Summary Report
for
Spatial Prioritization Seafloor Mapping for Washington's Pacific Coast (Phase III and IV)

MAPPING AND MODELING SUPPORT
FOR MARINE SPATIAL PLANNING

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Submitted to
STATE OF WASHINGTON,
DEPARTMENT OF NATURAL RESOURCES

Prepared by
U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NATIONAL OCEAN SERVICE
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1. SUMMARY

On May 14, 2015, NOAA conducted a Spatial Prioritization Planning Workshop (2) in collaboration with the State of Washington to support the State's efforts to conduct marine spatial planning. This one day workshop was held at the Department of Ecology, Lacie, WA as part of NOAA's technical support to the State to assist in spatially prioritizing seafloor mapping needs along the Pacific Coast of Washington. This Workshop and report represents the completion of Phase III and IV components of this effort that compliments the prior report submitted to Washington (December 1, 2014) summarizing Phase I and II.

2. PHASE III - CONDUCT SPATIAL PRIORITIZATION EXCERCISE

This workshop was preceded by *Phase III - Conduct Spatial Prioritization Exercise* which included tasks and objectives listed below.

> This task entails conducting a Web-based Spatial Prioritization by Agency representatives. Post Exercise analysis will be conducted by NOAA. The Spatial Prioritization Exercise tasks include, but are not limited to the following:
>
> - Spatial Prioritization memo sent to participants that were selected to represent and consolidate input for their respective agency.
> - Key Components of Exercise include:
> A. Web-based data viewer which compiles existing seafloor mapping information and spatial grid for organizing input (completed)
> B. Online Spatial Prioritization Tool to support user entry
> - Each participant completes prioritization using the Prioritization Tool based on input criteria established by the Technical Advisory Committee.
> - Input is submitted to the Technical Advisory Team for further spatial and thematic analysis.

2.1. WASHINGTON STATE PRIORITIZATION TOOL (WASP)

The exercise was designed such that a respondent would solicit and submit priority information for their respective group (Figure 1). The Spatial Prioritization Exercise was conducted January 29 to March 18, 2015. Eighteen respondents representing Federal and State Agencies, and Tribes participated in the spatial prioritization exercise (Table 1).

Figure 1: Spatial Prioritization Exercise conceptual process.

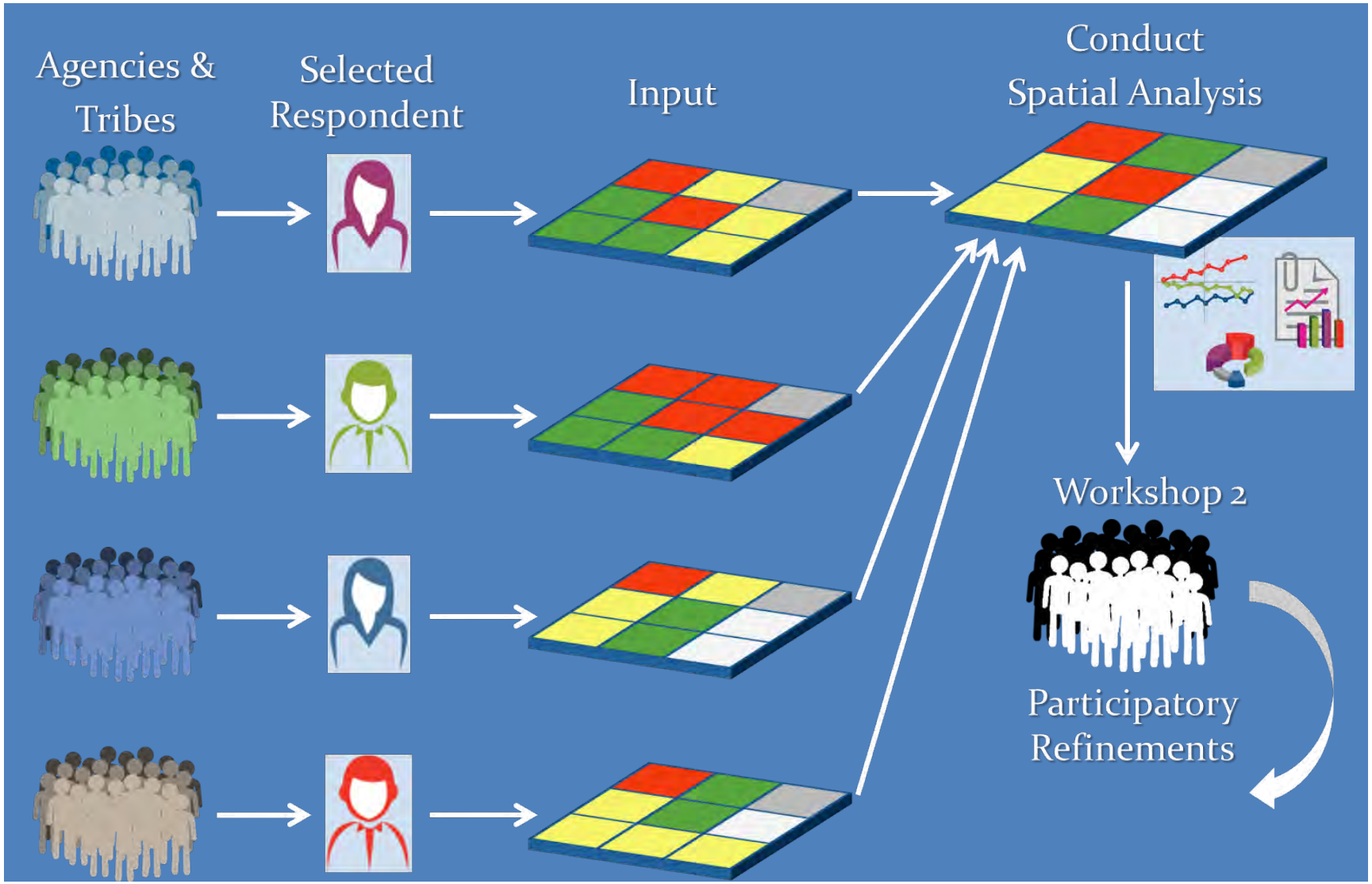
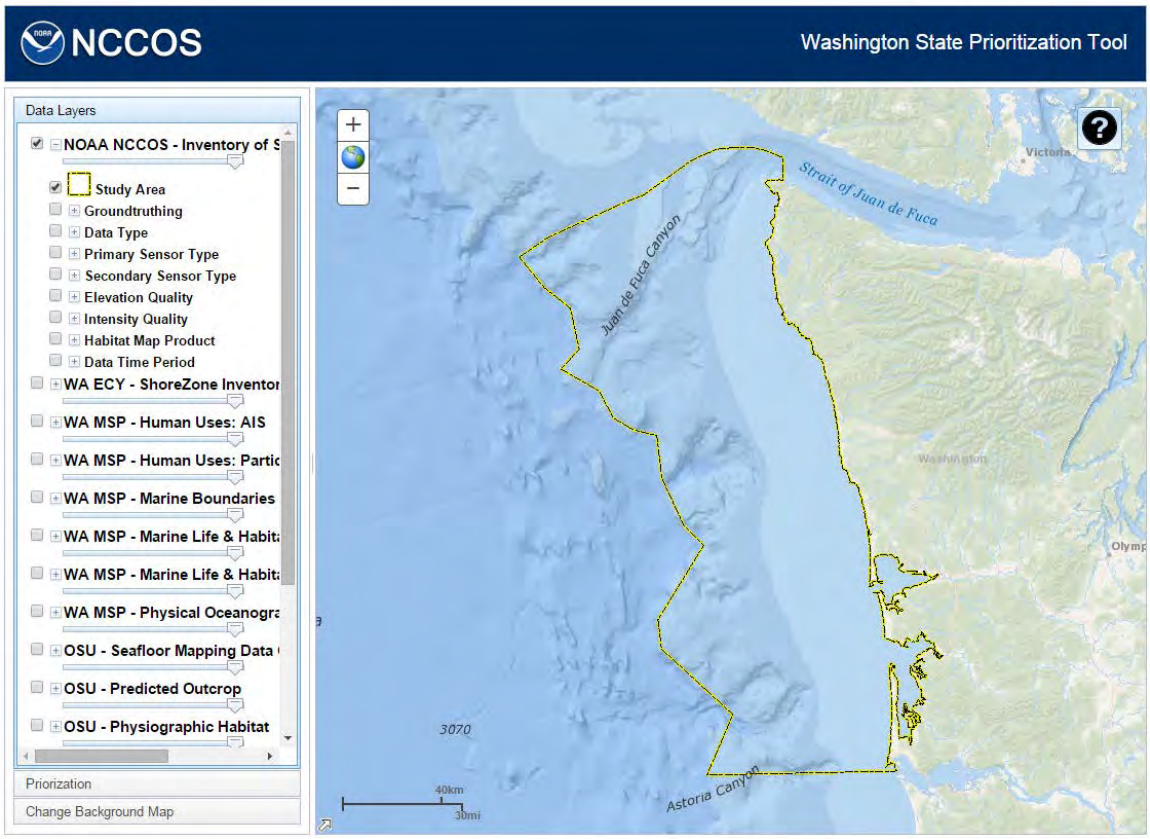


Table 1: List of Spatial Prioritization Respondents.

Designated Respondent	Affiliation
Nancy Wright	NOAA Olympic Coast NMS
Marie Eble	NOAA PMEL
Steve Copps	NOAA NMFS West Coast Regional
Waldo Wakefield	NOAA NMFS Groundfish Research
Kelly Andrews	NOAA NMFS Ecosystem Science
Crescent Moegling	NOAA Office of Coast Survey
Nadine Golden	USGS Pacific Coast & Marine Science Center
Michele Schallip	USCG District 13
Tim Siwiec	EPA Region 10
George Hart	Navy Northwest region
Frank Pendleton	BOEM - Pacific Region
Lonnie Reid-Pell	USACE Geospatial Section
Jennifer Hagen	Quileute Tribe
Joe Schumacker	Quinault Indian Nation
Jennifer Hennessey	WA Dept of Ecology
Corey Niles	WA Dept of Fish and Wildlife
Michal Rechner	WA Dept of Natural Resources
John Schelling	WA Emergency Management Division
	Unable to Participate
	DOI USFWS
	Hoh Tribe
	Makah Tribe
	Shoalwater Bay Tribe
	DOI National Park Service
	USACE Portland District

The Washington State Prioritization Tool (WASP) website was developed using ESRI's ArcGIS API for JavaScript to allow invited participants to select areas and assign priorities to the cells, justifying this priority level by choosing a management issue and up to three ranking criteria. The application contains both a query component and an edit component. The query component ("Data Layers" tab) is open to all participants while the edit component ("Prioritization" tab) is available to only invited participants (Figure 2).

Figure 2: **Washington State Prioritization Tool (WASP).**



The query component uses an interactive Table of Contents tool (a third party tool, available on ArcGIS.com), which lists all of the contents of the collected datasets in a tree-like structure. The individual layers or groups of layers can be turned on and off by clicking on the checkbox next to their names. The site was designed to use map services from a number of different sources. It contains services from NOAA/National Centers for Coastal Ocean Science (Inventory of Seafloor Mapping Surveys), NOAA/National Marine Fishery Service (Habitat Areas of

Particular Concern and EFH Areas Protected from Fishing) NOAA/Office of Coastal Management (Undersea Feature Place Names), Washington State Department of Ecology (ShoreZone Inventory) and Department of Natural Resources (Human Uses, Marine Boundaries, Marine Life and Habitat, Kelp, and Physical Oceanography), and Oregon State University (Seafloor Mapping Data Quality, Predicted Outcrop, Physiographic Habitat, Primary Lithologic Seabed, and Seafloor Induration).

When the user clicks on the map, each layer that is turned on is queried. The features that are present at that point are presented in a popup with the features in each layer on a separate tab listed in a table with all the visible attributes of the features (Figure 3). When the user clicks on one of the rows in the tables, the corresponding feature will be highlighted on the map. This information will be used in the decision-making process in assigning priorities to the cells.

In the editing component, the invited user will log on to gain access to the tools to assign priorities, management issues, and ranking criteria (*Selection Definitions* - see below). Each user was given an account on NOAA's GeoPortal, NOAA's ArcGIS Online account. This is a GIS application environment for use by NOAA employees, giving participants the ability to quickly share NOAA data, web maps, applications, tools, and web services with internal project teams as well as with NOAA partners and the public.

Selection Definitions:

Priority: A relative measure of the need for seafloor mapping information for a grid cell. The user must select 1 of the 4 options for each grid cell.

- High - immediate need; of critical importance (may be required or mandated); the absence severely impacts services or decision-making. "Need it now".
- Medium - needed in the near future; non-critical importance but still of value; moderate impact on services or decision-making if not available. "Need in the near future".
- Low - undetermined future need; non-critical importance but still of value; no direct impact on services or decision-making if not available. "Would be nice to have in the future".
- None – Insufficient information to make a decision **or** not a priority for mapping.

Management Issue: Select the overarching management issue for a grid cell driving the "Priority" designation. While there can be multiple concerns, please select the single most critical issue.

- Living Resource Management - data needed to inform resource management decisions including harvested species as well as protected species and their habitats (e.g., EFH, seabirds, marine mammals, fisheries, shellfisheries, aquaculture, SAV, etc.).
- Ecosystem Based Management - this includes better baseline information, proving oceanographic models.
- Safety and Navigation - information needed to support the management of maritime traffic or use-activities.

- Coastal Inundation and Natural Coastal Hazards - information needed to support the management of areas at risk from coastal hazards and inundation.
- Spill Response - information needed to support spill response management or planning.
- Sediment Management - data needed to support dredging and management of sediment disposal areas, or sand mining.
- Cultural Heritage and Historical Resource - information needed to inform the management of locations of known cultural or historical significance.
- Marine Debris including Derelict Fishing Gear - information needed to inform the management of areas of marine debris convergence or impact.
- Defense and Homeland Security Activity Areas - information needed to inform areas with restrictive operational use.
- Other Regulatory - information needed to inform other permitting or regulatory assessments not captured by other categories (environmental assessments, NEPA, leasing, ownership, SMP's)
- Research - information needed to inform research program investigations.
- Other - other management issue not included above.
- Insufficient Information - insufficient familiarity with location to be able to make a decision (associated with "None" priority).
- Not a Priority for Management - locations not a priority for management (associated with "None" priority).
- None - not a priority for Management Issues

Ranking Criteria (1 through 3): Select up to 3 Ranking Criteria options for each grid cell. The Ranking Criteria is intended to modify or describe the Management Issue in further detail. The Ranking Criteria are listed in descending order (1 being most important, 2 & 3 being successively less important.). The user must define at least one Ranking Criteria. The other two are optional.

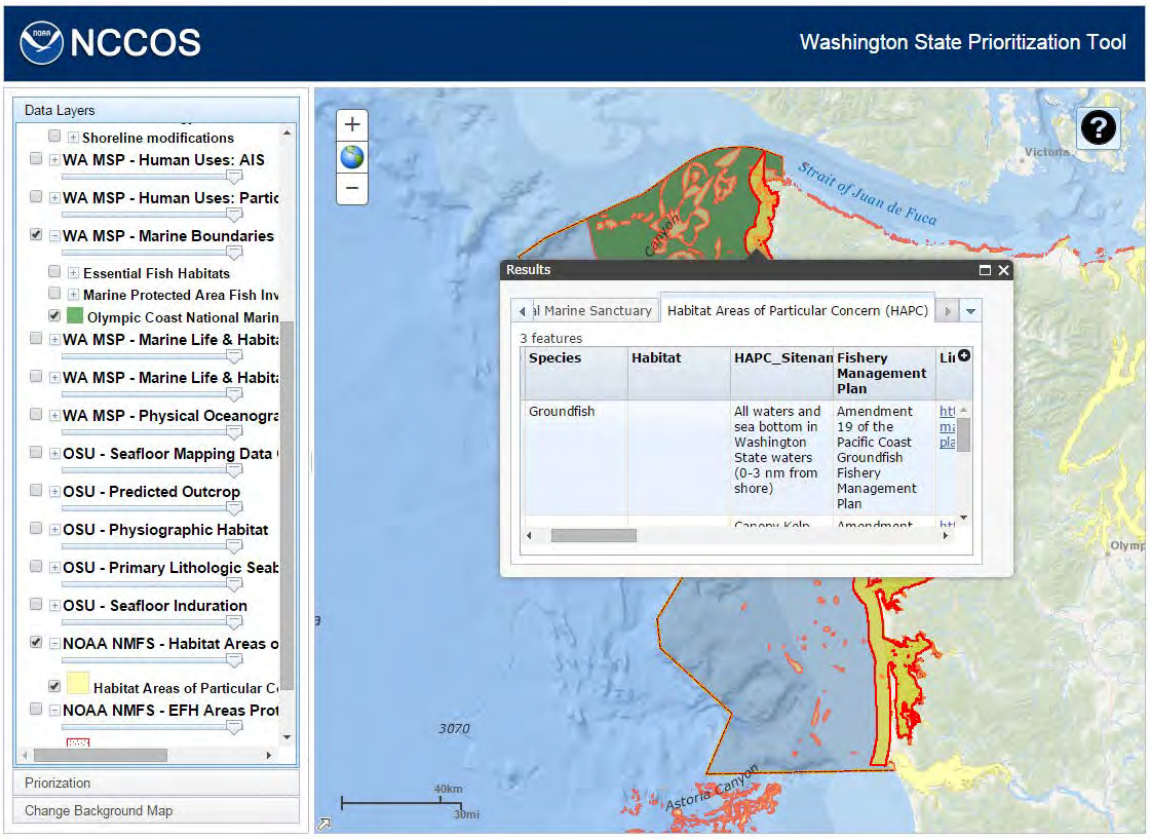
- Multiple Use Conflict - An area with known, existing, multiple competing uses (e.g., commercial fishing and recreational boating).
- Managed Areas - special use, managed resource harvest areas, or other designated State/Federal/Tribal/Local managed areas (e.g., EFH, shellfish beds, dredge material disposal sites).
- Knowledge Gap - areas where there is no, limited, poor quality, or outdated information and where it is needed.

- Significant Natural Areas - areas known to be of unique or important ecological value, but not necessarily having any official or legislated designation (e.g., rocky intertidal, cold-water coral, kelp beds, etc).
- High Use Areas - (e.g., ship traffic, fishing, and recreation).
- Existing Infrastructure - (e.g., jetties, cable, pipeline, etc).
- Potential Infrastructure or other potential uses - area that could be targeted for future infrastructure projects or other new uses (e.g., cable, pipeline, wind/wave turbines, tidal energy devices, new dredge material sites, etc).
- Other Important Areas - other activities not included above (e.g. research areas, cultural resources).
- None - not a priority for Management Issue.

The NOAA participants were given the standard User privileges, giving them the ability to create new content, share maps and apps, join and create groups, and edit features. All other external participants were given a custom privilege, only allowing them to edit existing features. When the user account was created, an invitation to join the NOAA GeoPortal was sent to the participant.

A polygon grid was created in the study area, which is defined by the Washington Marine Spatial Planning study area, covering the shoreline to the 700 fathom line. This dataset contains 996 cells, based on the Office of Coast Survey blocks of 4.8x4.8 km (3x3 mi). This grid was stored in the file geodatabase and contains fields for a unique grid number, priority, management issue, and three ranking criteria. The priority, management issue, and criteria fields were assigned attribute domains, which describe the valid values of the fields and enforce data integrity. The fields would accept only numeric values and the attribute domains translate these into defined text. The user is presented with the text descriptions of the attribute choices and cannot add any custom text.

Figure 3: Data layers and services available through WASP to support user priority selections.



For each user, a feature service was created in the NOAA GeoPortal using the polygon grid. The user was given the permission to edit the attributes, but not the geometry, of the feature service. Since content on ArcGIS.com cannot be shared with groups and not specific participants, a group was set up for each participant and the user was invited to join the group. Once this invitation was accepted, the user could log onto the prioritization website and edit their grid.

The user can select features using the tools provided, selecting a single feature at a point or multiple features using a line, polygon, or rectangle. When features are selected, a window containing the drop-down attribute selections for priority, management issue, and ranking criteria is opened (Figure 4). Depending on the priority chosen, the user will be presented with two different set of choices for management issue and ranking criteria (Figure 4). Choosing “None” will include management issues of “None”, “Insufficient Information”, and “Not a priority for Management Issue” and ranking criteria of “None” and “Knowledge Gap”. The other priorities will include all management issues except “Insufficient Information” and “Not a priority for Management Issue” and all ranking criteria. A management issue and at least one ranking criteria must be chosen before these edits can be saved by

clicking the “Apply choices” button. If not, a warning dialog will appear listing the fields to be selected. The total number of cells to be designated as “high” or “medium” priority is limited to 300. If the user selects more than that limit, a warning dialog will appear stating how many cells have been selected over that limit. The table (Priority cell counts) keeps track of how many cells have been selected and how many cells have been assigned the different priorities. The map will show the priority attribute by default, but the user can also display the management issue or ranking criteria attributes by selecting from a list in the “Change attribute display” section. Once the “Apply choices” button is clicked, the feature service will be updated with the new attributes (Figure 5).

Once the Prioritization exercise was closed, the editing permissions for all feature services were turned off. The participants could still see their data but could not make any further changes to the attributes. Each feature layer was exported into a file geodatabase on ArcGIS.com to maintain the attribute domains and downloaded to a local drive for analysis.

Figure 4: WASP user selection options.

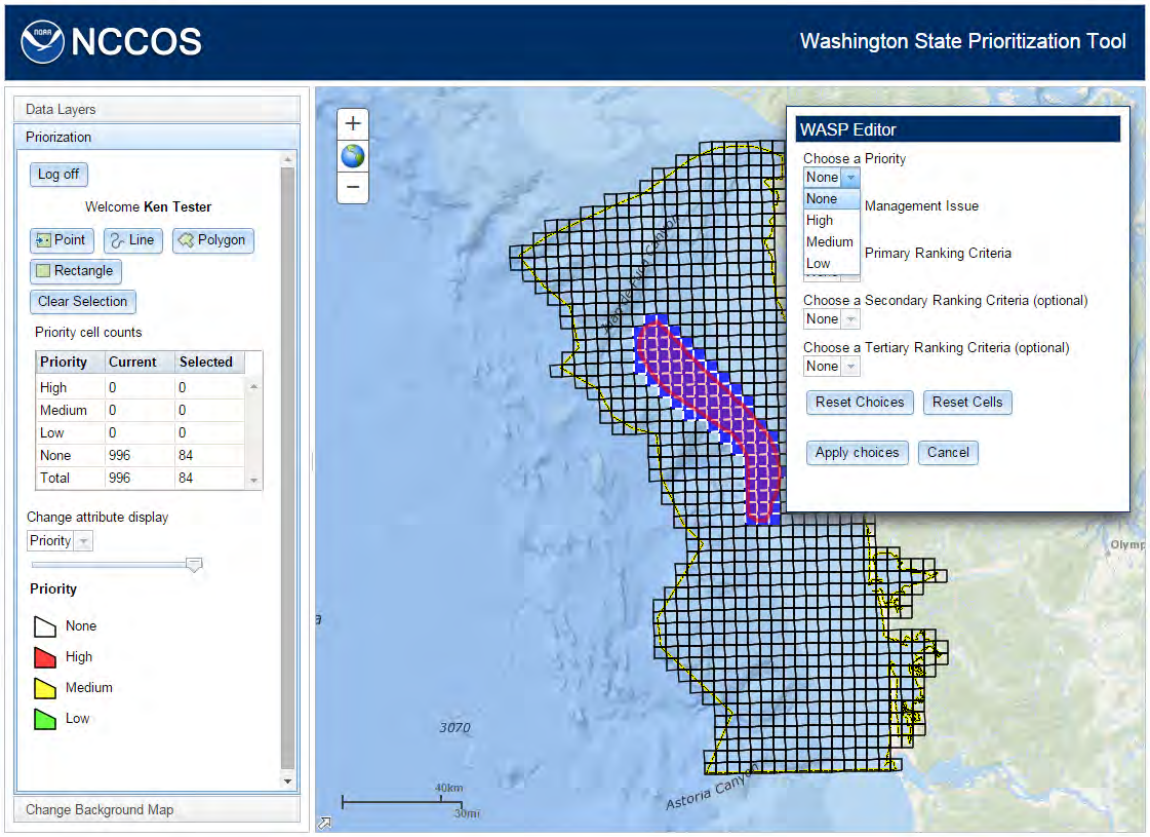
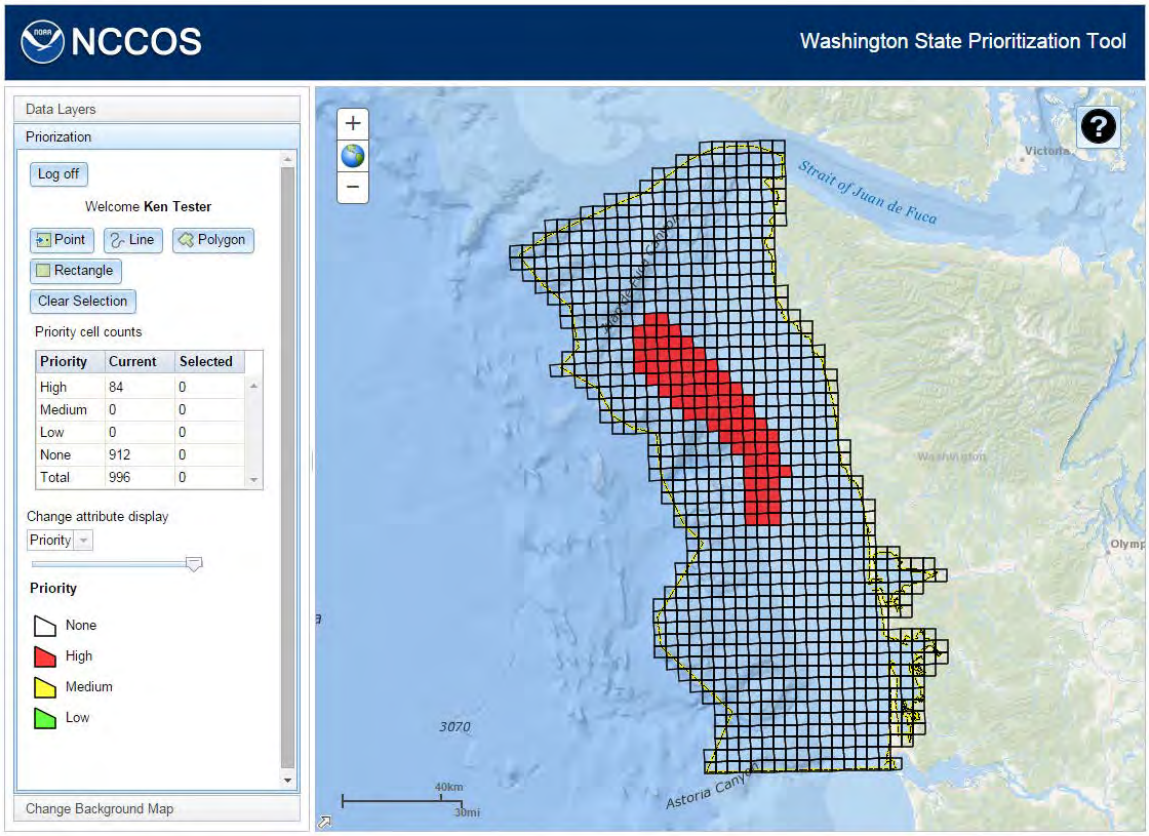


Figure 5: Completed priority selection in WASP.



2.2. METHODS - PRELIMINARY SPATIAL PROIRITIZATION

2.2.1. Prioritization Survey Results and Analysis

The participant survey data were first exported from the survey GIS into a JMP (SAS Institute) statistical analysis file to both organize and explore the harvested survey data. Table 2 depicts the spatial prioritization submissions totaled across survey respondents, with the quantity of grid cells scored (number of responses) by Priority (High, Medium, Low) for each Management Issue category. These results provided initial insight towards the range in quantity of response and the similarities and differences between respondents in perceived needs (Management Issue) and application (Ranking Criteria).

We suspected there may be relationships between the Issues, Priorities, and Criteria that could be used to help further identify priority mapping areas. As the survey data collected were non-normally distributed, we used chi-square tests and nonparametric statistical procedures to test these hypotheses (Sokal and Rohlf 1995). Considering Issues and Priorities first, we used a null hypothesis that there was no inherent relationship, and expected the test to reject this if a statistically significant relationship did in fact exist. Chi-square tests are based on comparing a test statistic with calculations of observed, expected, and contingency values (cell Chi-square). Observed results were compiled directly from the submitted survey data. Expected results and associated contingency values reflect what the responses might be in an idealized situation and are defined by:

Expected Value = the product of the corresponding row total and column total divided by the grand total (*i.e.,* all responses in the survey)

and where:

$$\textbf{\textit{Contingency}} \quad \frac{(\text{Observed Priority Value - Expected Priority})^2}{\text{Observed Priority Value}}$$

In addition to the observed priority values across Priority and Issue, Table 2 lists the percent that each cell count contributes to the grand total (total%), expected, and contingency calculations (cell Chi-square) for the Management Issues.

Table 2: Spatial prioritization submissions totaled across survey respondents.

	None	Low	Med	High	Σ
No Response Given					
Count	4408	0	0	0	4408
Total %	32.0	0.0	0.0	0.0	32.0
Expected	1469.9	1161.0	882.3	894.8	
Cell Chi^2	***5873.1***	***1161.0***	***882.3***	***894.8***	
Ecosystem Based Management					
Count	0	1401	1123	846	3370
Total %	0.0	10.2	8.2	6.1	24.5
Expected	1123.7	887.6	674.5	684.1	
Cell Chi^2	***1123.7***	***296.9***	***298.2***	38.3	
Living Resource Management					
Count	0	53	772	877	1702
Total %	0.0	0.4	5.6	6.4	12.4
Expected	567.5	448.3	340.7	345.5	
Cell Chi^2	***567.5***	***348.6***	***546.1***	***817.7***	
Coastal Inundation and Natural Coastal Hazards					
Count	0	786	322	470	1578
Total %	0.0	5.7	2.3	3.4	11.5
Expected	526.2	415.6	315.9	320.3	
Cell Chi^2	***526.2***	***330.0***	0.1	***69.9***	
Other Regulatory					
Count	0	0	260	259	519
Total %	0.0	0.0	1.9	1.9	3.8
Expected	173.1	136.7	103.9	105.4	
Cell Chi^2	***173.1***	***136.7***	***234.6***	***224.1***	
Sediment Management					
Count	0	9	31	176	216
Total %	0.0	0.1	0.2	1.3	1.6
Expected	72.0	56.9	43.2	43.8	
Cell Chi^2	***72.0***	40.3	3.5	***398.3***	
Research					
Count	0	0	113	94	207
Total %	0.0	0.0	0.8	0.7	1.5
Expected	69.0	54.5	41.4	42.0	
Cell Chi^2	***69.0***	***54.5***	***123.6***	***64.3***	

	None	Low	Med	High	Σ
Safety and Navigation					
Count	0	360	60	61	481
Total %	0.0	2.6	0.4	0.4	3.5
Expected	160.4	126.7	96.3	97.6	
Cell Chi^2	***160.4***	***429.6***	13.7	13.7	
Other					
Count	0	382	0	0	382
Total %	0.0	2.8	0.0	0.0	2.8
Expected	127.4	100.6	76.5	77.5	
Cell Chi^2	***127.4***	***786.9***	***76.5***	***77.5***	
Spill Response					
Count	0	256	76	13	345
Total %	0.0	1.9	0.6	0.1	2.5
Expected	115.0	90.9	69.1	70.0	
Cell Chi^2	***115.0***	***300.1***	0.7	46.4	
Defense and Homeland Security					
Count	0	269	0	0	269
Total %	0.0	2.0	0.0	0.0	2.0
Expected	89.7	70.9	53.8	54.6	
Cell Chi^2	***89.7***	***554.1***	53.8	54.6	
Not a Priority for Management					
Count	132	0	0	0	132
Total %	1.0	0.0	0.0	0.0	1.0
Expected	44.0	34.8	26.4	26.8	
Cell Chi^2	***175.9***	34.8	26.4	26.8	
Marine Debris					
Count	0	112	0	0	112
Total %	0.0	0.8	0.0	0.0	0.8
Expected	37.3	29.5	22.4	22.7	
Cell Chi^2	37.3	***230.7***	22.4	22.7	
Insufficient Information					
Count	53	0	0	0	53
Total %	0.4	0.0	0.0	0.0	0.4
Expected	17.7	14.0	10.6	10.8	
Cell Chi^2	***70.6***	14.0	10.6	10.8	

A test statistic of 54.6 was determined by standard statistical look-up tables based on a 95% confidence interval and the degrees of freedom (39) within our data given by:

(number of rows – 1) * (number of columns – 1)

The contingency values in Table 2 greater than 54.6 allow us to reject the null hypothesis and confirm there is a statistically significant association between Management Issues and Priority beyond random chance. These significant values are shaded as light green if the value was significantly higher than expected, and as light red if significantly lower than expected. Additionally, cells shaded in dark green indicate where a management issue received a total number of responses that exceeded 15% of the grand total. We conclude, therefore:

a) Cell chi-square values for Living Resource Management, Coastal Inundation & Natural Coastal Hazards, "Other Regulatory", Sediment Management, and Research suggest respondents implicitly considered them to be a high priority;
b) The Issue of Ecosystem based management was the most often cited management issue across respondents; however; the cell-chi-square value was not significant at the "High Priority" level;
c) Living Resource Management and Coastal Inundation & Natural Coastal Hazards both exceeded 10% of the overall responses and were a selected as a high priority more often than otherwise expected;
d) "No Response" was the most frequent occurrence in the survey, representing 32% of the Grand Total;
e) Marine Debris was the least frequently selected management issue in the survey, representing 0.8% of all responses.

Additional chi-square tests determined relationships also exist between Management Issues and Ranking Criteria and the results are summarized in Table 3.

Table 3: Primary selection criteria that were determined to be significantly associated with management issue.

Management Issue	Significant Primary Criteria
Ecosystem Based Management	*Managed areas* *Knowledge gap* *Significant natural areas*
Living Resource Management	*Potential infrastructure* *Knowledge gap* *Significant natural areas* *Other important areas*
Coastal Inundation and Natural Coastal Hazards	*Existing infrastructure* *Other important areas*
Other Regulatory	*Potential infrastructure*
Sediment Management	*Knowledge gap*
Research	*Knowledge gap*
Other	*Other important areas*
Spill Response	*Significant natural areas*
Defense and homeland Security	*Other important areas*
Not a Priority for Management	*None*
Marine Debris	*Managed areas*

2.2.2. Spatial Processing

After gaining a deeper understanding of the relationships among Issues, Criteria, and Priorities, we conducted analyses to explore the spatial pattern of responses. With 14 possible management issues, 8 possible selection criteria, and 4 levels of priority; there were 448 possible mapping permutations. Rather than map each of these permutations, we decided to map only those management issues that were determined to be significantly higher than expected in the "High Priority" classification and/or those where the total issue response exceeded 10% of the Grand total. As such, the following 6 management issues were mapped: 1) Ecosystem Based Management, Living Resource Management, Coastal Inundation & Natural Coastal Hazards, "Other Regulatory", Sediment Management, and Research.

Basic and Composite GIS Layers

Survey responses for the issues listed above were aggregated into a master spreadsheet, cross-checked for transposition accuracy and used to create basic spatial data layers depicting location and interests of the respondents. The grid cells defined the spatial extents, and the Management Issue, Criteria, and Priority data formed the attribution schema. Separate layers were developed to display both responses by

organization and responses by Issue to broadly see where groups were interested and how Issues were distributed. We then created a composite Issue layer by combining the individual layers to provide a unified assessment of the study area on a grid-cell by grid-cell basis. Here, multiple instances of data for the same grid cells are preserved, thus showing all unique responses at that location. From the composite layer we then created a merged data layer reducing multiple instances of grid cells to a single instance and totaling the survey counts. A frequency field captured the number of times each cell received a "High Priority" response.

Geospatial Clustering Analysis

The ESRI ArcGIS Geostatistical Hot Spot Analysis tool was used to process the results of this frequency analysis and determine if statistically significant clusters or patterns of values exist that would more definitively represent areas to prioritize (ESRI 2012). At a basic level, the tool works by looking at each grid cell within a context of neighboring cells. A cell with a high score may be interesting, but to be statistically significant, it would need a high score and be surrounded by other cells with high scores as well.

The process returns a statistic (z-score)—in essence, a standard deviation value—for each feature in the dataset. For statistically significant positive z-scores, a larger z-score is indicative of intense clustering of high values. Conversely, statistically significant negative z-scores are indicative of intense clustering of low values. The tool also provides a probability statistic (p-value) that measures whether a spatial pattern reflects random chance. In areas with appropriately small p-values and either a very high or a very low z-score, it is unlikely that the spatial pattern is completely random and thus is a significant cluster.

Figures 6 to **Error! Bookmark not defined.** show maps of the frequency of "high priority" selections tallied across all respondents for the 6 significant management issues identified (left panel) alongside the associated hotspot analysis described above. Frequency of selection analysis is color coded into 20 percentile groupings, and hotspot analyses are mapped as "hot spots" (red) or cold spots (blue) with associated statistical confidence. Where the z-score was not statistically significant, cells are transparent.

Figure 6: Frequency of "high priority" selections and associated hotspots for Living Resource Management.

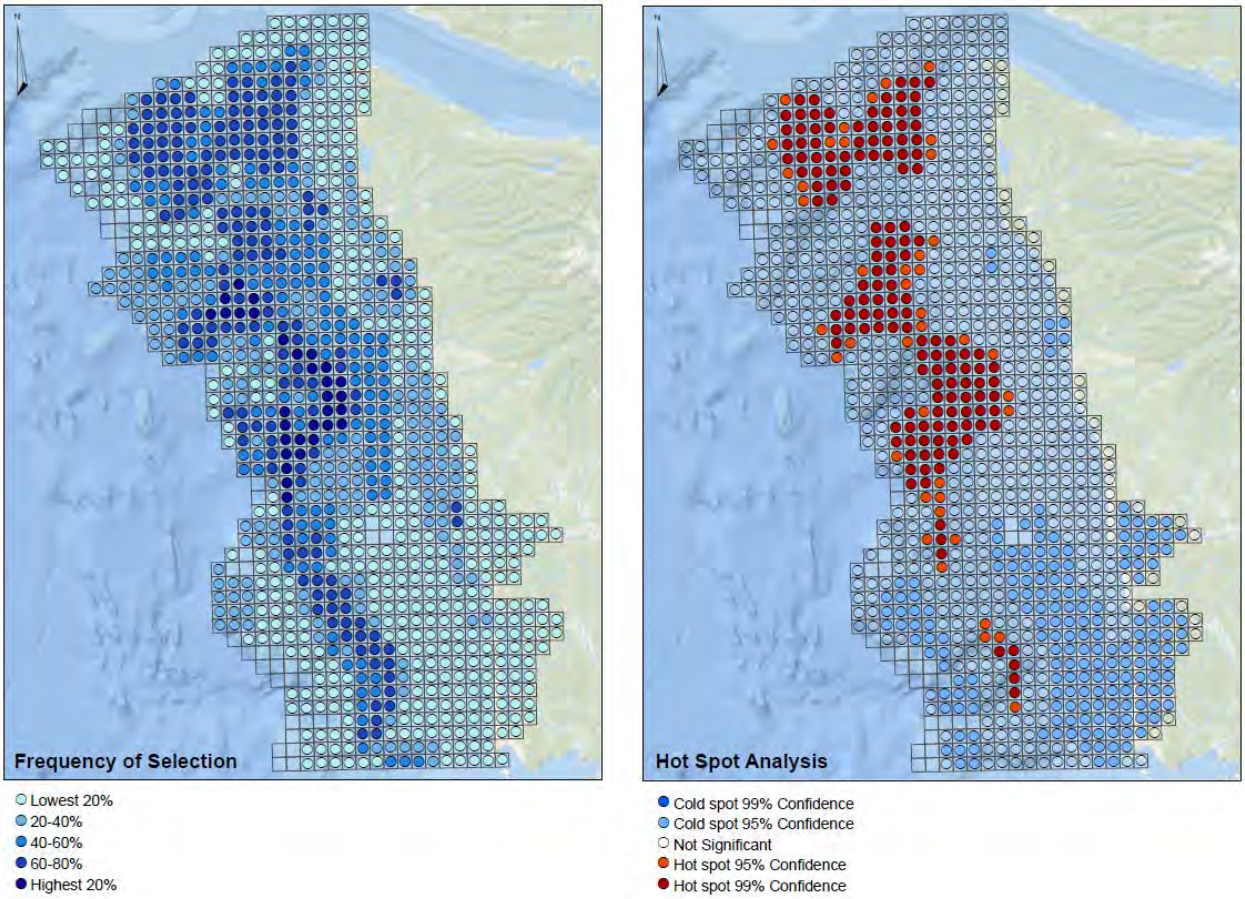


Figure 7: Frequency of "high priority" selections and associated hotspots for Ecosystem-based Management.

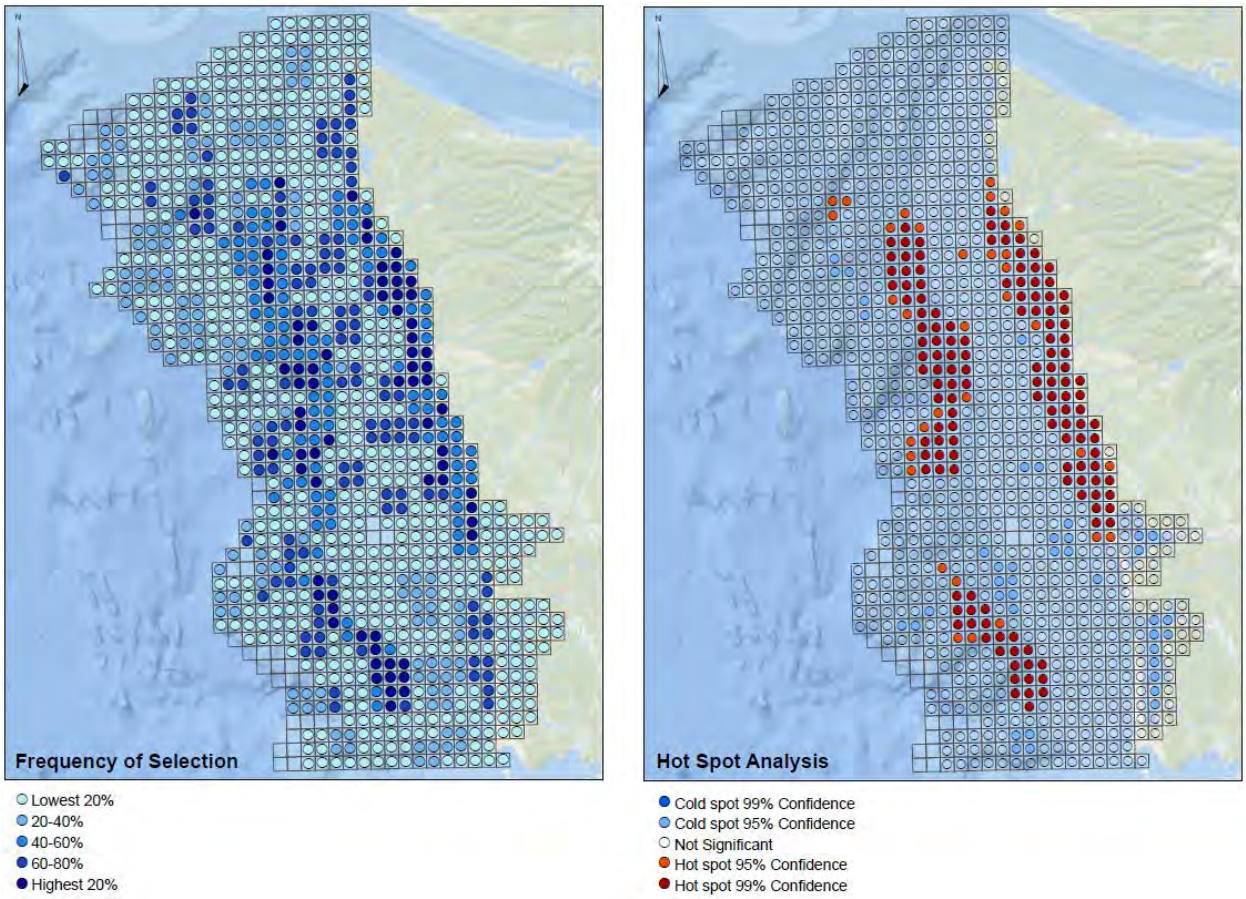


Figure 8: Frequency of "high priority" selections and associated hotspots for Coastal Inundation and Natural Coastal Hazards**.**

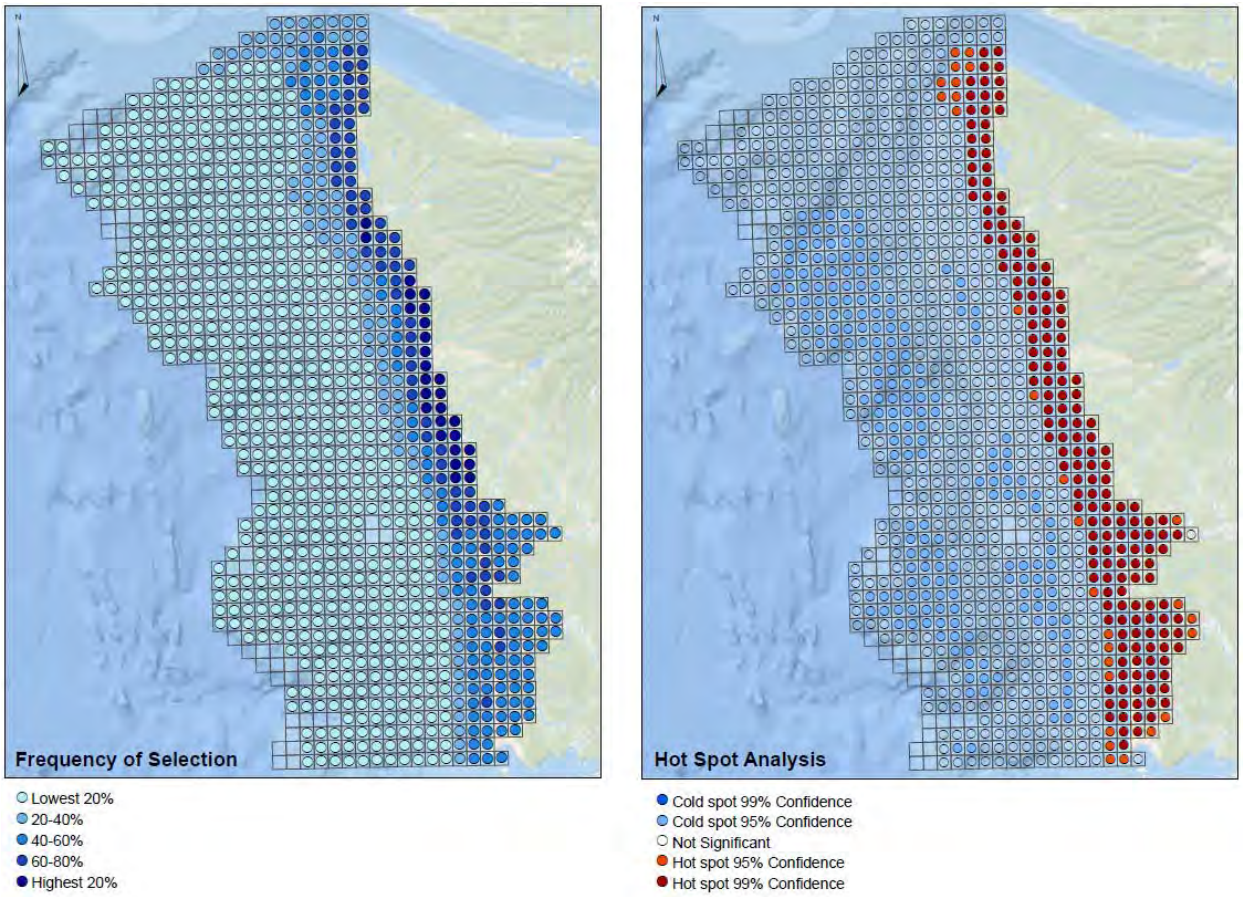


Figure 9: Frequency of "high priority" selections and associated hotspots for Other Regulatory.

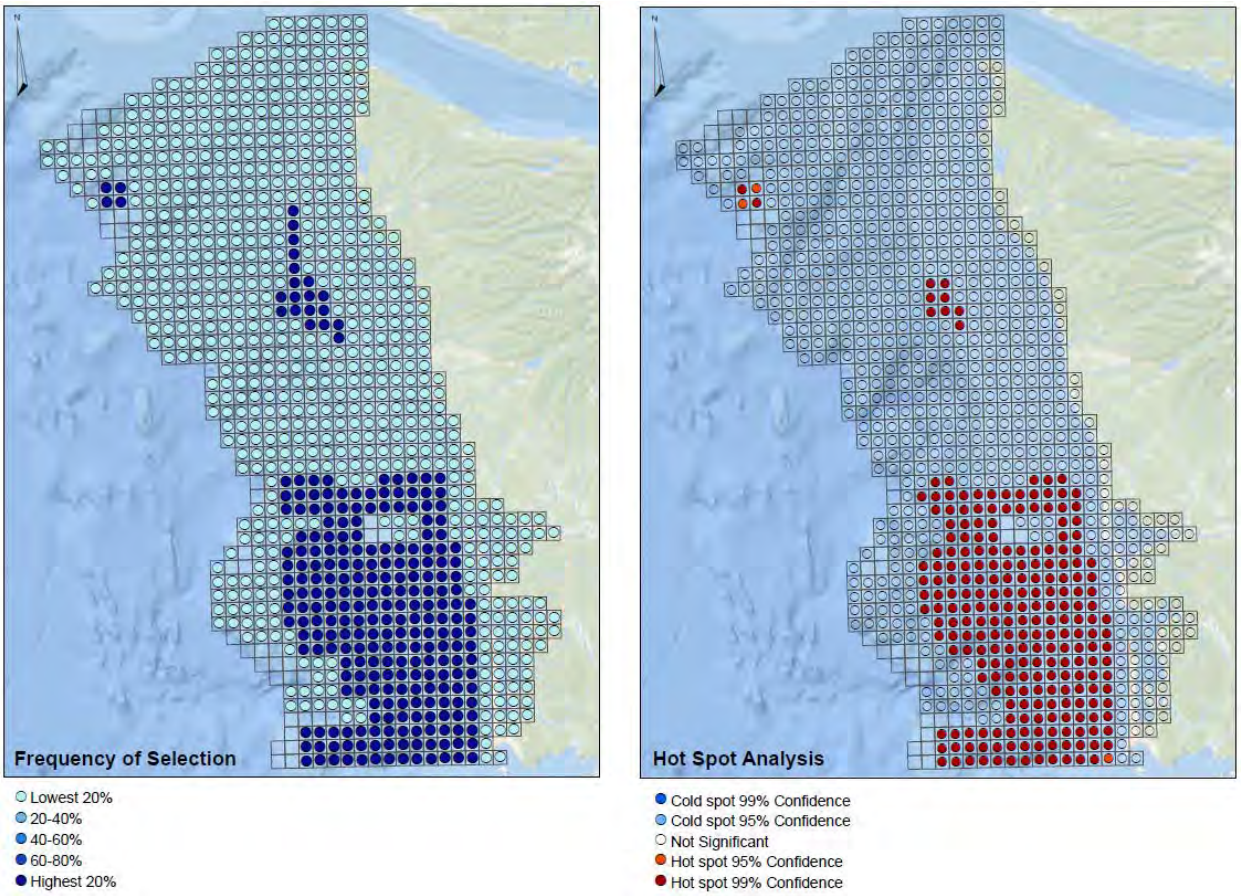


Figure 10: Frequency of "high priority" selections and associated hotspots for Sediment Management**.**

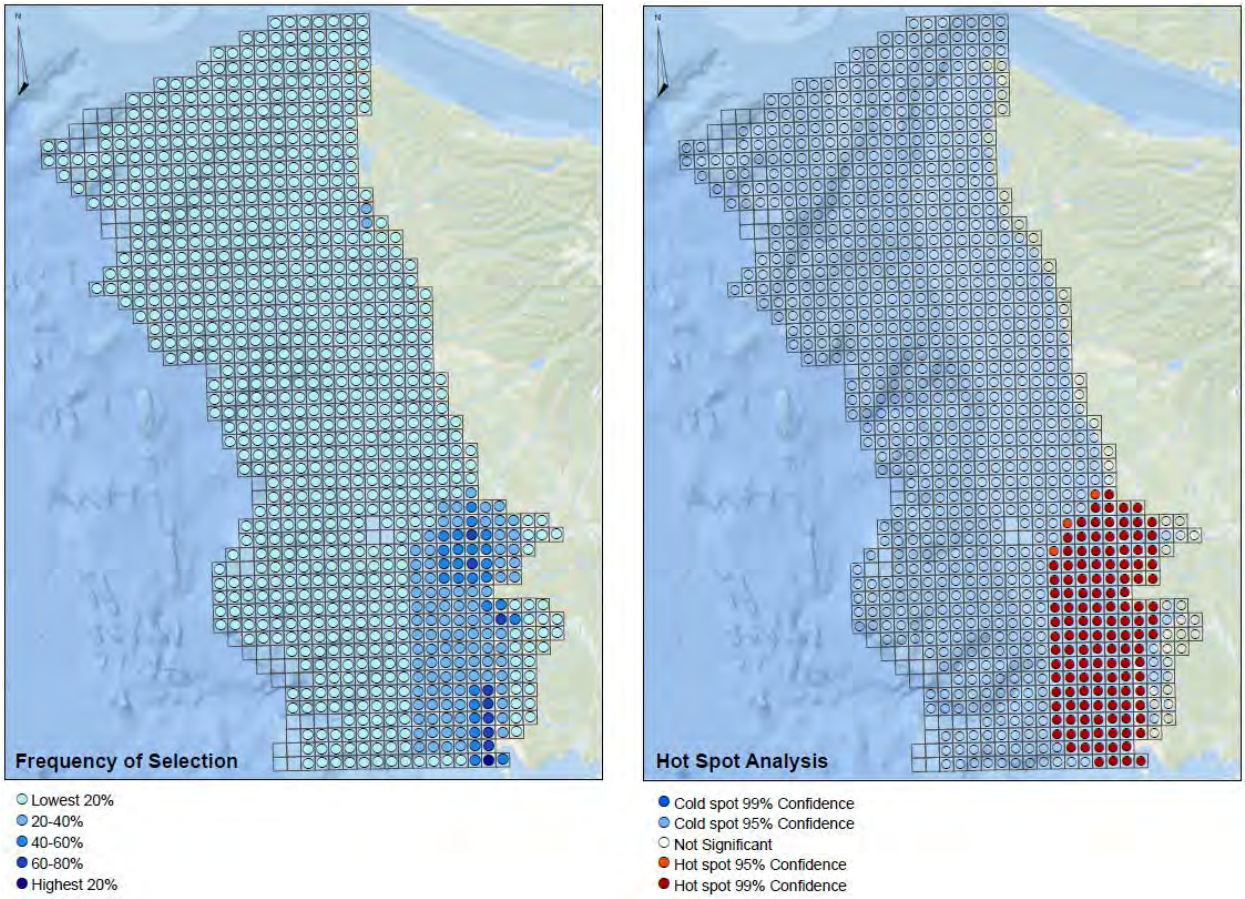
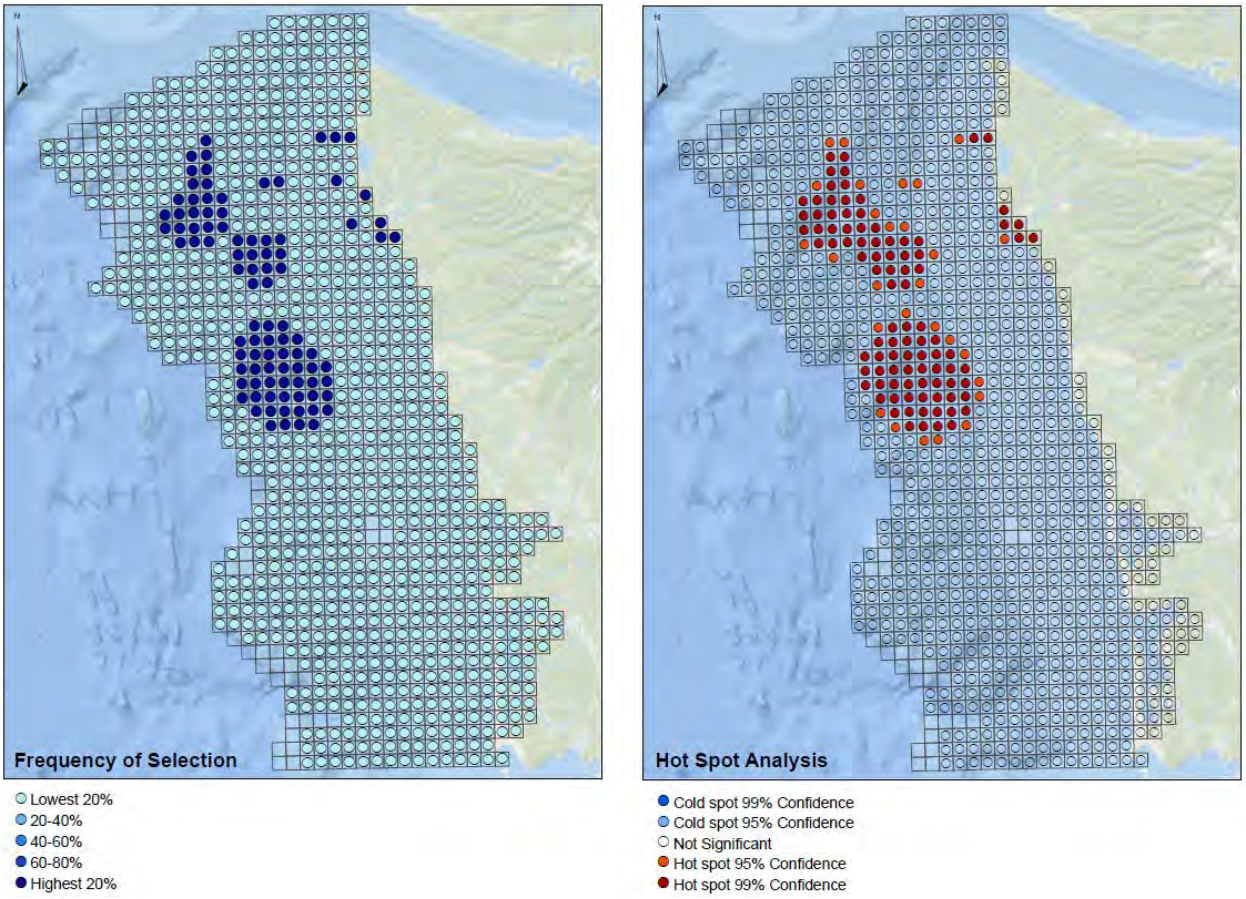


Figure 11: Frequency of "high priority" selections and associated hotspots for Research.



Integration and Spatial Prioritization

To identify regions in the area of interest as initial priority mapping targets, results of the 6 hotspot analysis were integrated into a single map depicting the cumulative frequency of hotspot detection. Furthermore, the original z-scores from individual hotspot maps were modeled using ESRI's geostatistical analyst "kriging" tool. Kriging is an interpolation technique in which the surrounding measured values are weighted to derive a predicted value for an unmeasured location. Weights are based on the distance between the measured points, the prediction locations, and the overall spatial arrangement among the measured points. Kriging is unique among the interpolation methods in that it provides an easy method for characterizing the variance, or the precision, of predictions.

This resulted in an interpolated hotspot map (heat map) for each of the 6 priority management issues identified. The heat maps were then integrated using ESRI's map algebra tool to generate a composite heat map. As a starting point to identify priority mapping targets, we generated an isopleth around the top 25th percentile of the composite heat map (Figure 12). A total of 5 unique regions were identified in

this process, and labelled as “offshore areas” 1, 2, and 3, and 2 “nearshore areas” (Figure 13). By comparing the priority boundaries and the gridded versions of the survey responses, a clearer perspective can be gained on the issues and criteria that prevailed in these areas where future mapping and analysis should be geared to address.

Noteworthy statistics for each preliminary mapping area are provided below.
Offshore area 1: Total Area=126 square miles; minimum depth=361 feet; maximum depth=2,428 feet; represents 1.5% of the entire area of interest, represents 2% of all “high priority” selections made by survey respondents; captures 4% of all “high priority” selections for the “living resource management” issue.

Offshore area 2: Total Area=738 square miles; minimum depth=275 feet; maximum depth=4,800 feet; represents 8% of the entire area of interest, represents 13% of all “high priority” selections made by survey respondents; captures 20% of all “high priority” selections for the “research” issue.

Offshore area 3: Total Area=387 square miles; minimum depth=275 feet; maximum depth=3,367 feet; represents 4% of the entire area of interest, represents 6% of all “high priority” selections made by survey respondents; captures 17% of all “high priority” selections for the “other regulatory” issue.

Nearshore area 1: Total Area=18 square miles; minimum depth=0 feet; maximum depth=141 feet; represents 0.2% of the entire area of interest, represents 0.6% of all “high priority” selections made by survey respondents.

Nearshore area 2: Total Area=1,332 square miles; minimum depth=0 feet; maximum depth=240 feet; represents 15% of the entire area of interest, represents 27% of all “high priority” selections made by survey respondents; captures 23% of all “high priority” selections for the “ecosystem based management” issue; captures 52% of all “high priority” selections for the “coastal inundation and hazards” issue, captures 67% of all “high priority” selections for the “sediment management” issue.

Additional summary statistics of response attributes for each of these areas is provided in Tables 4 to 8 below. Selection criteria associated with each management issue that were statistically significant are ***bolded and italicized***.

Figure 12: Frequency of hotspot analysis (left panel) and composite heat map.

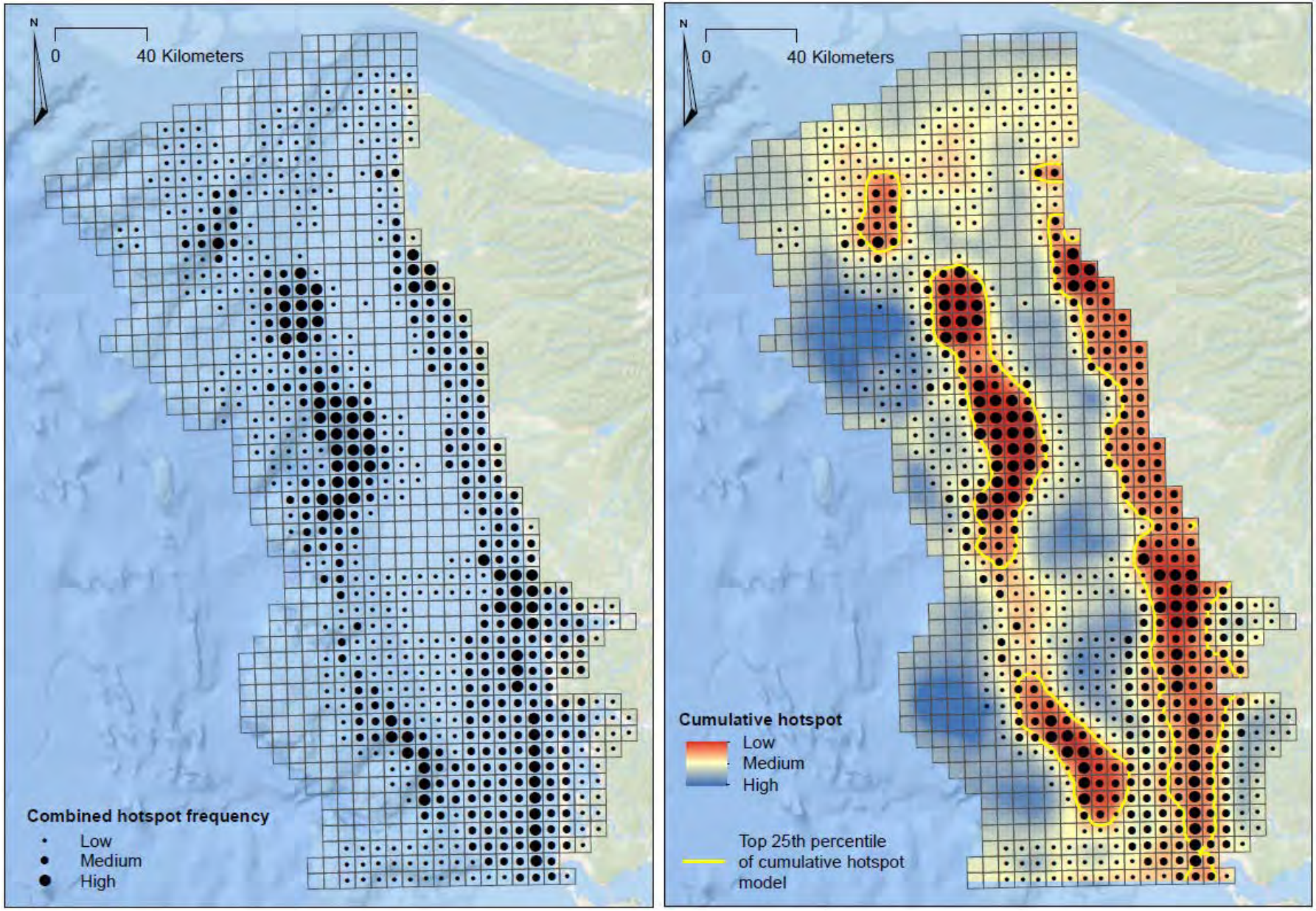


Figure 13: Preliminary priority mapping areas identified through cumulative hotspot analysis.

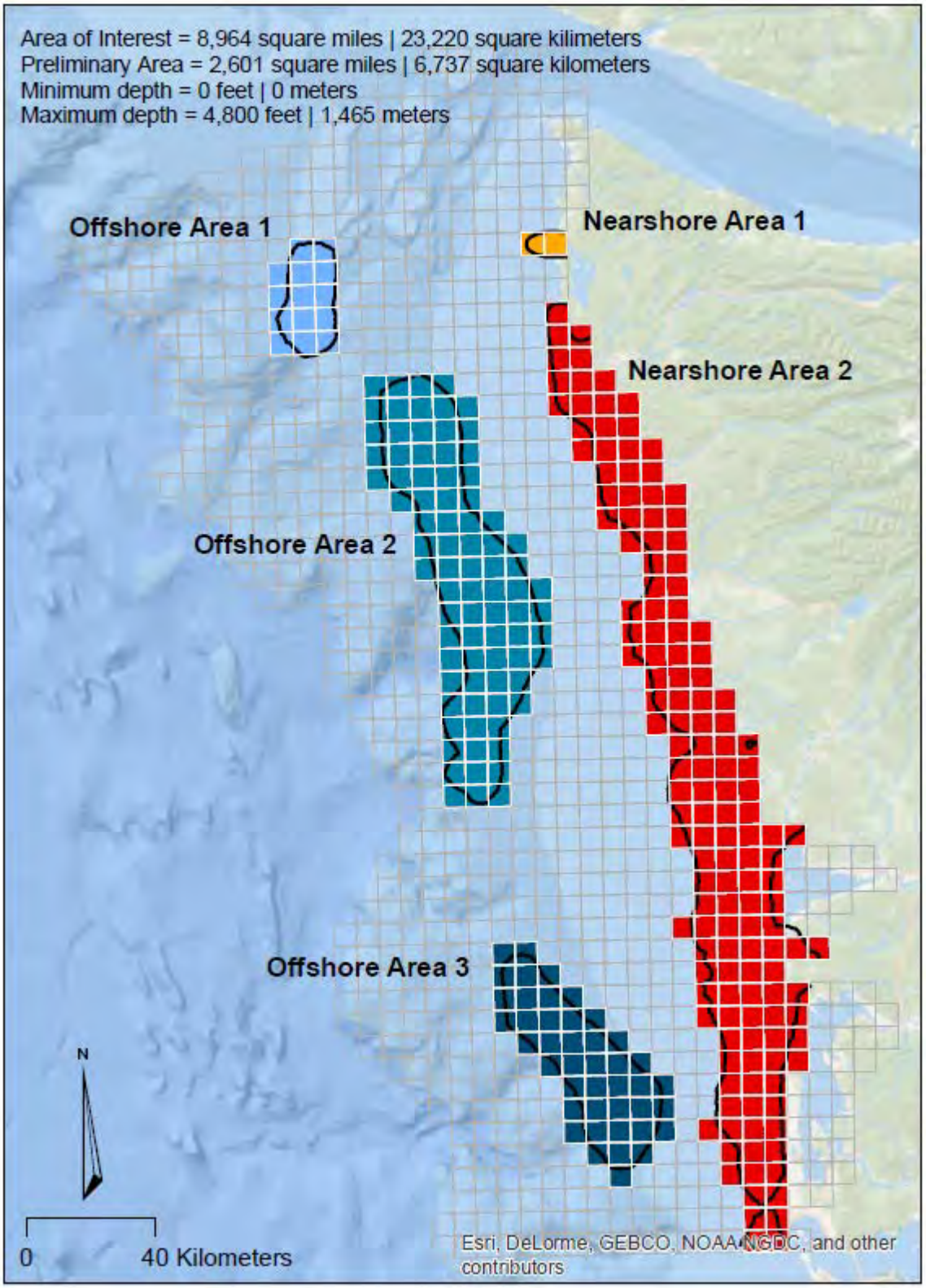


Table 4: Summary statistics of survey response attributes for offshore area 1.

Issue Captured	# Responses	% of Responses	Listed Criteria Captured
Ecosystem based management	62	34.6%	Multiple use, ***managed areas, knowledge gap, significant natural areas***, potential infrastructure
Living resource management	51	28.5%	***Knowledge gap, Significant natural area***
Coastal inundation	28	15.6%	***Other important areas***
Safety and Navigation	14	7.8%	***Multiple use***
Other	13	7.3%	***Other important areas***
Research	10	5.6%	***Knowledge gap***
Other regulatory	1	0.6%	***Potential infrastructure***
TOTALS	***179***	***100.0%***	

Table 5: Summary statistics of survey response attributes for offshore area 2.

Issue Captured	# Responses	% of Responses	Listed Criteria Captured
Living resource management	355	29.8%	***Knowledge gap, significant natural area,***existing infrastructure
Ecosystem based management	280	23.5%	Multiple use, ***managed areas, knowledge gap, significant natural areas***, high use areas
Coastal inundation	216	18.1%	Significant natural areas
Safety and Navigation	82	6.9%	***Multiple use***
Spill response	70	5.9%	***Significant natural areas***
Defense & homeland security	54	4.5%	***Other important areas***
Other	54	4.5%	***Other important areas***
Research	42	3.5%	***Knowledge gap***
Other regulatory	39	3.3%	***Potential infrastructure***, other important areas
TOTALS	***1192***	***100.0%***	

Table 6: Summary statistics of survey response attributes for offshore area 3.

Issue Captured	# Responses	% of Responses	Listed Criteria Captured
Ecosystem based management	228	41.6%	Multiple use, ***knowledge gap, significant natural area***, high ise area, potential infrastructure
Coastal inundation	118	21.5%	Significant natural areas, potential infrastructure, ***other important areas***
Living resource management	109	19.9%	***Knowledge gap, significant natural area***
Safety and Navigation	45	8.2%	***Multiple use, high use area***
Other regulatory	43	7.8%	***Potential infrastructure***
Sediment management	3	0.5%	***Knowledge gap***
Research	2	0.4%	***Knowledge gap***
TOTALS	***548***	***100.0%***	

Table 7: Summary statistics of survey response attributes for nearshore area 1.

Issue Captured	# Responses	% of Responses	Listed Criteria Captured
Coastal inundation	6	27.3%	Managed areas, knowledge gap, potential infrastructure, ***other important areas***
Ecosystem based management	5	22.7%	***Managed areas, knowledge gap***
Living resource management	3	13.6%	***Knowledge gap, significant natural area***
Safety and Navigation	2	9.1%	***Multiple use conflict***
Spill response	2	9.1%	***Significant natural areas***
Research	2	9.1%	***Knowledge gap***
Other	2	9.1%	***Other important areas***
TOTALS	22	100.0%	

Table 8: Summary statistics of survey response attributes for nearshore area 2.

Issue Captured	# Responses	% of Responses	Listed Criteria Captured
Living resource management	488	23.4%	Managed areas, ***knowledge gap, significant natural areas***, high use areas
Coastal inundation	482	23.1%	Managed areas, knowledge gap, significant natural areas, high use areas, ***existing infrastructure***, potential infrastructure, ***other important areas***
Ecosystem based management	420	20.2%	Multiple use, ***managed areas, knowledge gap, significant natural area***, potential infrastructure
Safety and navigation	253	12.1%	***Multiple use***, managed areas, ***high use areas***, existing infrastructure, potential infrastructure
Sediment management	121	5.8%	Multiple use, managed areas, ***knowledge gap***, significant natural area
Spill response	95	4.6%	***Significant natural areas***, high use areas, existing infrastructure
Other	67	3.2%	***Other important areas***
Other regulatory	59	2.8%	***Potential infrastructure***
Marine debris	34	1.6%	***Managed areas***
Defense and homlend security	34	1.6%	***Other important areas***
Research	30	1.4%	Managed areas, ***knowledge gap***
TOTALS	2083	100.0%	

3. PHASE IV: SPATIAL PRIORITIZATION WORKSHOP PART 2

The Phase IV workshop was intended assemble individuals, agencies, tribes, and other groups engaged in WA marine spatial planning to present the results of the Spatial Prioritization Exercise and seek further convergence on priority areas along Washington's Pacific Coast. The following specifies the tasks and objectives of the *Phase IV: Spatial Prioritization Workshop Part 2* as detailed in the Statement of Work:

> The task entails presenting the results and analysis from the Spatial Prioritization Exercise (Task 3) to Agency representatives. The Workshop is intended to further refine results to achieve consolidated consensus. A one-day workshop will be conducted either on-site or via Webex (to be determined by the State). If the State prefers an on-site Workshop, they will arrange the logistics of the venue, any costs associated with using the venue, and travel associated with participants attending the Workshop. A Technical Report on the Spatial Prioritization Process and results will be provided at the conclusion of this task. The Workshop tasks include, but are not limited to the following:
>
> - Workshop participants are sent results of spatial prioritization exercise prior to the workshop.
> - Exercise results are presented to the group
> - Participants modify and consolidate exercise results to produce consensus.
> - For each High priority region, the participants identify the types of products needed to support management needs identified in the survey and further clarify the explicit management needs of each high priority area.
> - Strategize on resources and funding to complete seafloor mapping in high priority areas.
> - Compile Workshop findings and action items in report including details on the high priority areas identified
> - Post-Workshop Activities (Multiple Months)
> - Outreach and coordination
>
> A report with compiled findings and action items identified during the second workshop will be delivered June 2015.

A workshop was held May 14th in which over 90 individuals were invited from federal and State agencies, tribes, academic institutions, and non-governmental organizations. Forty-three individuals participated in the workshop (25 in person and 18 via web-conferencing) (Table 9). See Figure 14 for workshop agenda. Briefings were given to provide the participants background on the project intent, methodologies use to analyze the spatial prioritization survey results, and individual agency survey responses (Figures 15 to 32).

Table 9: List of attendees at the WA Spatial Prioritization Workshop 2.

Name	Affiliation	Email Address:
Kelly Andrews	NOAA NWFSC	Kelly.Andrews@noaa.gov
Justine Barton	EPA Region 10	Barton.Justine@epa.gov
Tim Battista	NOAA NCCOS	Tim.Battista@noaa.gov
Ken Buja	NOAA NCCOS	Ken.Buja@noaa.gov
John Christensen	NOAA NCCOS	John.Christensen@noaa.gov
Ray Colby	Makah Tribe	Ray.Colby@makah.com
Jessi Doerpinghaus	WA DFW	Jessi.Doerpinghaus@dfw.wa.gov
Tim Doherty	NOAA OCM	Tim.Doherty@noaa.gov
Barry Eakins	NOAA NGDC	hbar461@ecy.wa.gov
Marie Eble	NOAA OAR	Marie.C.Eble@noaa.gov
Ben Evans	NOAA OCS	Benjamin.K.Evans@noaa.gov
George Galasso	NOAA OCNMS	George.Galasso@noaa.gov
Amanda Hacking	WA DOE	Amanda.Hacking@ecy.wa.gov
Jennifer Hagen	Quileute Tribe	Jennifer.Hagen@quileutenation.org
George Hart	USN	George.Hart1@navy.mil
Jennifer Hennessey	WA DOE	Jennifer.Hennessey@ecy.wa.gov
Rob Jones	NWIFSC	rjones@nwifc.org
Katherine Krueger	Quileute Tribe	Katie.Krueger@quileutetribe.com
Katrina Lassiter	WA DNR	Katrina.Lassiter@dnr.wa.gov
Jaime Liljegren	WA DOE	Jali461@ecy.wa.gov
Morgan McLemore	WA DAHP	Morgan.Mclemore@dahp.wa.gov
Charlie Menza	NOAA NCCOS	Charles.Menza@noaa.gov
Lonnie Reid-Poll	USACE	Lonnie.M.Reid-pell@usace.army.mil
James Robertson	TNC	jrobertson@tnc.org
Emily Roland	UW	eroland@uw.edu
Chris Romsos	OSU	cromsos@coas.oregonstate.edu
Michele Schallip	USCG	Michele.L.Schallip@uscg.mil
Donna Schroeder	BOEM	Donna.Schroeder@boem.gov
Joe Schumaker	Quinault Indian Nation	jschumacker@quinault.org
Tim Strickler	WA DNR	Tim.Strickler@dnr.wa.gov
Theresa Tien-Shui Tsou	WA DFW	Tien-shui.Tsou@dfw.wa.gov
Waldo Wakefield	NOAA NWFSC	Waldo.Wakefield@noaa.gov
Tim Walsh	WA DNR	Tim.Walsh@dnr.wa.gov
Heather Weiner	WA DOE	hbar461@ecy.wa.gov
Curt Whitmire	NOAA NWFSC	Curt.Whitmire@noaa.gov
Lindsey Wright	UW JISAO	Lyndsey.Wright@noaa.gov
Nancy Wright	NOAA OCNMS	Nancy.Wright@noaa.gov

Figure 14: WA Spatial Prioritization Workshop 2 Agenda.

Prioritizing Seafloor Mapping for Washington's Pacific Coast
Workshop 2 (May 14, 2015) 9:30am-3:30pm PST
Department of Ecology, Lacey, WA
On-site Host Contact: Jennifer Hennessey, Jennifer.Hennessey@ecy.wa.gov, 360-407-6595

9:30-9:45	J. Hennessy	Goals, Agenda, Around the Room Introductions
9:45-10:00	T. Battista	Spatial Prioritization Process and High Level Results
10:00-10:30	J. Christensen	Spatial Prioritization Process and Detailed Results
10:30-10:45	Break	
10:45-11:15	All	Group Discussion of Results
11:15-12:00	Groups	Breakout Groups: Nearshore and Offshore PGIS and Justification
12:00-12:45	Lunch (On your own in cafeteria)	
12:45-1:15	Groups	(continue) Breakout Groups: Nearshore and Offshore PGIS and Justification
1:15-1:45	Group Leads	Nearshore and Offshore Report Out
1:45-2:30	Groups	Breakout Exercise: Product Categories Ranking
2:30-2:45	Group Leads	Nearshore and Offshore Report Out
3:00-3:30	J. Hennessey & T. Battista	Next Steps, Action Items, & Discussion. The way forward.

Figure 15: BOEM Spatial Prioritization Response.

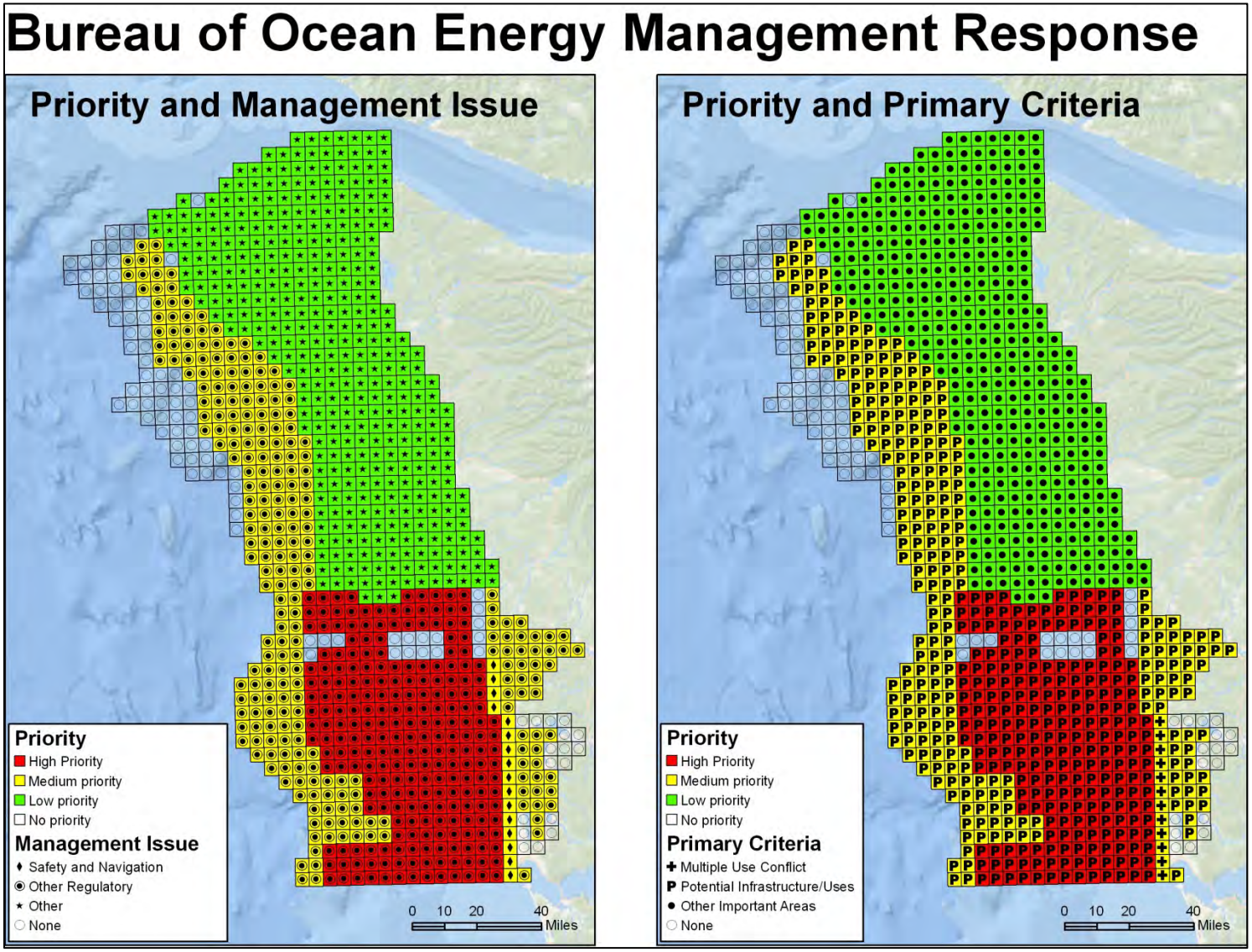


Figure 16: EPA Spatial Prioritization Response.

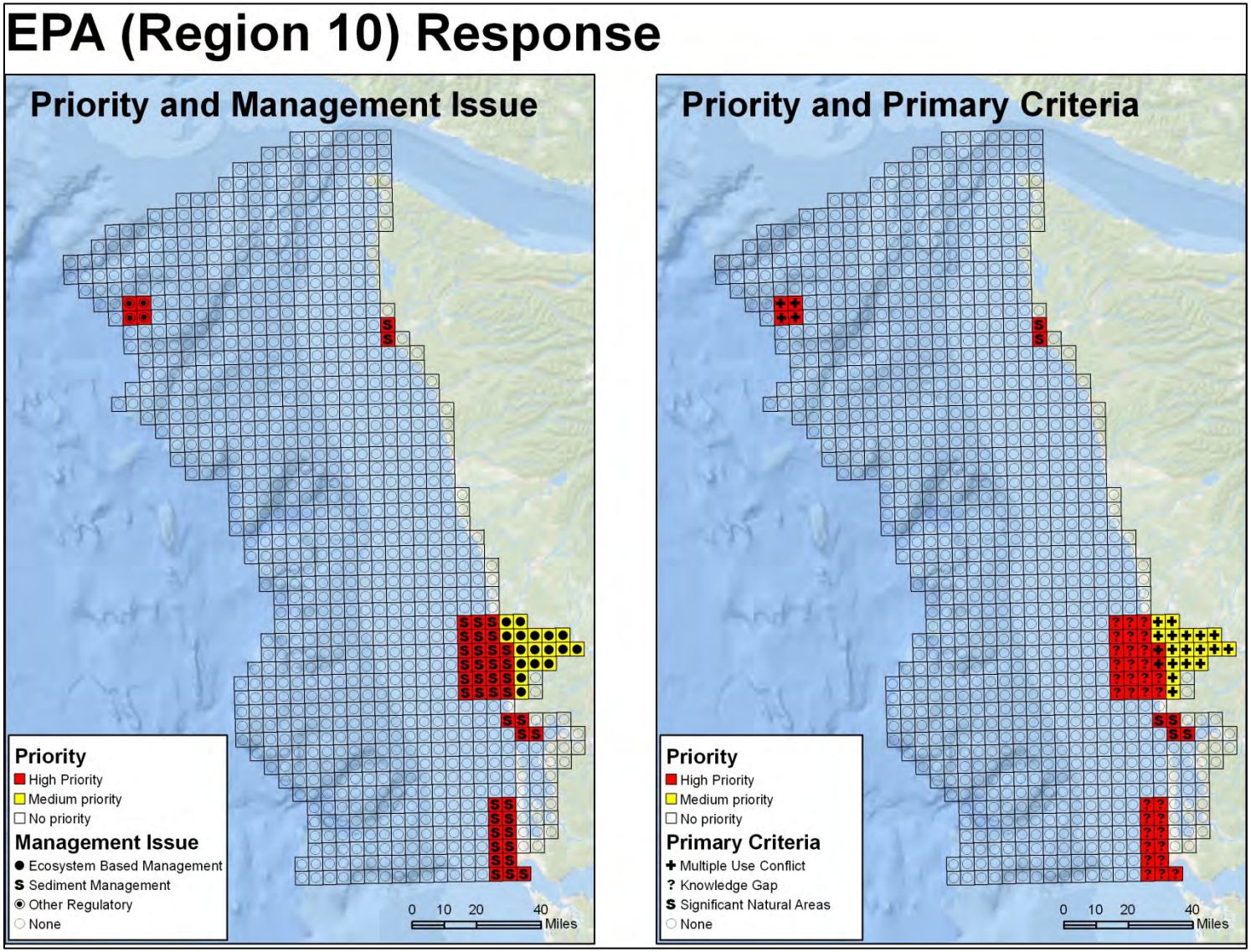


Figure 17: US Navy Spatial Prioritization Response.

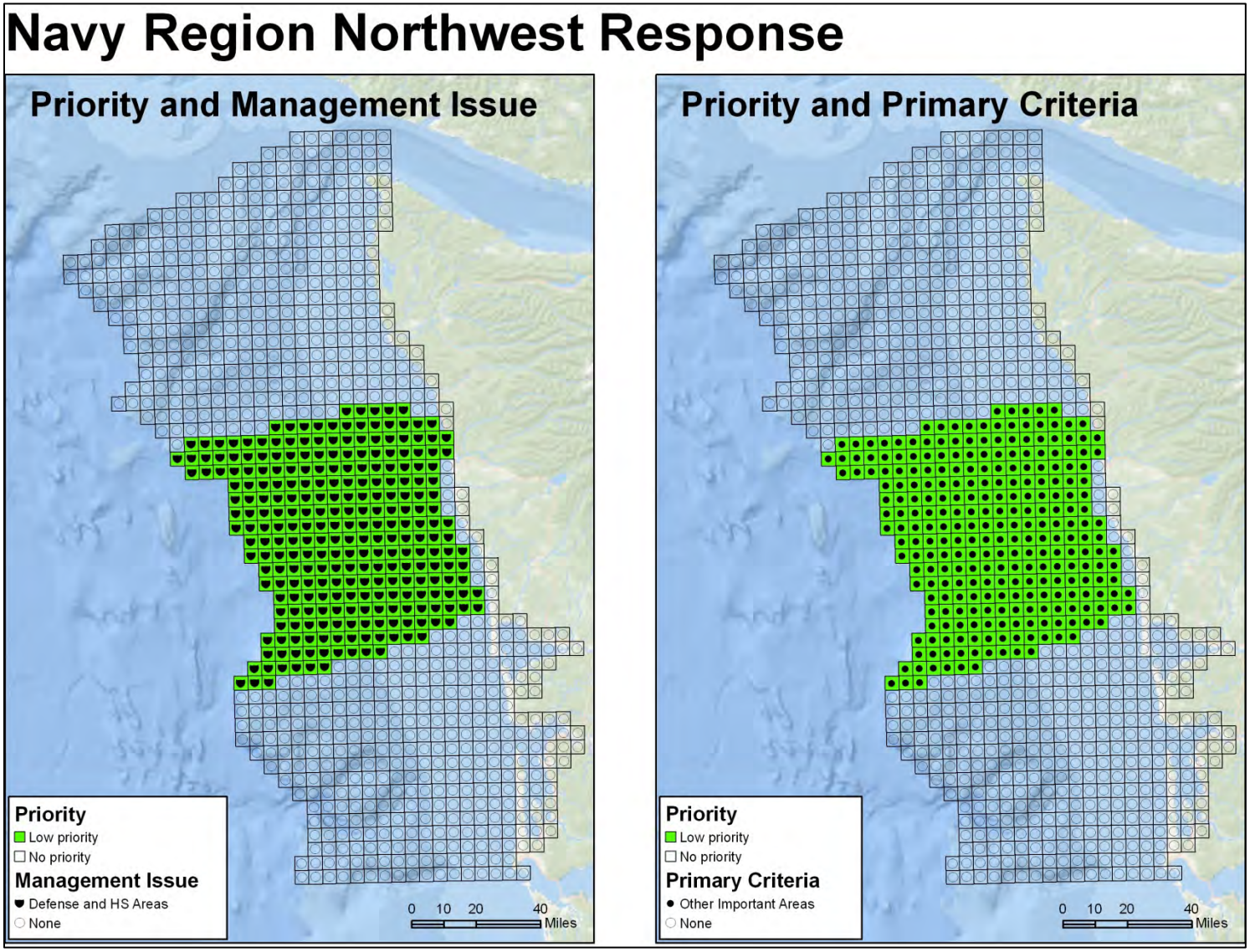


Figure 18: NOAA NWFSC ESP Spatial Prioritization Response.

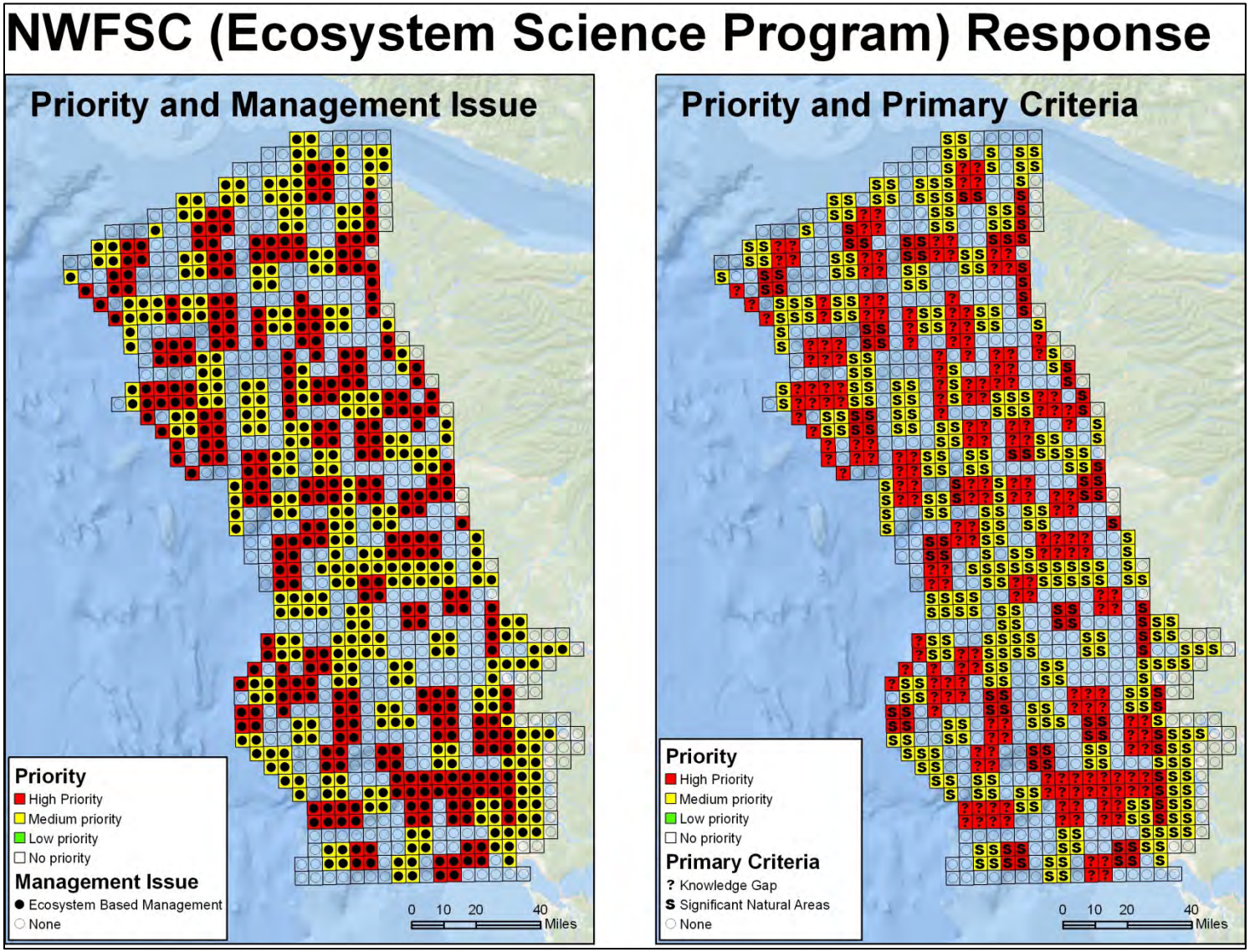


Figure 19: NOAA NWFSC GRD Spatial Prioritization Response.

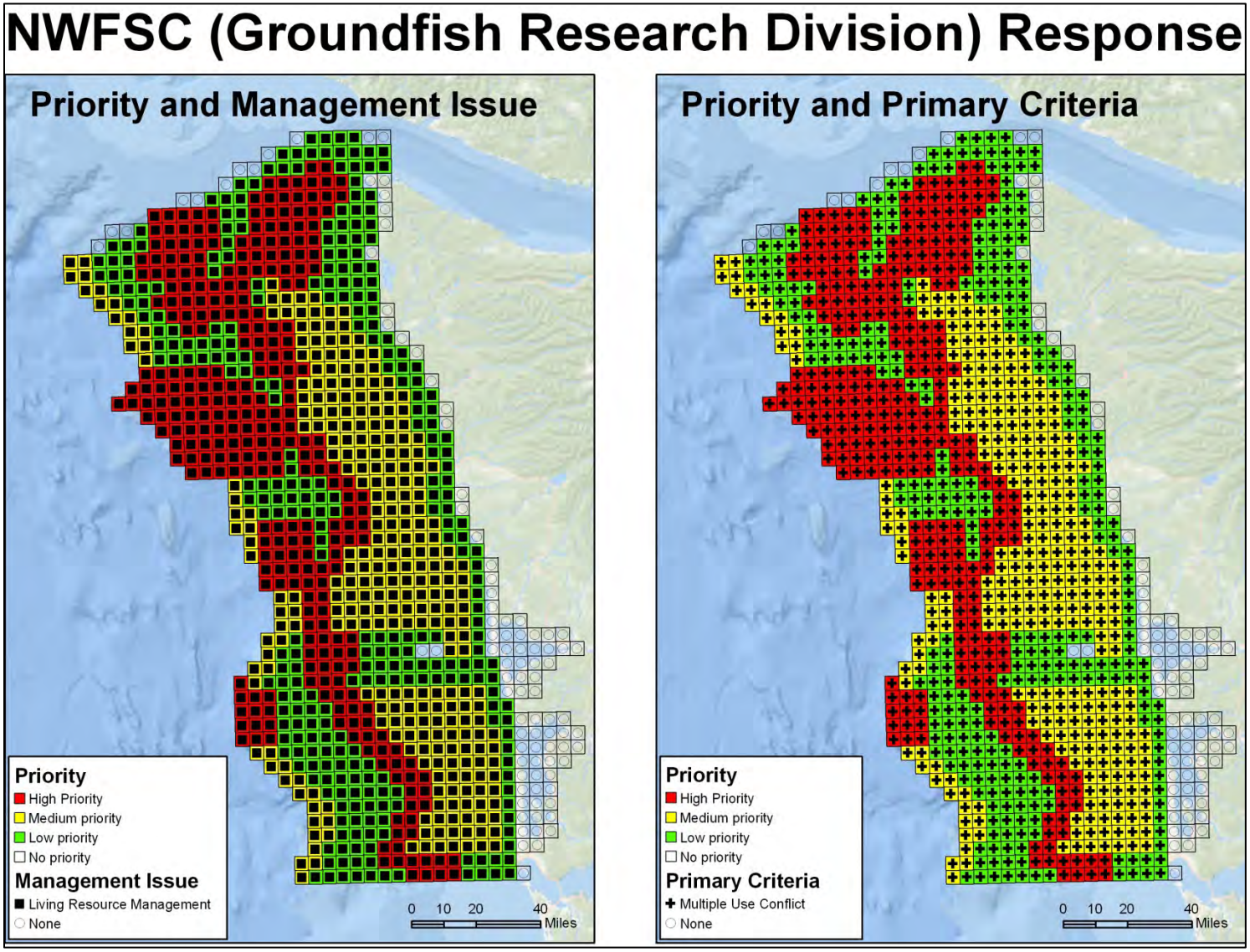


Figure 20: NOAA NMFS West Coast Region Spatial Prioritization Response.

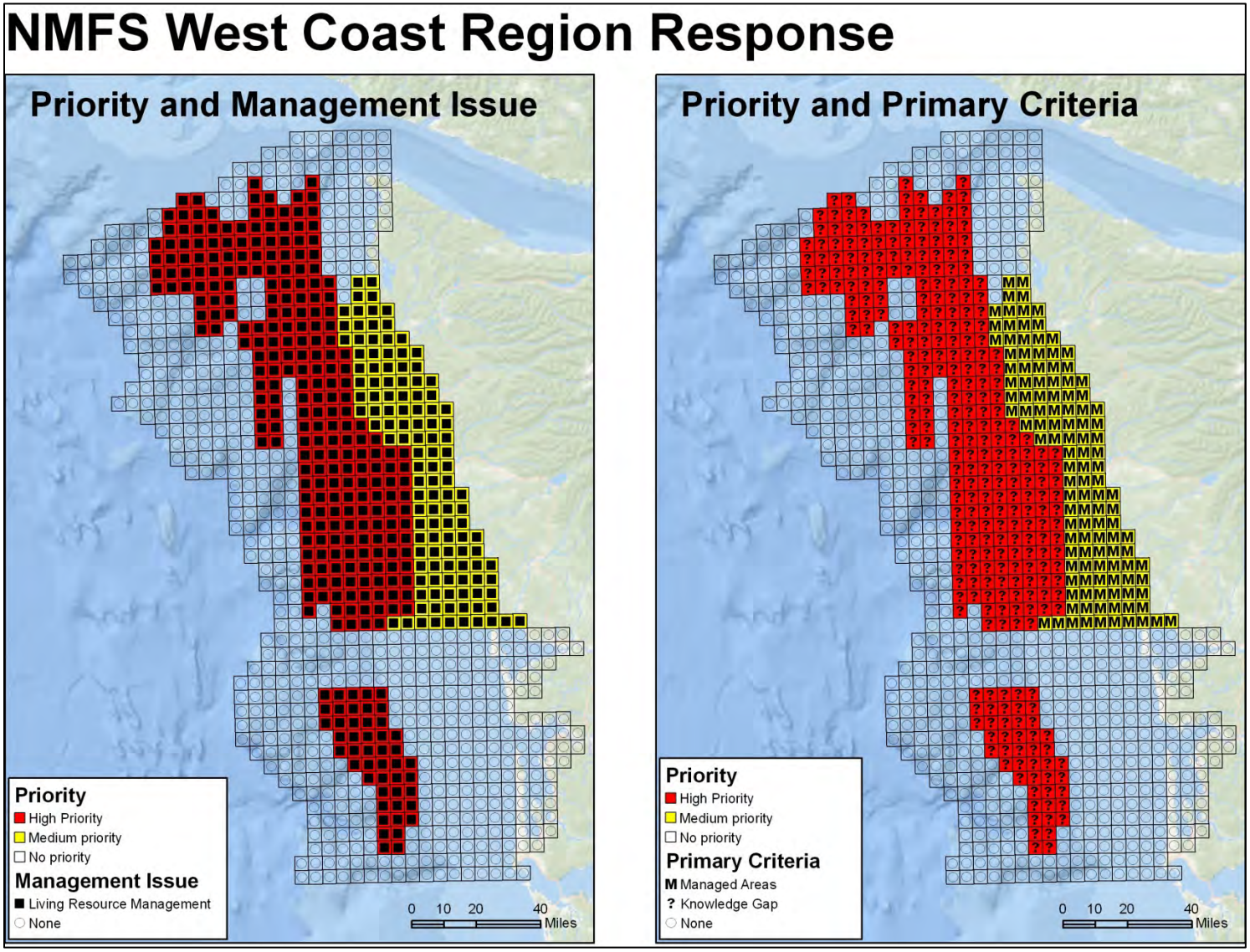


Figure 21: NOAA OCS Spatial Prioritization Response.

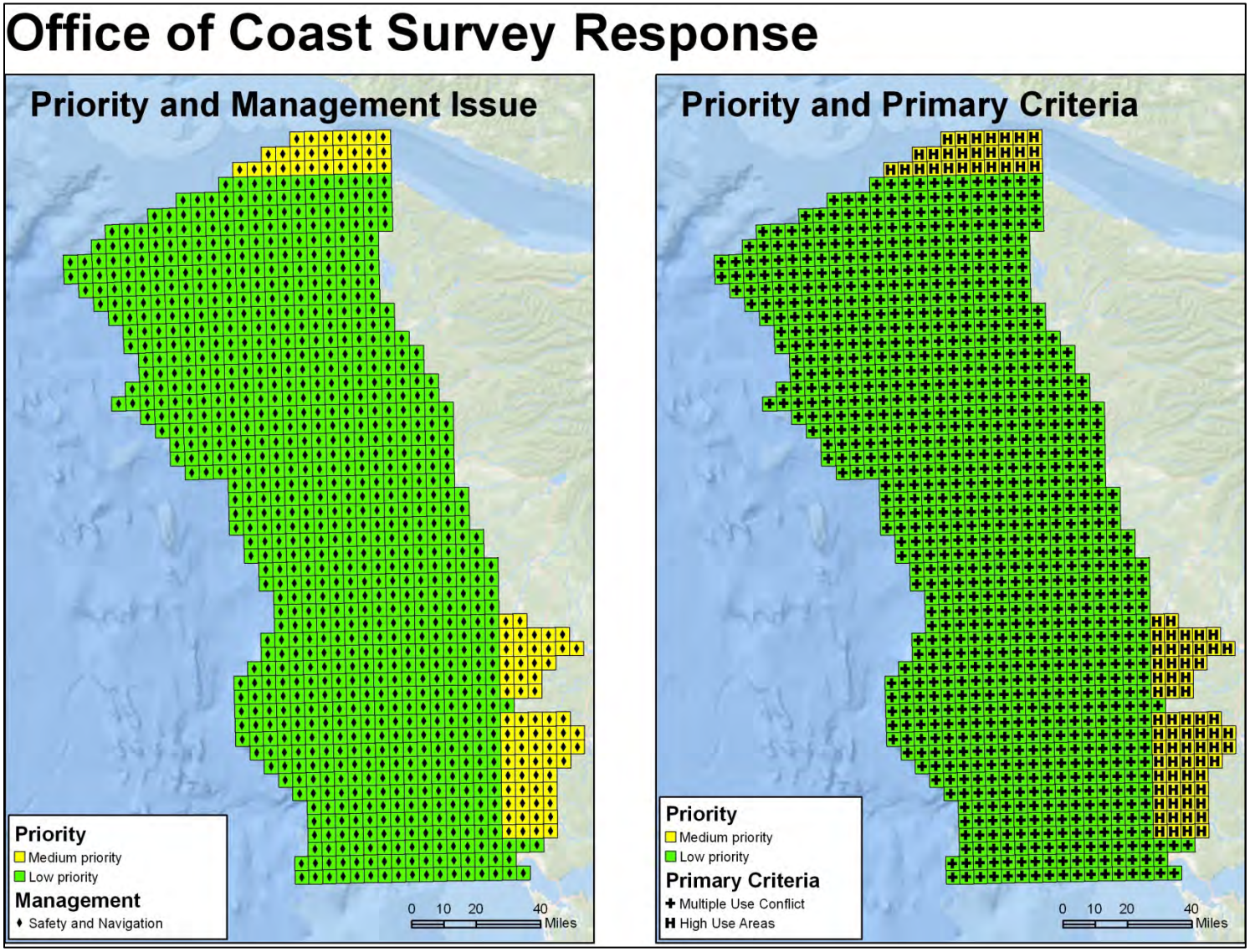


Figure 22: NOAA OCNMS Spatial Prioritization Response.

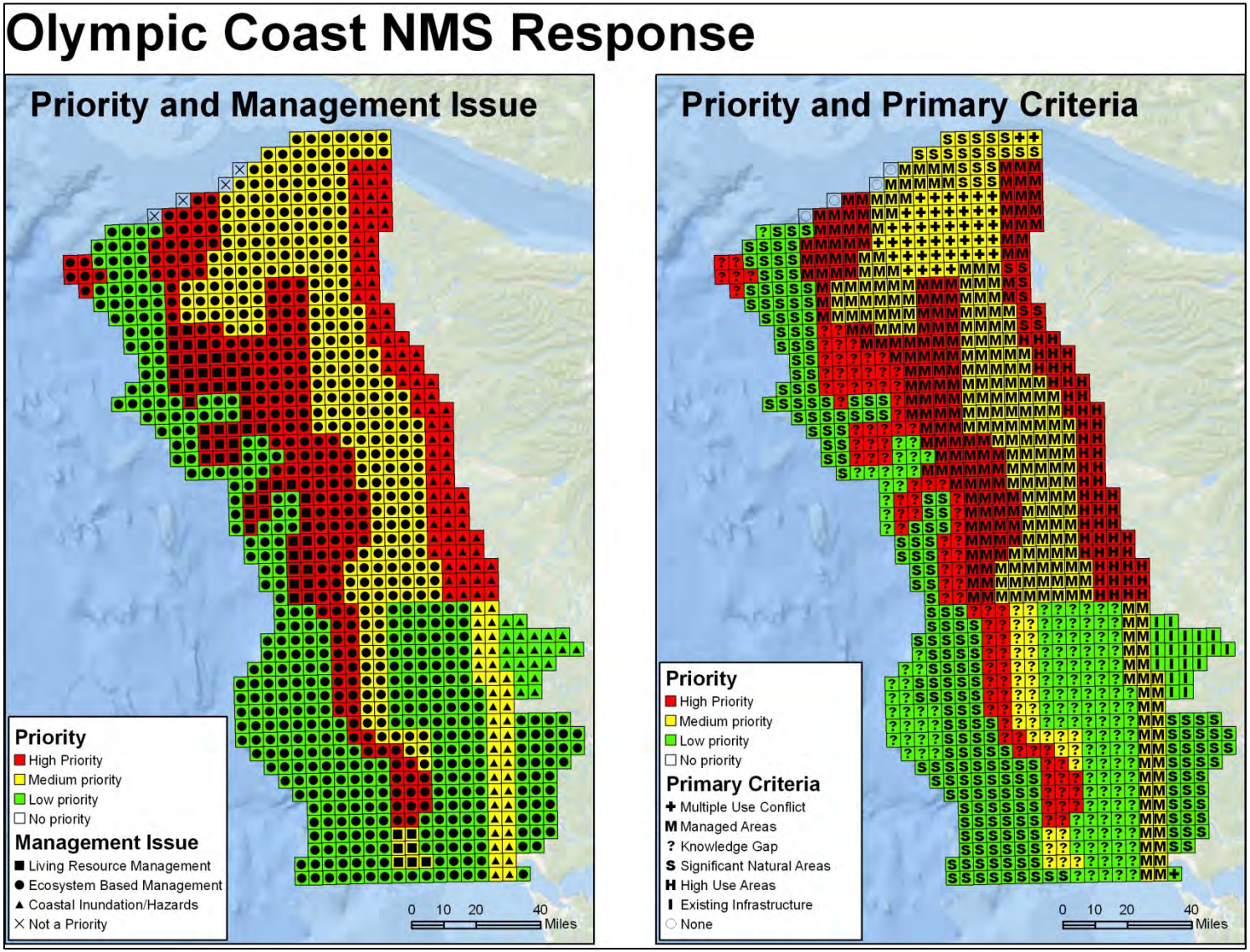


Figure 23: NOAA PMEL Spatial Prioritization Response.

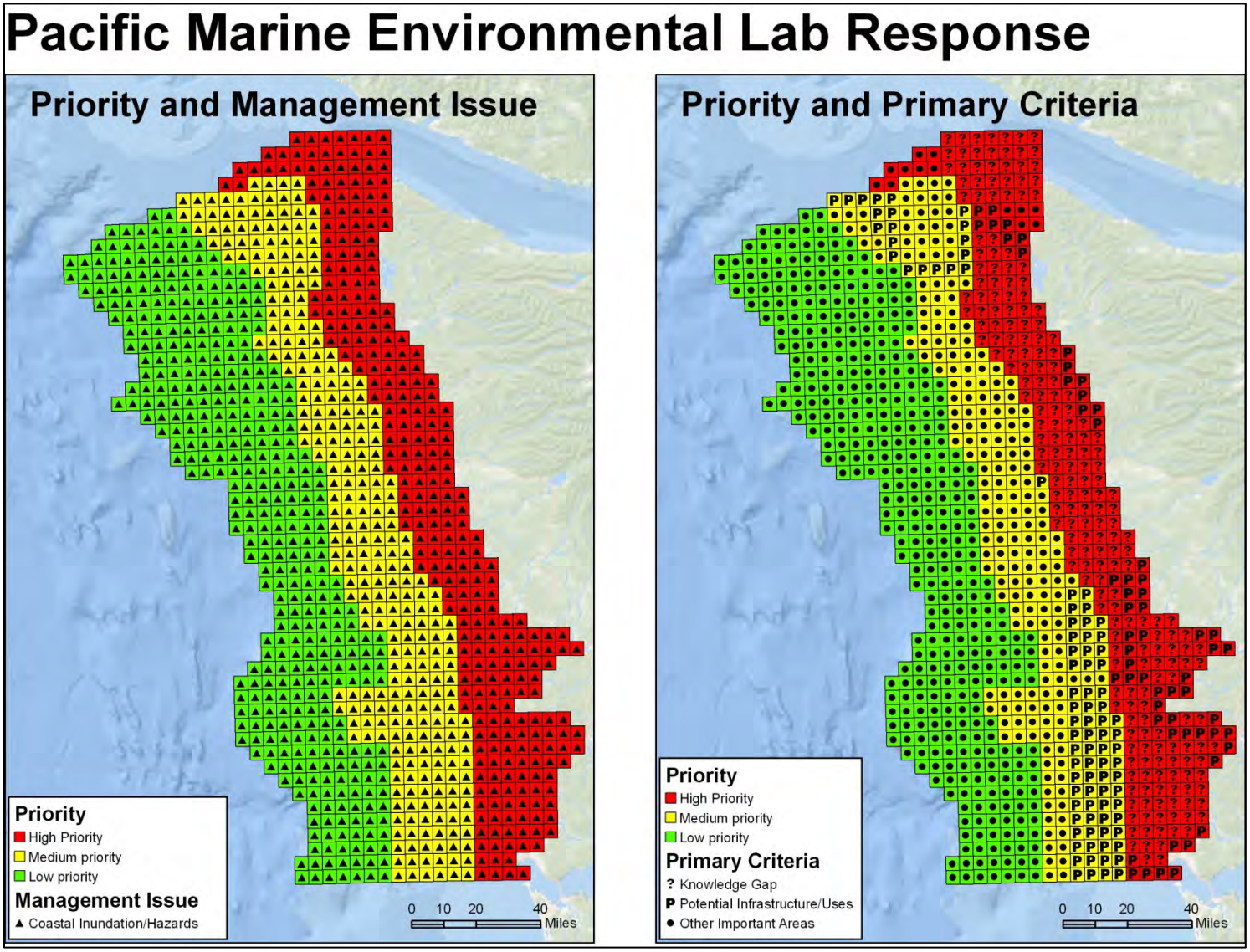


Figure 24: Quileute Tribe Spatial Prioritization Response.

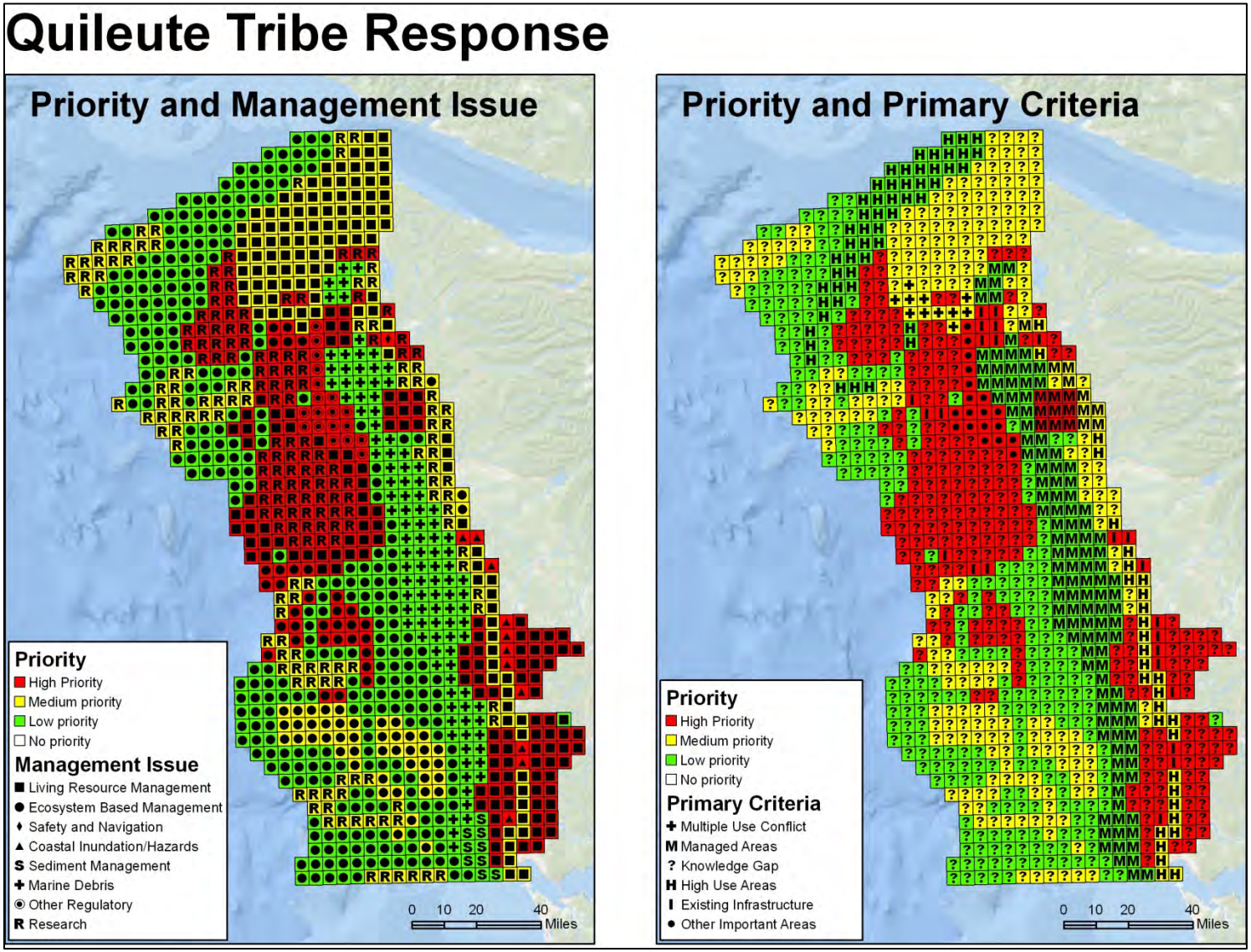


Figure 25: Quinault Indian Nation Spatial Prioritization Response.

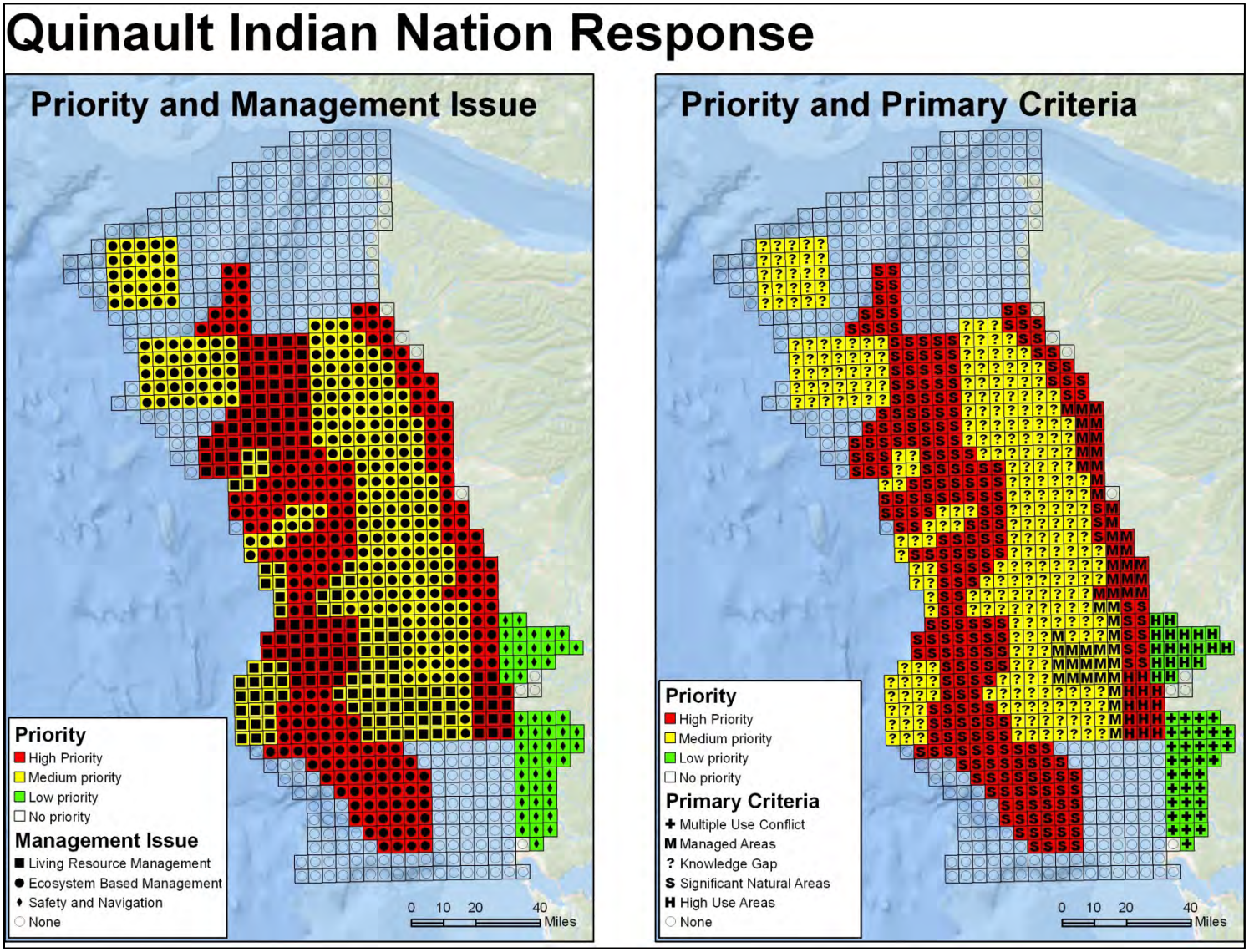


Figure 26: USACE Spatial Prioritization Response.

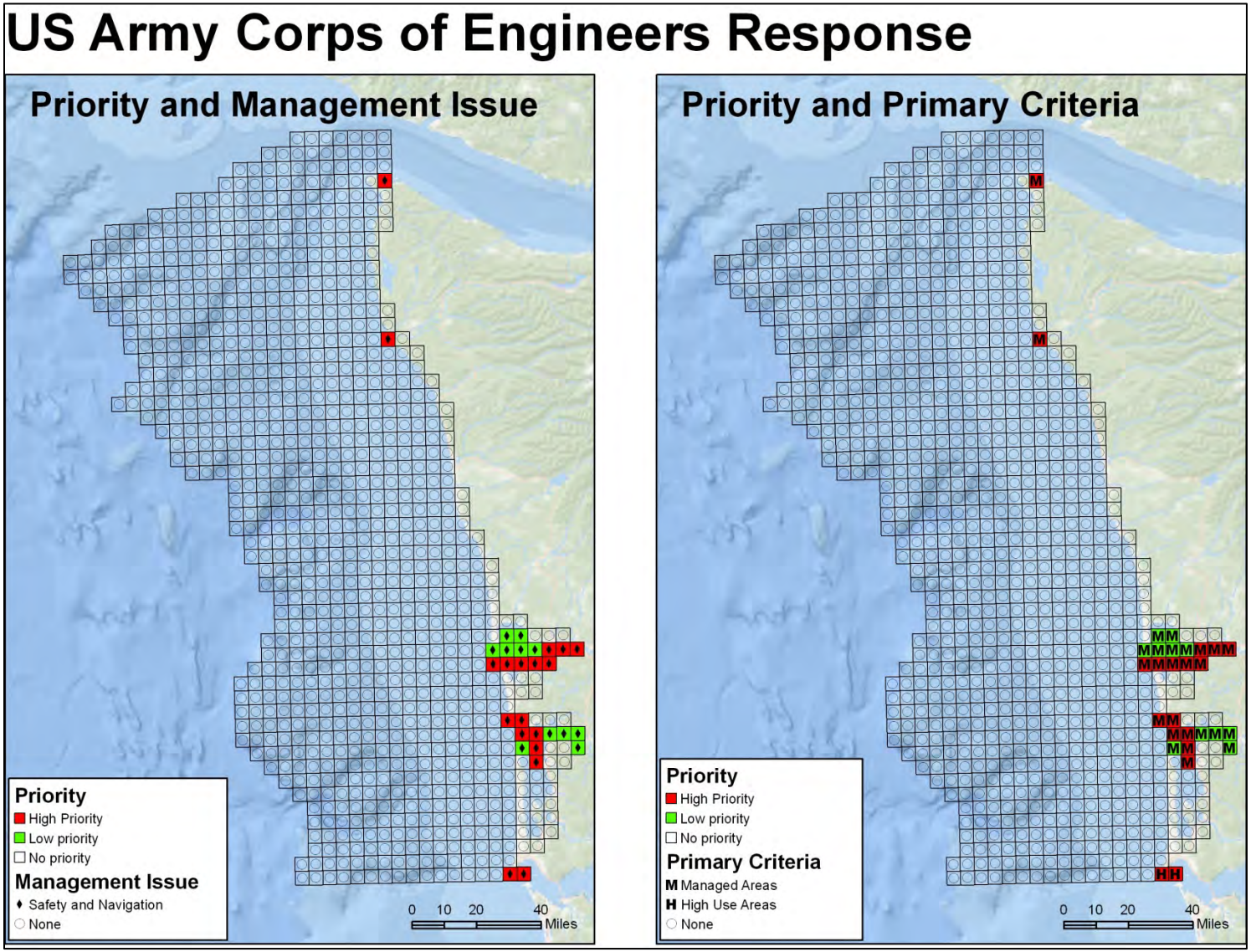


Figure 27: USCG Spatial Prioritization Response.

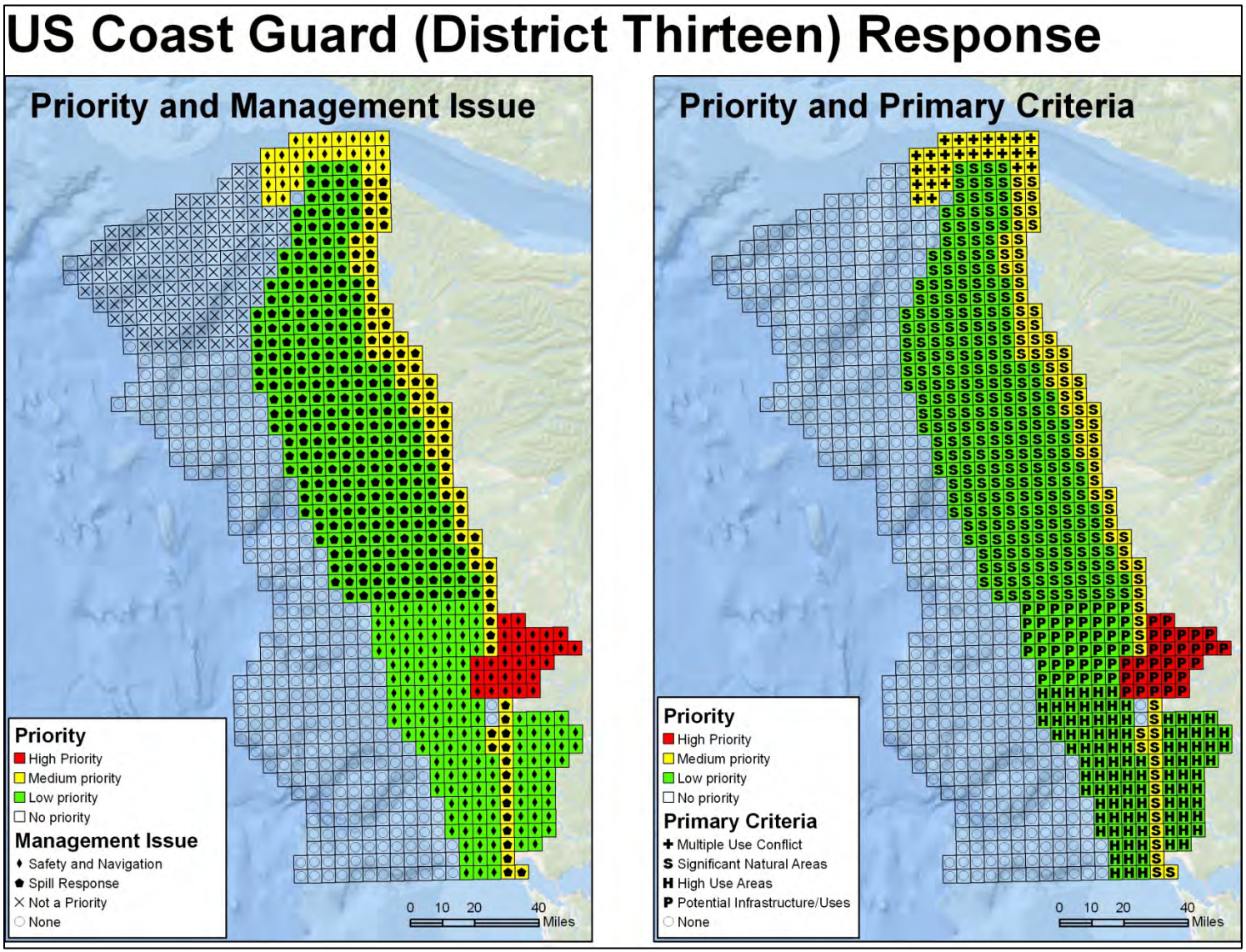


Figure 28: USGS Spatial Prioritization Response.

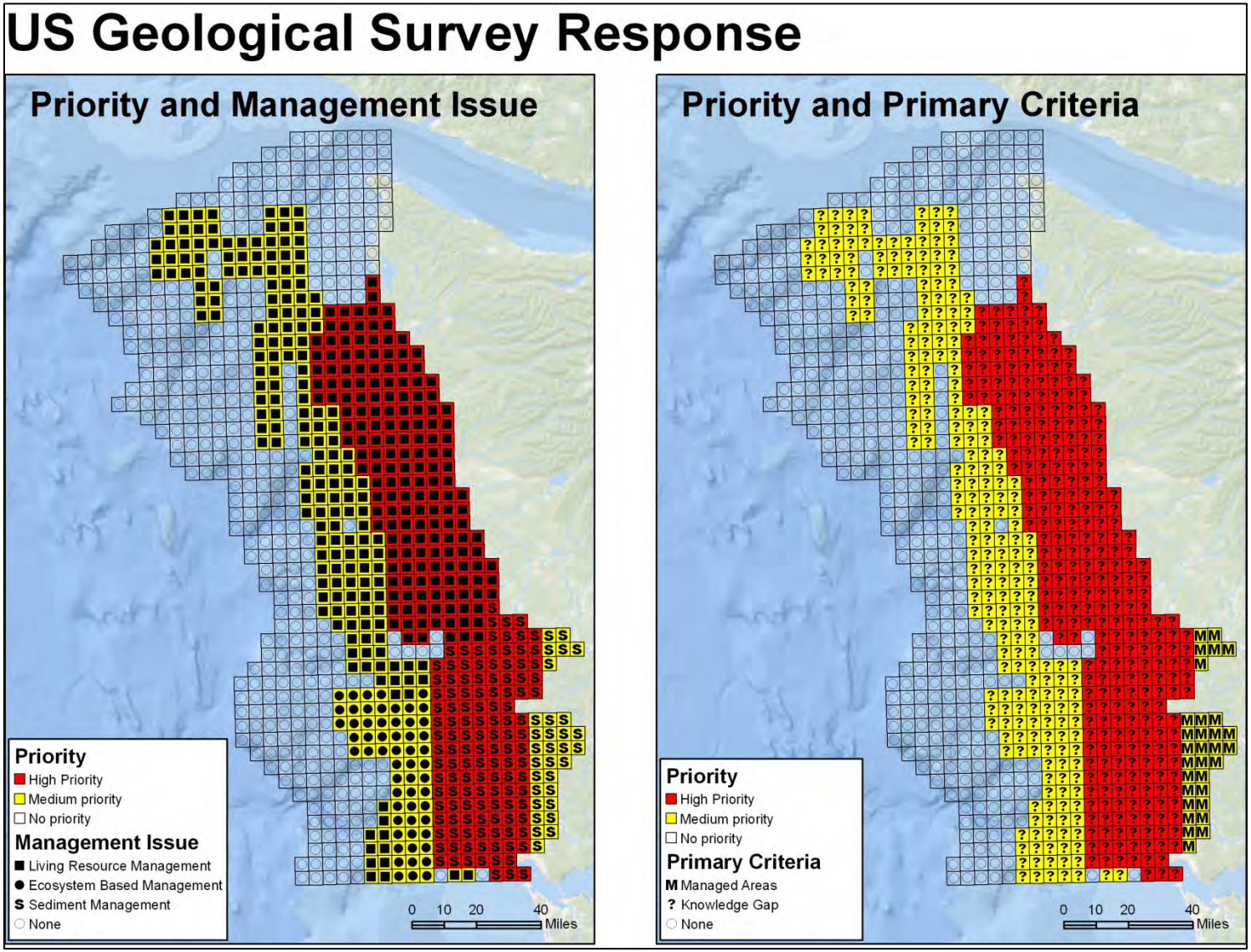


Figure 29: WA DFW Spatial Prioritization Response.

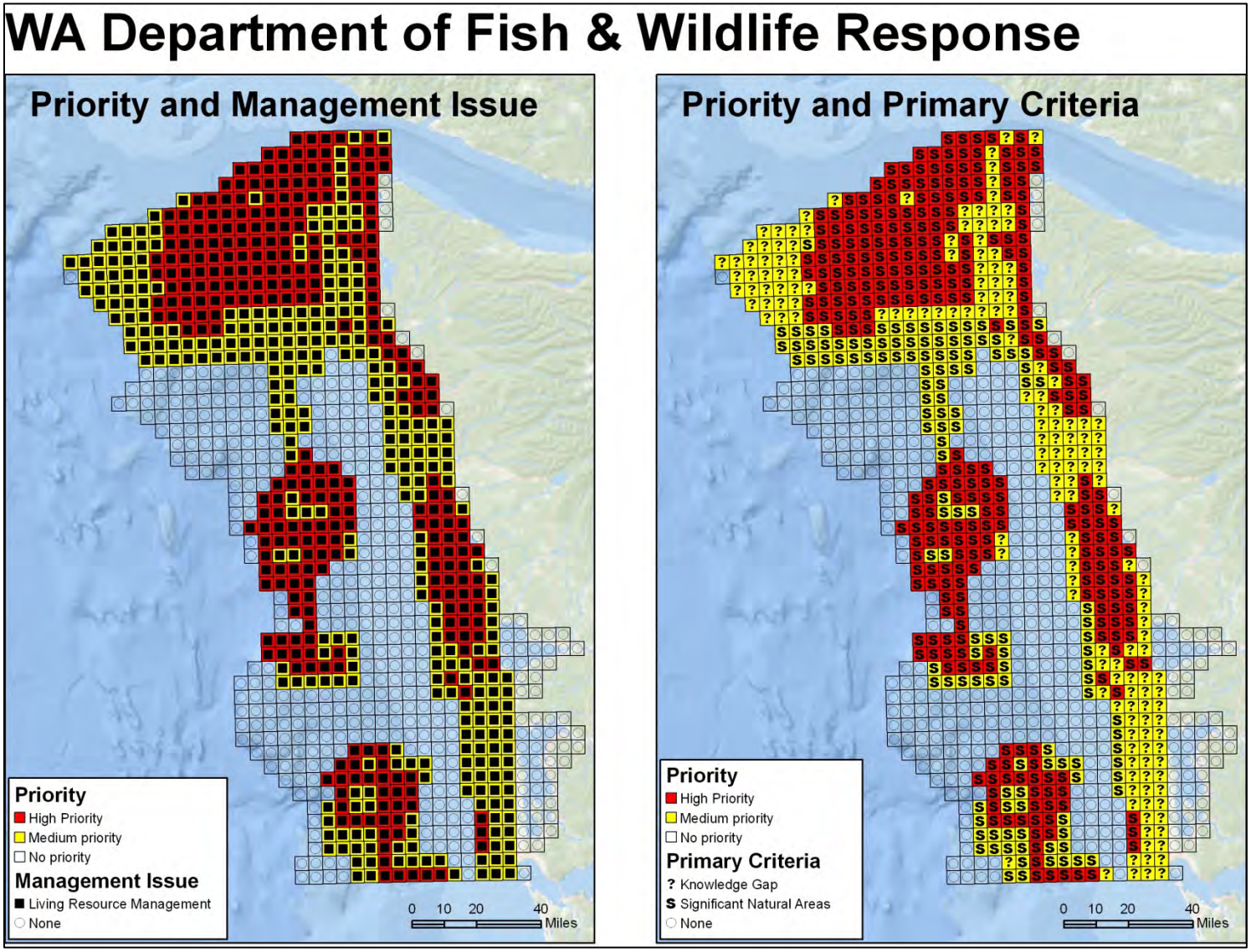


Figure 30: WA DNR Spatial Prioritization Response.

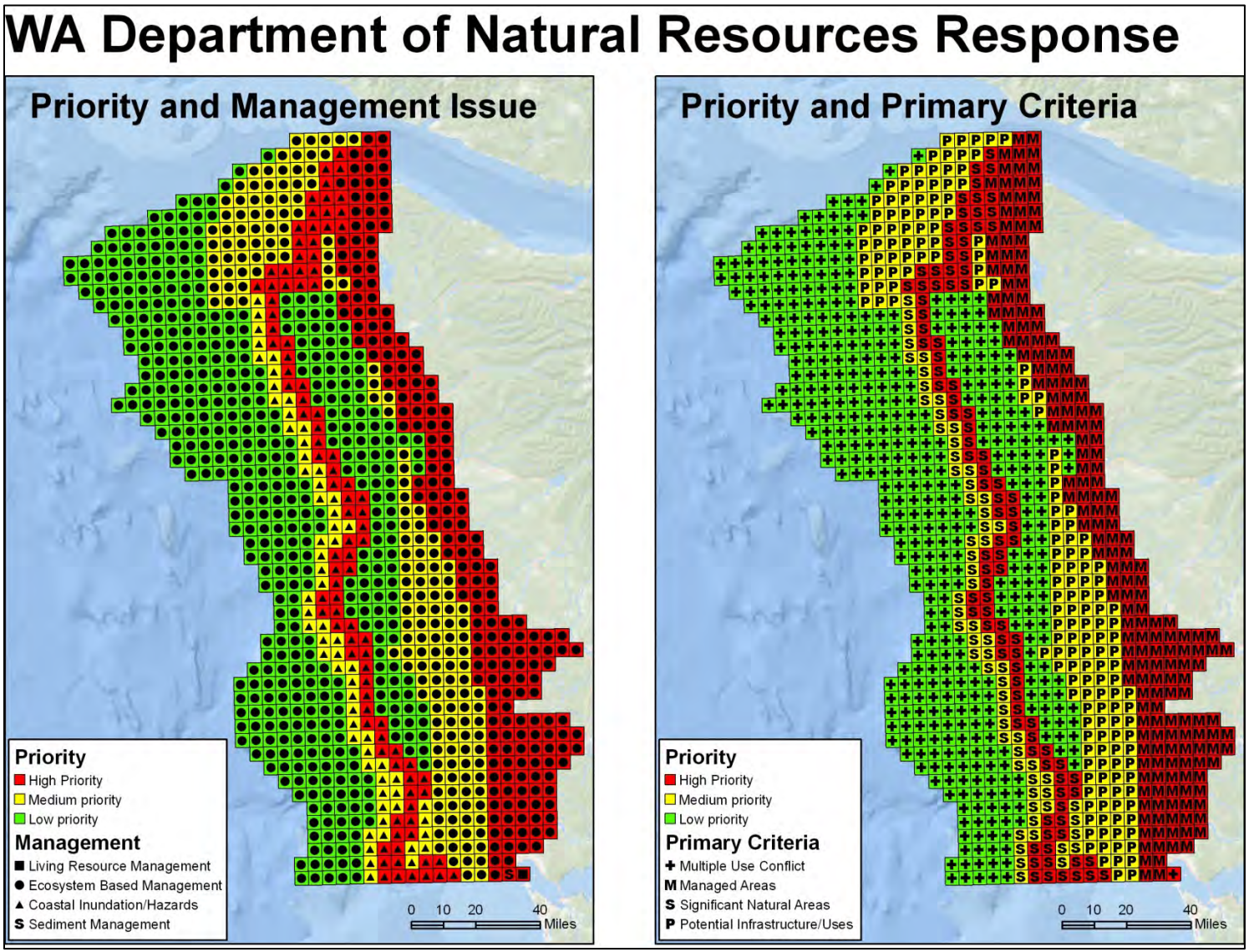


Figure 31: WA DOE Spatial Prioritization Response.

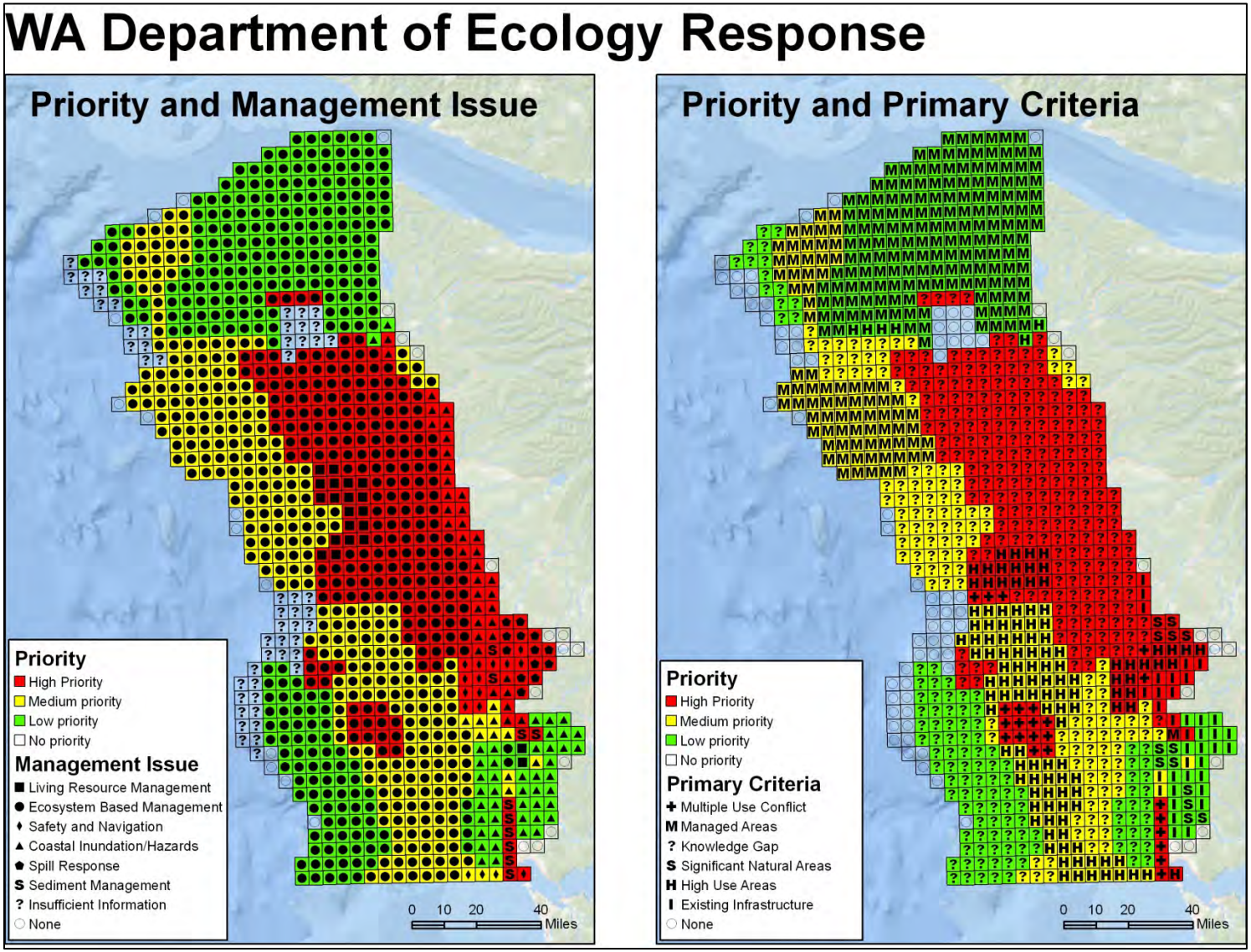
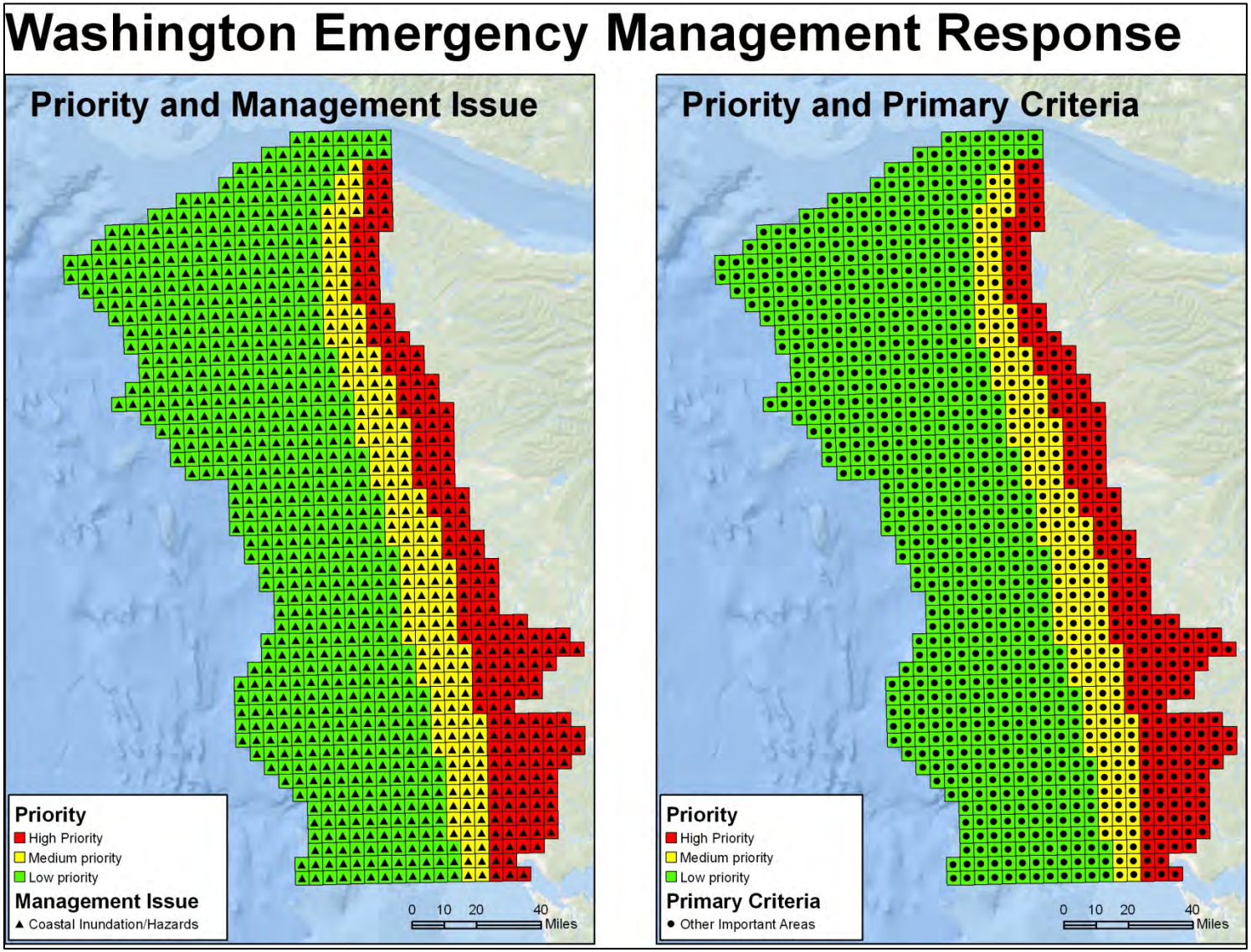


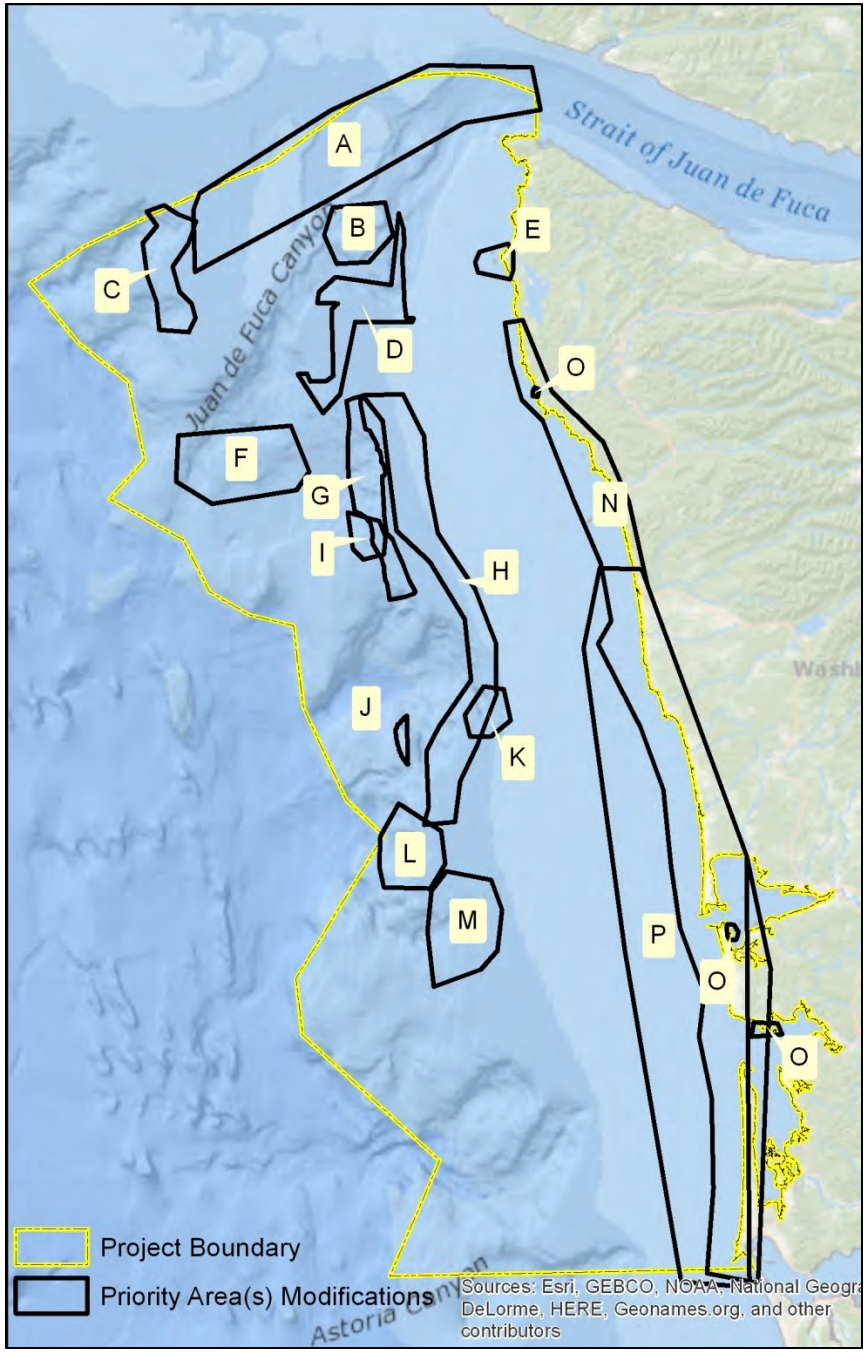
Figure 32: WA EMR Spatial Prioritization Response.



3.2. PRIORITY AREA(S) REFINEMENT (BREAKOUT GROUPS)

The workshop participants divided into two sub-groups to discuss and comment on the proposed priority areas identified (Figure 13) through the analysis. Discussions focused on the need to expand, contract, or add additional areas of management significance not captured through the spatial prioritization exercise. The group focused on reviewing supporting information available within the priority areas to ascertain whether sufficient existing seafloor mapping data was available which would preclude the necessity for additional collection. Several locations were identified meeting this criterion, and through Participatory GIS boundary modification were proposed and comments captured (Figure 33). A total of sixteen boundary modifications were annotated which can be incorporated in subsequent analysis and revisions.

Figure 33: Workshop participant comments on priority areas.



Label	Comments
A	Important Chilipepper rockfish habitat but subsequent evaluation shows good data coverage.
B	Identified as EFH area lacking existing data
C	Identified as important fish habitat area adjacent to Nitinat Canyon. Subsequent evaluation shows good data coverage here for western portion.
D	Identified as important habitat along 200m isobath.
E	Reduce this area to areas where sufficient data is not available to support cultural resource issues.
F	Identified as EFH area but subsequent evaluation shows good data coverage.
G	Potential to remove from priority area as data already exists.
H	This area could be mapped at coarser resolution to further prioritize mapping effort.
I	Included important fish habitat areabut subsequent evaluation shows good data coverage.
J	Potential to remove from priority area as data already exists.
K	Included important fish habitat area.
L	Identified as important area along the 200m isobath but subsequent evaluation shows good data coverage.
M	Medium priority area as is a knowledge gap
N	Narrow the nearshore highest priority to 0-25m (and locations straddling the 200m shelf break) where higher resolution data is needed. Collect lower resolution data >25m depth.
O	Expand to include Toke Point, La Push, and Westport Tsunami Inundation Priority locations
P	Refine southern nearshore to focus data collection surrounding population density centers to support coastal inundation risk assessment.

3.3. SEAFLOOR MAPPING PRODUCT CATEGORIES (BREAKOUT GROUPS)

The workshop participants were asked to consider a suite of possible products for Washington's Outer Coast, and rank them according to their utility in supporting management decisions for both the nearshore and offshore priority areas. . The results of the rankings are listed in Table 10 in which Seafloor Topography and Texture was valued of greatest importance for both the nearshore and offshore priority areas.

Table 10: Weighted ranking of Seafloor Mapping Product Types.

Seafloor Mapping Product Categories	Nearshore	Offshore
A. Beach Morphology	13%	N/A
B. Seafloor Topography and Texture	42%	45%
C. Seafloor Geomorphology	15%	20%
D. Sediment Environment	7%	2%
E. Subsurface Environment	3%	7%
F. Sediment Texture	11%	15%
G. Seafloor Ecology	10%	11%

The following categories were provided for consideration:

A. Beach Morphology:
Data source(s) types: RTL-GPS, acoustic and Lidar surveys, radar imaging, scanning Lidar.
Product(s) types: Nearshore profiles, change detection maps
Definition: *Depict changes in the shape and depth of the nearshore with repeated surveys over time.*

B. Seafloor Topography and Texture
Data source(s) types: acoustics and Lidar
Product(s) types: DEM models and backscatter mosaics maps
Definition: *Depict the shape, depth, texture, and roughness of the seafloor.*

C. Seafloor Geomorphology:
Data source(s) types: grab samples, video transects; acoustic, multispectral, Lidar surveys
Product(s) types: geomorphologic type maps
Definition: *Describes the physical structure of the environment across multiple scales. Spatial scales include from physiographic setting which describe large, global features, to geoforms which describe meso- and microscale units (extending down to features at the meter scale) including geologic, biogenic, and anthropogenic types.*

D. Sediment Environment:
Data source(s) types: sub-bottom surveys, sediment cores
Product(s) types: energy regime maps
Definition: *The sedimentary environment describes the processes controlling a certain location such as deposition or erosion. It defines the dynamics of the seafloor and, therefore, is important for identifying and understanding areas that are stable or changing.*

E. Subsurface Environment:
Data source(s) types: sub-bottom surveys, sediment cores
Product(s) types: Seismic reflection profiles, sediment depth and surface outcrop identification maps
Definition: *The subsurface environment describes the subsurface structure, sediment thickness and stratigraphy.*

F. Sediment Texture:
Data source(s) types: acoustic surveys, sediment grabs, sediment profile imaging
Product(s) types: Grain size and substrate class maps
Definition: *Includes shape, size and three-dimensional arrangement of sediment particles.*

G. Seafloor Ecology:
Data source(s) types: sediment grabs, video transects; acoustic, multispectral, Lidar surveys
Product(s) types: organism diversity, richness, abundance, and density.
Definition: *Include the identification of macro epifaunal and infaunal benthic communities and other*

4. FUTURE RECCOMENDATIONS

The following recommendations were provided by participants in the Seafloor Mapping Spatial Prioritization effort. These items identify near-term and future opportunities that will continue the momentum developed during this process, but also help invigorate additional awareness and support so as to realize and implement the priorities identified.

- Stand up Washington Seafloor Mapping Working Group: group of individuals actively engaged in mapping, those interested in the application of mapping data. This group will likely be responsible for engaging and prioritizing the recommendations listed. This group should be become the nexus for improving coordination and collaboration.

- Solicit and actively encourage opportunities to collaborate data collection. This could include activities such as the collaboration with University of Washington's graduate school mapping program.

- Encourage the use of NOAA National Centers for Environmental Information (NCEI) data centers for archiving seafloor mapping data collected and for assisting data dissemination.

- Encourage the use of the SeaSketch Mapping Coordination site for broadcasting future seafloor mapping areas.