents the location and density (vessels per square mile) of ship traffic passing through the study area in 2013 and 2014.

Types of ships and their movement through the study area were identified by analyzing satellite-derived automatic identification system (AIS or SAIS) data from exactEarth.com. AIS is a tracking system used to identify and locate vessels; the Coast Guard requires that AIS systems be carried by large commercial ships in the United States, though they are also used by some smaller and/or private vessels. OCNMS sorted reported vessel positions into six categories which include both shipping data (cargo, tanker, and tug & tow vessels) and data on other types of vessels (recreational, military, and passenger ships), and mapped traffic density using ArcGIS software. The resulting maps show where AIS data indicates that each category of vessel traffic is occurring at a low, moderate, or high intensity in the study area.

Vessel trends and forecasts: In 2014, BST Associates compiled a report for use in the Marine Spatial Planning process on the current state of the shipping sector and calculated projections for future shipping activity in the Pacific Northwest. Projections of future vessel traffic are based on data including past trends in cargo volume and value, transit routes, previous export and import studies, and forecasts for trade patterns in the northwest and abroad. This report also assesses the potential for offshore energy development to affect marine shipping.

Economics: Using the information compiled by BST Associates as well as other recent studies, Cascade Economics conducted an analysis of Washington's coastal economies, completed in 2015. This report describes economic profiles of several marine sectors including commercial shipping. It assesses economic impacts associated with shipping, discusses areas of risk and vulnerability in the sector, and summarizes potential impacts of new coastal uses on commercial shipping. Economic models were produced for five counties in Washington with heavily coastal use-dependent economies, as well as for the entire state.

Ports: Available sources for port data use different methods and criteria to identify port locations. Additional datasets and stakeholder feedback were used to supplement the Army Corps of Engineers port information for some uses.

REMAINING DATA GAPS AND CHALLENGES:

Vessel transit and tonnage data for economic analysis: Vessel transit information is readily available for international trade and the domestic transportation of petroleum products. However, available data on the tonnage of domestic non-petroleum products being transported is more limited.

Potential impacts of new uses: Information on how shipping conditions could be impacted by potential new uses remains limited, including potential economic impacts.

DATA SUMMARY: RENEWABLE ENERGY

Marine spatial planning (MSP) is a process for gathering information on coastal and ocean activities and environments, providing recommendations for siting new ocean uses, creating a process for coordinating across all levels of government, and ensuring stakeholder input on new ocean uses in a comprehensive plan.

For more detailed information on the planning process in Washington, specific data or projects, or to use the interactive MSP spatial data viewer, please visit the Marine Spatial Planning website at www.msp.wa.gov. Links are also provided to some project reports or data sources below.

RENEWABLE ENERGY:

The following data provides information relevant to potential future offshore wind, wave, and tidal energy development within the study area. Data was collected about existing infrastructure relevant to renewable energy facilities, as well as the technical suitability of Washington's marine waters for energy production.

MAJOR DATA SOURCES:

Information about renewable energy potential in the study area was provided by:

- [Pacific Northwest National Laboratory](#): Technical suitability analysis for renewable ocean energy
- [Olympic Natural Resources Center](#): Line of sight analysis for offshore facilities
- [Industrial Economics](#) and [Cascade Economics](#): Economic analyses of marine sectors including renewable energy

Data on existing infrastructure relevant to offshore energy facilities was provided by:

- [US Army Corps of Engineers](#): Location of ports
- [Bonneville Power Administration](#): Location of transmission lines and substations
- [National Oceanic and Atmospheric Administration](#): Location of submarine cables

PRODUCTS AND METHODS:

Technical Suitability Analysis: The Department of Energy's Pacific Northwest National Laboratory (PNNL) modeled offshore energy suitability off the coast of Washington for three types of wind technology, four types of wave technology, and one type of tidal energy technology. Suitability was determined based on factors including available energy resources, distance to shore support and electrical transmission infrastructure, water depth, and bottom sediment type. Results were calculated and mapped in ArcGIS. For this analysis, PNNL acquired technical specifications for renewable energy devices from industry advisors and the U.S. Department of Energy's Marine and Hydrokinetic Technology Database. Various federal, state, and academic sources provided spatial datasets describing existing conditions in the study area. A full list of data sources is available in the final project report on the MSP website.

Viewsheds: The Olympic Natural Resources Center provided a map showing the predicted visibility of offshore structures from land. Sight line distances were calculated and displayed in ArcGIS using a formula describing sight distance in terms of structure height, viewer height, and atmospheric conditions. Three potential facility heights were based on typical wind and wave structures, and three observer heights were based on viewing from the shoreline or a multistory onshore structure.

Economics: A sector analysis by Industrial Economics summarizes the potential economic implications of planning, constructing and operating wind, tidal, and wave energy facilities off the coast of Washington. The authors describe the current status of the sector and predict future trends based on sources including the PNNL suitability analysis, other suitability studies in the US, expert interviews, and information on past research and development projects for marine renewable energy in Washington. Additionally, Cascade Economics conducted an analysis of Washington's coastal economies. This report summarizes potential impacts of offshore renewable energy development on existing uses including fishing, aquaculture, recreation, and shipping.

REMAINING DATA GAPS AND CHALLENGES:

Technical Suitability: The final report provided by PNNL cites known uncertainty issues related to substrate information and data collected in shallow water, such as wave resource data. Additionally, it is unclear how rapidly renewable energy technology may advance in coming years, but changes in technology will affect assessments of the technical suitability of the study area for both pilot- and full-scale development.

Economics and Market Influences: PNNL's analysis focused only on technical requirements for development, and did not incorporate detailed information related to the cost of planning, installing, or operating offshore energy facilities.

Marine renewable energy development is still a relatively new sector and has not occurred in the study area to date. So while economic data related to the renewable energy industry is available for other locations and at broader scales, Cascade Economics' report notes that quantitative information specific to the study area is limited. There are also unknowns related to some of the broader market and energy policy influences that could affect where renewable energy projects may actually be of interest to developers in the future.

Appendix D: Definitions

A list of definitions will be included in formal draft plan. In general, definitions will refer to already established definitions in laws and regulations to facilitate implementation.

Appendix E: Acronyms

A list of acronyms used throughout the plan will be compiled for the formal draft.