NOAA Technical Memorandum NOS CS 51

GREAT LAKES SPATIAL PRIORITIES STUDY

Silver Spring, Maryland
September 2022

noaa **National Oceanic and Atmospheric Administration**

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Coast Survey Development Laboratory

Office of Coast Survey
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

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There are four components of OCS:

The Coast Survey Development Laboratory develops new and efficient techniques to accomplish Coast Survey missions and to produce new and improved products and services for the maritime community and other coastal users.

The Marine Chart Division acquires marine navigational data to construct and maintain nautical charts, Coast Pilots, and related marine products for the United States.

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The Navigational Services Division is the focal point for Coast Survey customer service activities, concentrating predominately on charting issues, fast-response hydrographic surveys, and Coast Pilot updates.

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GREAT LAKES SPATIAL PRIORITIES STUDY

Karen Gouws[1], Peter Esselman[2], Linden Brinks[3], Timothy Kearns[3], Xiaofan Zhang[3], Ashley Chappell[1], Brandon Krumwiede[4], Ken Buja[5], Meredith Westington[1], Cathleen Yung[1]

[1] **NOAA, Office of Coast Survey, Integrated Ocean and Coastal Mapping, Silver Spring, MD**
[2] **US Geological Survey, Great Lakes Science Center, Ann Arbor, MI**
[3] **Great Lakes Observing System, Ann Arbor, MI**
[4] **NOAA, Office for Coastal Management, Duluth, MN**
[5] **NOAA, National Centers for Coastal Ocean Science, Silver Spring, MD**

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EXECUTIVE SUMMARY

Spatial data about the bathymetry, habitat characteristics, underlying geology, and other features of the ocean and inland seas are essential for decision-making. Marine research and management organizations use these data to help ensure safe navigation, promote sustainable fisheries, extract energy, and protect marine habitats in the coastal and ocean waters of the U.S. Exclusive Economic Zone (EEZ) and Laurentian Great Lakes. Many of these organizations may have overlapping or shared mapping interests without knowing it.

In a multi-jurisdictional planning environment, it can be challenging and cumbersome to determine where other entities have shared or overlapping mapping interests, especially across a transnational region such as the Great Lakes. State and provincial governments, federal governments, academia, tribes and First Nations, and other stakeholders from both the U.S. and Canada all have mapping interests across Great Lakes waters. Identifying and communicating target geographies for new data collection that are shared among multiple organizations can both help to avoid redundancy of new mapping efforts, and create opportunities for greater efficiency through collaboration.

To address this issue, a spatial priorities study was conducted using a geospatial tool developed by the National Ocean Service's National Centers for Coastal and Ocean Science (NCCOS). The tool provided an easy-to-use online interface in which programs can identify their priorities in a simple and straightforward way. This study asked representatives of Great Lakes management and science organizations to identify the areas for which they needed maps of lakebed features on a near-term, mid-term, and long-term timeframe, and why. Then, the responses were analyzed and overlaid to determine areas of shared mapping need and opportunity and to determine the types of map products needed.

The analysis revealed high interest among multiple organizations in discrete geographies including the Minnesota and Wisconsin shoreline from Duluth to the eastern extent of the Bayfield Peninsula, Green Bay in Lake Michigan, and the southern coastlines of Lake Erie and Lake Ontario, the St. Mary's River, and the northern Lake Superior coastal waters near Grand Portage, MN. Lower priority mapping interest were distributed widely across all lakes, but tended to be concentrated in nearshore areas (<30 m depth).

The analysis also indicated that the top mapping justifications were 'Habitat/biota/natural area', 'Benthic exploration', 'Commercial and recreational fishing', and 'Scientific research'. The top desired map product types were 'Elevation', 'Substrate/sub-bottom geologic characterization', and 'Habitat map/characterization', although participants on some lakes noted other less prevalent product types.

Following from previously conducted NOAA and non-NOAA Federal spatial prioritization exercises, the results of this regional focus can help mapping organizations better understand how their priorities align with the needs of regional organizations, allow for more efficient coordination and funding, and enable partners to leverage assets and resources to fill their most pressing data

and information gaps across Great Lakes waters. The U.S. Mapping Coordination Site hosts the results of this study and other spatial prioritization studies. Through this website, one can interact with the study results along with recent and planned mapping efforts.

NOAA intends to update their spatial priorities on a three- to five-year basis. Future studies should strive to expand participation of federal agencies, state and local governments, federally-recognized tribes, academia, and private industry (among other stakeholders) to seek out ocean mapping partnerships in conjunction with the National Ocean Mapping, Exploration and Characterization (NOMEC) goals "map once, use many times."

1. INTRODUCTION

Ocean and coastal mapping data, or spatial information about the bathymetry, habitat characteristics, underlying geology, and other ocean features, are essential for decision-making. Marine and lake research and management organizations use these mapping data to help ensure safe navigation, promote sustainable fisheries, extract energy, and protect marine habitats in the coastal and ocean waters of the U.S. Exclusive Economic Zone (EEZ). Bottom habitats are not well mapped in many portions of the U.S. EEZ and the Great Lakes, leading many local and regional organizations around the country to plan and execute their own mapping activities, in addition to substantial annual effort by NOAA and others toward the same end. A recent study concluded that only 7% of the U.S. portion of the Laurentian Great Lakes have been mapped to modern standards (https://iocm.noaa.gov/seabed-2030-bathymetry.html).

Understanding the mapping priorities of different organizations in a multi-jurisdictional context is essential to create opportunities for collaboration. For instance, understanding both where and what kinds of new sea/lakebed data are needed to support management and research can lead to opportunities for coordination and cost sharing. Without such insight, it is easy for different organizations to map the same area over and over again, not realizing that other entities can share the burden, leading to wasted money, time, and effort. Understanding where organizations need new mapping data by overlaying geospatial representations of need can streamline data acquisition, spur collaboration, leverage resources, and avoid redundant collections. Mapping priorities also inform interagency activities under the National Strategy for Mapping, Exploring, and Characterizing the United States Exclusive Economic Zone (NOMEC Strategy).

To collect Great Lakes mapping priorities, a spatial priorities study was conducted using a geospatial tool developed by the National Ocean Service's National Centers for Coastal and Ocean Science (NCCOS). The tool, known as the Spatial Prioritization Widget, provided an easy-to-use online interface in which organizations could identify their priorities in a simple and straightforward way. Participants of the study were from the Lakewide Action and Management Planning (LAMP) network that supports activities under the Great Lakes Water Quality Agreement. Each of the five Great Lakes has its own LAMP partnership, which are comprised of bi-national participants from the U.S. and Canada, with the exception of Lake Michigan which is entirely within the U.S. LAMP participants at management and research organizations were asked to identify lake areas for which they needed improved bathymetry, habitat, or other maps on a near-, mid-, and long-term timeframe, and why. The responses were analyzed and overlaid to determine hotspots of shared mapping needs among different organizations. The analysis and results of this study allow Great Lakes mapping partners to see where resources can be allocated efficiently to meet the needs of the greatest number of organizations.

This study was made possible through longtime collaboration between the Great Lakes Observing System (GLOS), the U.S. Geological Survey (USGS), NOAA's Office for Coastal Management (OCM), NOAA's Office of Coast Survey (OCS), and the Great Lakes Restoration Initiative

(GLRI). These organizations have worked together to provide a framework and methodology for this study, reaching out to contacts across the region in order to ensure their input was heard, and coordinating with governmental, tribal, and non-governmental organizations to ensure that the needs of the broadest cross-section of lakewide management partners were considered.

Previous studies have successfully applied this approach in the states of Washington (Battista et al., 2017), Florida (Florida Fish and Wildlife Commission), and coastal Alaska (Kumle and Overbeck, 2021), as well as in the U.S. Caribbean (Kraus et al., 2020), and on the U.S. West Coast for offshore regions of Washington, Oregon, and California (Costa et al., 2019). It has also been applied in specific regions of the Great Lakes, such as the Thunder Bay National Marine Sanctuary (Kendall et al., 2020), and Wisconsin Shipwreck Coast National Marine Sanctuary (Kendall et al., 2018).

The following report discusses the rollout, usage, analysis and results of the Great Lakes Spatial Priorities Study, which covered all five (5) Great Lakes in both U.S. and Canadian waters. Surveyed organizations included U.S. states, Canadian provinces, tribal governments, First Nations, U.S. and Canada federal government, academia, and other stakeholders.

1.1. Summary

The Great Lakes Spatial Priorities Study surveyed Great Lakes management and science organizations on their mapping needs and goals. To do this, participants were chosen to represent their organizations and input their organization's priorities into the GIS web mapping application. Participants entered their priorities using the NCCOS-developed process and Spatial Prioritization Widget.

While identifying their priorities, participants answered the following questions:

1. *Where?:* Where are mapping priorities for your organization?
2. *Why?:* Why do you need this area mapped?
3. *What?:* What data do you need from this area?

Once all participants had completed their submissions, the results were analyzed to identify relationships between priorities, justifications, and map products in order to identify areas of shared mapping interest among multiple Great Lakes stakeholders. The analysis answered the following questions, among others:

1. What are the highest priority (urgent) areas?
2. Where do multiple organizations need mapping data?
3. Where do multiple agencies/organizations need the same type of data?

The results of this work will help Great Lakes mapping stakeholders better understand how their priorities align with the needs of other mapping stakeholders, allow for more efficient mapping

coordination and funding, and enable partners to leverage assets and resources to fill their most pressing data and information gaps across Great Lakes waters.

2. METHODS

The study was conducted using an online GIS web application. Multiple organizations across the Great Lakes were contacted to solicit their participation in the study. Organizations were invited to participate in a series of presentations to the LAMP partners for each Great Lake. The LAMP groups are convened under the bi-national Great Lakes Water Quality Agreement by the US EPA and Environment and Climate Change Canada. Interested individuals were asked to volunteer to submit their priorities via the web application on a lake-by-lake basis.

Participants in the LAMPs for each lake were contacted in webinars in January and August 2020 describing the mapping data needs survey. They were sent follow-up emails in August to register for access to the web application to begin making their priority selections. The survey application was accessible to users from October 15, 2020 to January 31, 2021.

2.1 Application

The application was designed using ESRI's Web AppBuilder (https://www.esri.com/en-us/arcgis/products/arcgis-web-appbuilder/overview) and incorporated the Spatial Prioritization Widget, designed by the National Centers for Coastal Ocean Science (NCCOS) for previous prioritization studies (Buja and Christensen, 2019). The widget allows participants to mark their priorities and describe their mapping interests. It sits within the application and allows participants to easily select cells for prioritization from a pre-loaded grid.

The widget was modified slightly for the Great Lakes study. In prior NCCOS-run studies, participants were asked to assign a numerical "coin" value to the locations of interest for their organization. Higher numbers of coins equated to a higher priority. In the Great Lakes study, participants were asked to assign a High, Medium, or Low value. The High, Medium, or Low values were defined to participants in terms of how soon mapping data were needed in a given location, with a high priority corresponding to the most urgent need. Drop down menu selections were also customized for the Great Lakes study. A screenshot of the Spatial Prioritization Widget window can be seen in **Figure 1**.

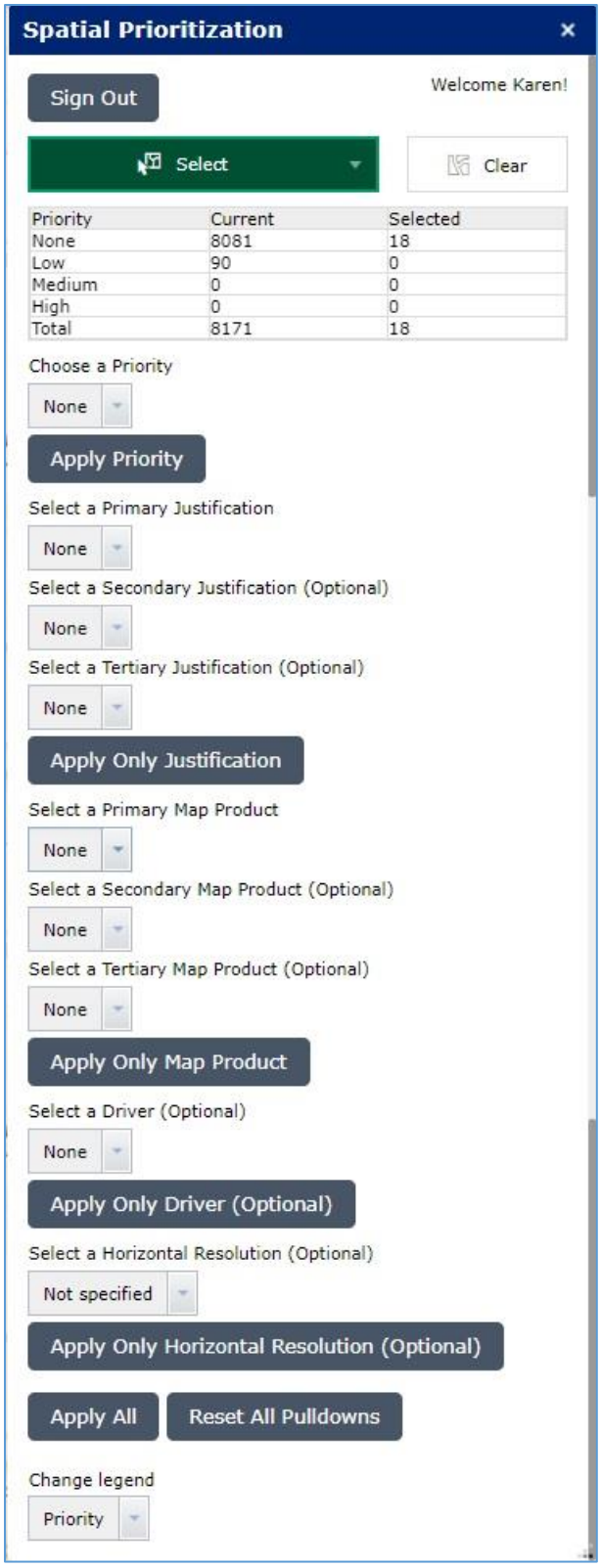

Figure 1. Study participants entered their priorities through this interface of the Spatial Prioritization Widget, created by NOAA NCCOS using Esri's Web AppBuilder.

2.2 Grid Coverage

Participants entered their mapping priorities into 10 km x 10 km grid cells covering all Great Lakes waters under both U.S. and Canadian jurisdiction, including connecting channels. Canadian waters were included due to frequent cross-border collaboration with Canadian mapping and management entities. The grid extended all the way to shoreline to ensure that coastal features could be included. The grid covered five (5) regions, one for each lake (**Figure 2**): Lake Superior, Lake Michigan, Lake Huron, Lake Erie, and Lake Ontario.

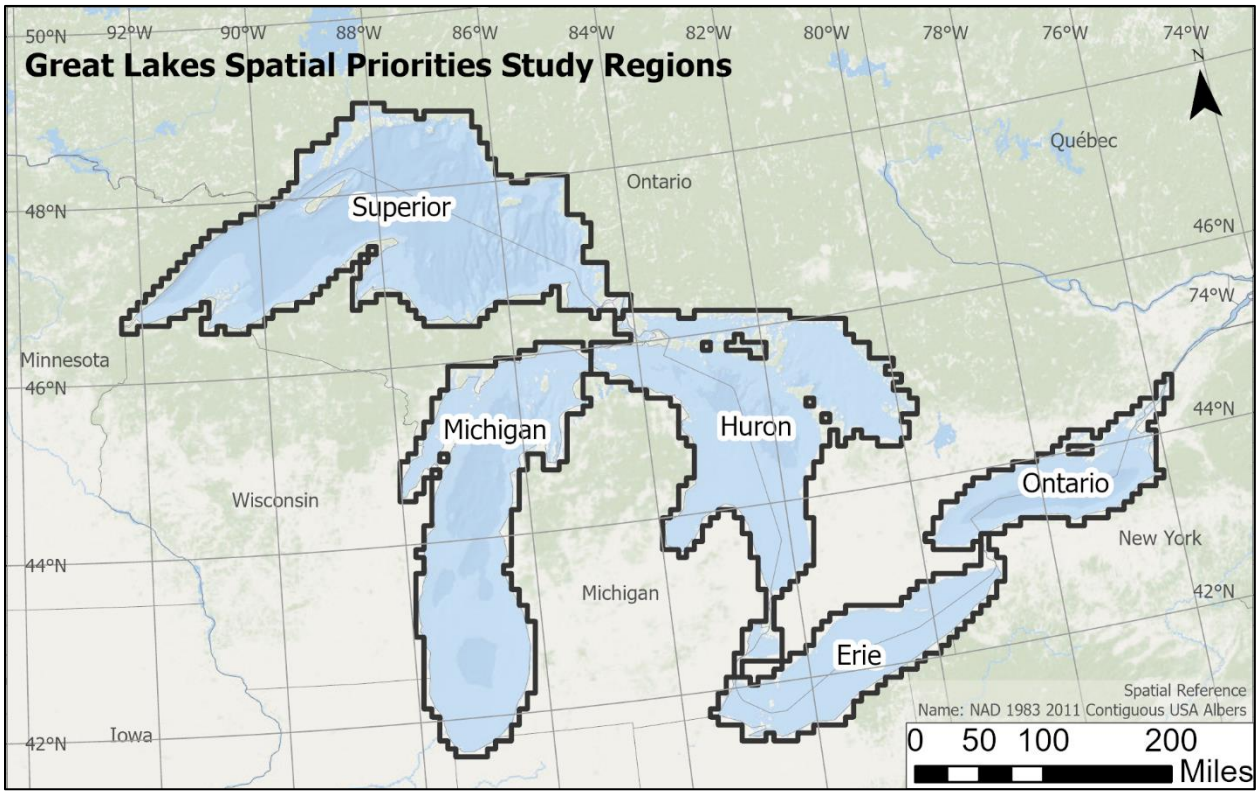

Figure 2. Map displaying the five Great Lakes associated with this spatial prioritization study. The study areas were divided into 10 x 10-kilometer grid cells and included coastal features as well as Canadian waters.

2.3 Criteria

The Spatial Prioritization Widget included the following nine (9) drop-down menus:

- **Priority** (*where* are there mapping priorities for your organization?)
- **Primary Justification**, **Secondary Justification**, **and Tertiary Justification** (*why* do you need this area mapped?)

- **Primary Map Product**, **Secondary Map Product**, **and Tertiary Map Product** (*what* data do you need from this area?)
- **Driver** (is there an executive, legislative, or program driver motivating your mapping interests?)
- **Horizontal Resolution** (what spatial resolution is desired for your priority area? For example, if participants wanted high resolution data in their priority area, such as <1 meter, they could specify this information in the application.)

The criteria drop-down menus are listed below, along with instructional definitions of each option.

2.3.1 Priority

Participants used the drop-down menus to define priority levels for each selection. This answered the question: Where are there mapping priorities for your organization? **Table 1** identifies each of the drop-down options for priority.

The priority method High/Medium/Low was chosen for a number of reasons. In prior studies, regional prioritization surveys generally used the coin method, which allowed for robust statistical analysis. However, the coin method may not be easily understood by the end users of the map results that did not themselves enter data in the study. For this reason, the nationwide study used the High/Medium/Low prioritization method to make the prioritization results more easily interpretable.

Selection rules were defined to limit the number of cells that users could allocate to High, Medium, or Low selections. The rules were defined to force study participants to limit their high and medium priority locations to relatively few cells to make the highest mapping priorities more apparent when responses were combined. The rules were as follows:

- Participants could only select up to 10% of cells as High *in a given lake.* For example, if the Lake Superior grid has one hundred (100) cells, participants could only put ten (10) of those cells in the High priority bin. Cell selections in one lake did not impact cell selections in another, nor did they reduce the number of available cells in another lake.
- Participants could only select up to 25% of cells as Medium *in a given lake.* For example, if the Lake Superior grid has one hundred (100) cells, participants could only put twenty-five (25) of those cells in the Medium priority bin. Cell selections in one lake did not impact cell selections in another, nor did they reduce the number of available cells in another lake.
- Participants could only select up to 50% of cells as Low *in a given lake.* For example, if the Lake Superior grid has one hundred (100) cells, participants could only put fifty (50) of those cells in the Low priority bin. Cell selections in one lake did not impact cell selections in another, nor did they reduce the number of available cells in another lake.
- While participants had percent limits in each lake (10% High, 25% Medium, etc.) they *did not* have to meet these limits. For example, if a participant had no priorities in Lake

Superior, they did not have to select any cells to complete their submission. This ensured that participants only prioritized areas that were of interest to them and did not add extra priorities just to meet a submission cap, making the data more robust.

Table 1. Priority drop-down menu options, using a High, Medium, and Low-ranking system corresponding to when mapping data are needed, were included in the Spatial Prioritization Widget.

Priority Type	Priority Description
None	Default
Low	Maps needed in 6-10 years (50% of grid cells in a given region)
Medium	Maps needed in 3-5 years (25% of grid cells in a given region)
High	Maps needed in 1-2 years (10% of grid cells in a given region)

2.3.2 Justification

Participants used the drop-down menus to define mapping justifications for each selection. This answered the question: Why do you need this area mapped? **Table 2** identifies each of the drop-down options for Justification.

Within the application, there were three Justification drop-down menus: Primary Justification, Secondary Justification, and Tertiary Justification. This allowed participants to identify multiple rationales for their mapping needs. Only the Primary selection was required; Secondary and Tertiary selections were optional. Primary, Secondary and Tertiary Justifications were not weighted against each other; i.e. all were weighted equally in the results.

Table 2. Justification drop-down menu options included in the Spatial Prioritization Widget. Participants selected up to three reasons for listing a given cell as a priority.

Justification Type	Justification Description
None	None
General knowledge gap	Default/general option; select if none of the other criteria meet your needs
Benthic exploration	Targeted benthic exploration for seafloor characterization
Water column exploration	Targeted water column exploration for water column characterization (e.g. upwelling, seeps, biological origin, biotoxins, harmful algae)
Commercial and recreational fishing	Fisheries management and regulation (e.g. commercial/recreational fishing locations, aquaculture siting, fisheries sampling stations, high bycatch areas, sport/charter fishing)

Justification Type	Justification Description
Cultural/historical resources	Shipwrecks, tribal use areas and other archaeological/cultural/historic resources
Energy	Energy permitting, siting, management, transmission (e.g., oil/natural gas platforms, deepwater ports, wind turbine, tidal/hydropower, cables, pipelines, etc.)
Habitat/biota/natural area	Includes Essential Fish Habitat, Critical Habitat (for marine mammals and other protected species), spawning/nursery areas, feeding grounds, key benthic habitats, habitat mapping, coastal geomorphology and other ecologically significant areas
Coastal/marine natural hazards	Detection, forecast and management of coastal and marine hazards, including weather/storm surge, flooding, tsunamis, earthquakes, geologic faults, harmful algal blooms, etc.
Infrastructure (non-energy)	Existing or potential infrastructure development, includes port facilities, bridges, telecommunication cables, roads, etc.
Protection/Management Areas	Marine protected area, sanctuaries, conservation areas, restoration sites, dynamic management areas for marine mammals and other protected species
Monitoring	Monitoring of specific study areas for scientific or other purposes (such as coral health monitoring, invasive species monitoring, etc.)
Modeling	Modelling of specific study areas for scientific or other purposes
Navigation safety	Safe navigation in U.S. waters, e.g. shipping lanes, ferry routes, harbors/approaches, port facilities and marinas; includes detection of hazards to navigation (rocks, wrecks, other obstructions)
Scientific research	General scientific research, not including monitoring of a specific area
Mineral resources	Critical and base mineral resources, aggregate resources for beach re-nourishment and/or heavy sands mineral resource, other non-energy mineral resources
Sediment transport	Sediment movement and management needs, managing beach erosion/re-nourishment or sediment buildups in channels and ports
Maritime Boundaries, Maritime Domain Awareness and Enforcement	Authoritative boundary maintenance, DoD/DHS security operations, countermine measures, border patrols, law enforcement
Recreational activities (other than fishing)	Recreational activities (e.g. boating, ecotourism, swimming and diving)

Justification Type	Justification Description
Public health	Contaminants and hazards that could impact communities, subsistence cultures and food safety (e.g. seafood safety) such as contaminated sediments, marine biotoxins, chemicals around oil wells and pipelines, waste and dredge material dumping sites, etc.

2.3.3 Map Product

Participants used the drop-down menus to define map products for each selection. This answered the question: What data do you need from this area? **Table 3** identifies each of the drop-down options for Map Product.

Within the application, there were three Map Product drop-down menus: Primary Map Product, Secondary Map Product, and Tertiary Map Product. This allowed participants to identify multiple data products they may wish to acquire from the same priority area. Only the Primary selection was required; Secondary and Tertiary selections were optional. Primary, Secondary and Tertiary Map Products were not weighted against each other; i.e. all were weighted equally in the results.

Table 3. Map Product drop-down menu options included in the Spatial Prioritization Widget. Participants were required to select a primary map product and were given the option to select secondary and tertiary map products of interest.

Map Product Type	Map Product Description
None	None
Elevation (bathymetry/topography)	Measurement of height/depth of seabed or coastal terrain. Collected using multibeam sonar, airborne LiDAR or other methods. Processed into bathy grids, Digital Elevation Models for a wide variety of downstream products
Backscatter intensity	Seabed imagery of reflected intensity (acoustic or optical) for location and distribution of different substrate types and habitat
Magnetometer surveys	For detection of magnetic anomalies, ferrous objects, man-made objects or evidence of human activity, cultural resource surveys, archaeological assessment, unexploded ordnance, wrecks, debris, etc.

Map Product Type	Map Product Description
Photographs/videos/imagery (surface or underwater)	Imagery of seabed/benthos/water column. Includes video and still imagery in all spectral bands. May be collected with ROVs, AUVs, other camera platforms, satellites, etc.
Biological, chemical or physical samples	Samples collected from seafloor/subseafloor/water column using divers, AUVs, ROVs, cores, grabs, CTDs, rosettes, etc.
Substrate/Sub-bottom geologic characterization	Remote-sensing derived (i.e. seismic, chirp sub-bottom, multibeam sonar, sub-bottom profiling sonars, magnetic susceptibility, self-potential) seafloor type and characteristics (i.e. hardness/roughness/thickness/grain size/substrate type/mineralogy, etc.)
Water column mapping/characterization	Commonly collected with multibeam/split-beam sonar systems; used to identify bubbles, plankton layers, fish, harmful algae, biotoxins, seeps, etc.
Shoreline characterization/topographic maps	Delineation and characterization of shoreline/coastal topography/coastal infrastructure and features (port facilities, boat ramps, docks, pipe landfalls, etc.)
Habitat map/characterization	Identification/suitability of benthic environment and habitat distribution; derived from remote sensing, optical imaging, and physical sampling
Nautical map and chart products	Electronic Navigational Charts, other products for navigation
Human use statistics	Socioeconomic, demographic, and other statistics regarding human use of ocean areas
Wildlife population characterization	Includes marine mammal, bird, sea turtle surveys; stock assessments
Ocean use infrastructure site maps	Delineation and characterization of oil platforms, wells, pipelines, wastewater treatment plant outfalls, waste dredge material dump sites, shipping lanes, and aquaculture sites
Land use impacts on coastal zone	Location and metadata from wastewater treatment plant inputs and seepages, riverine runoff, storm water runoff, and other impacts from manmade coastal zone inputs
Other mapping products not listed	Other mapping products not listed

2.3.4 Driver

Participants used the drop-down menus to define drivers for each selection. This allowed participants to identify if an executive, legislative, or program driver was motivating their mapping interests, such as an executive order or legal mandate. This selection was optional. **Table 4** identifies each of the drop-down options for drivers.

Table 4. Driver drop-down menu options included in the Spatial Prioritization Widget. Though helpful for context, participants were not required to identify their motivations or drivers supporting their mapping data priorities.

Driver
None
Blue Economy
Coastal Zone Management Act
Endangered Species Act
Energy Policy Act of 2005
Executive Order 13817 (Reliable Supplies of Critical Minerals)
Executive Order 13840 (Ocean Policy to Advance Economic, Security, and Environment Interests)
Great Lakes Restoration Initiative
Magnuson-Stevens Fishery Conservation and Management Act
National Historic Preservation Act
National Marine Sanctuaries Act
National Park Service Organic Act of 1916
Oil Pollution Act
Outer Continental Shelf Lands Act
2019 Presidential Memorandum on Ocean Mapping (Mapping, Exploration, Characterization)
Public Law 89-560 (Soil Surveys Act)
Public Law 111-11 (Omnibus Public Land Management Act)
Public Law 1115-25 (Weather Research and Forecasting Innovation Act and Tsunami Warning, Education, and Research Act)
National Weather Service Organic Act
Marine Mammal Protection Act (MMPA)
Safety of Life at Sea Convention (Treaty)
Seabed 2030
Lakebed 2030
Great Lakes Water Quality Agreement
Great Lakes Council of Lakes Committees priorities
Coast and Geodetic Survey Act of 1947
Hydrographic Services Improvement Act
USGS Organic Act of 1879
Ocean and Coastal Mapping Integration Act
Ocean Exploration Act
Integrated Coastal and Ocean Observation System Act
Federal Food, Drug, and Cosmetic Act
National Shellfish Sanitation Program Model Ordinance
Other drivers not listed

2.3.5 Horizontal Resolution

Horizontal resolution refers to the desired X, Y pixel dimensions in eventual grid-based mapping products. Participants used the drop-down menus to define their preferred horizontal resolution for each selected cell. For example, if participants wanted high resolution data in their priority area, such as <1 meter, they could specify this information up front. This selection was optional. **Table 5** identifies each of the drop-down options for horizontal resolution.

Table 5. Horizontal resolution drop-down menu options included in the Spatial Prioritization Widget. Though helpful when planning for data acquisition, participants were not required to specify their preferred horizontal resolution.

Horizontal Resolution Type and Description	
Not specified	Resolution not specified
<100m	One pixel of data output must represent at most 100 m x 100 m of coverage
<25m	One pixel of data output must represent at most 25 m x 25 m of coverage
<10m	One pixel of data output must represent at most 10 m x 10 m of coverage
<5m	One pixel of data output must represent at most 5 m x 5 m of coverage
<1m	One pixel of data output must represent at most 1 m x 1 m of coverage

2.4 Participants

Results available in this technical memo include thirty-eight (38) organizations who submitted data. In some cases, multiple individuals from the same organization responded for the same lake, and some individuals also shared their priorities for multiple lakes. In total, one hundred fifty-one (151) individuals representing seventy-six (76) federal, state, tribal, and non-governmental entities were contacted for survey. Of this, a total of fifty-nine (59) individuals representing thirty-eight (38) organizations responded; a response rate of thirty-nine percent (39%) of all individuals contacted, and fifty percent (50%) of all organizations contacted.

Ten (10) Canadian organizations responded: Toronto and Region Conservation Authority, St. Clair Region Conservation Authority, Quinte Conservation, Pays Plat First Nation, Parks Canada, Ontario Ministry of the Environment, Ontario Ministry of Natural Resources and Forestry, Maitland Valley Conservation Authority, Grand River Conservation Authority, and Fisheries and Oceans Canada.

Twenty-eight (28) United States organizations responded respondents included: Wisconsin Department of Natural Resources, Wisconsin Coastal Management Program, U.S. Geological

Survey, U.S. Fish and Wildlife Service, University of Wisconsin Sea Grant, The Nature Conservancy, Red Cliff Band of Superior Chippewa, Pennsylvania Department of Environmental Protection, Penn State University, Ohio State University, Ohio Department of Natural Resources Coastal Management, Ohio Department of Natural Resources, NOAA Office for Coastal Management, New York Department of Environmental Conservation, National Park Service, Minnesota Department of Natural Resources, Michigan Department of Natural Resources, Michigan Department of Environment, Great Lakes, and Energy, Lake Superior Reserve, Indiana Department of Natural Resources, Indiana Department of Environmental Management, Illinois Department of Natural Resources, Great Lakes Indian Fish & Wildlife Commission, Endangered Species Protection Board, Door County Land Trust, Buffalo Niagara Waterkeeper, Bay Mills Indian Community, and the 1854 Treaty Authority.

2.5 Merging Datasets

For this study, each individual participant was given their own grid layer to submit priorities, instead of each organization being given a grid layer. This was done to make it simpler for participants to enter priorities without needing to do major coordination work within their organization.

All participant layers submitted for each organization were merged in post-processing to develop a unified, "organization-wide" response. This merging process used the following rules:

1. All prioritized cells (i.e., cells with a value of High, Medium, or Low, excluding cells with a value of None) were merged into a single dataset.
2. Duplicate cells (cells overlapping the same area) were deleted. The deleted value was the lower priority value.
3. When two duplicate priorities had the same priority level, the choice of which one to delete was made by removing the value that had a lower number of justification/map products defined. For example, if Cell 1 had three justifications and three map products, and Cell 2 had one justification and one map product, Cell 2 was deleted because Cell 1 provided more context. If the deleted cell contained a unique justification/map product, this was transferred to the retained cell.
4. If, after merging cells and deleting duplicates, there were over 10% of cells allocated to High, or over 25% cells allocated to Medium, or over 50% cells allocated to Low, the following procedure was used to re-prioritize cells to make sure the lake stayed within percent limits.
    - All priority values (for each cell) were "standardized" based on the combined responses of all of that organization's participants. To achieve this, each cell's priority values were converted to numbers based on the following procedure (**Table 6**):

Table 6. For each priority, a multiplication factor or weight was applied before combining participant responses using the methodology outlined in the table.

Priority	Value
High	3
Medium	2
Low	1
None	0

- For example, if three participants entered priorities for a given cell and their priorities were High (User 1), Low (User 2), and None (User 3), the cell would be given values of 3 (User 1), 1 (User 2) and 0 (User 3).
- These values were summed for each cell. So, for this cell, the summed, quantified priority value would be 3 + 1 + 0 = 4.
- Once all cells were summed, all cells were given adjusted priorities based on the maximum summed value for that organization. For example, if the maximum summed value across all cells in that organization was 10, then:
    - All cells with sum values 8-10 would be reassigned as High Priority,
    - All cells with sum values 5-7 would be reassigned as Medium Priority,
    - All cells with sum values 2-4 would be reassigned as Low Priority, and
    - All cells with sum values 0-1 would be reassigned as None.
- For the sample cell above, the reassigned priority would thus be Low.
- The ranges were based on *each organization's* max cell value.

The more involved merging procedure (Step 4) only needed to be done for the New York Department of Environmental Conservation, Ohio Department of Natural Resources, and U.S. Geological Survey responses. The combined layers were assumed to be fair representations of the combined response of the agency with multiple respondents; however, the agency was given the opportunity to revise their selection.

2.6 Analysis Methods

2.6.1 Priority

Priority values were analyzed in five ways, as follows:

High Priority, **Medium Priority**, and **Low Priority:** The number of organizations who selected a cell as High, Medium, or Low was summed for each grid cell to generate three maps: number of

organizations who selected a cell as High, number of organizations who selected a cell as Medium, and number of organizations who selected a cell as Low.

Any Priority: The number of organizations who assigned a cell as any priority (High, Medium, *or* Low) was summed. These locations represent potential collaborative opportunities between organizations regardless of priority level—i.e. even if one organization felt the area was urgent and another found it less so.

Weighted Priority: A "weight" was assigned to each priority value (High, Medium, Low, and None) in order to gain a subjective picture of which areas were of the highest interest among multiple organizations. High priority cells were assigned a weight of three (3), Medium of two (2), Low of one (1), and None of zero (0). It is important to note that the weights are subjective, i.e., they are only useful for visualization purposes. However, the Weighted Priority map gives a good indication of which areas are of high interest among multiple organizations.

2.6.2 Justification

Respondents were allowed to enter up to three (3) justifications in each cell to identify *why* they had mapping interests in a given location. **Table 2** identifies each of the drop-down options for justification.

For the analysis, each justification was summed across organizations for each cell. For a given justification J_a, all entries of J_a in a given cell were summed to gain an understanding of how many organizations had the same justification in that cell, regardless of whether Ja was a Primary, Secondary, or Tertiary Justification.

For example, if one organization gave Cell A a Primary Justification of Benthic Exploration, a Secondary Justification of Water Column Exploration, and a Tertiary Justification of Scientific Research, and a second organization gave Cell A a Primary Justification of Water Column Exploration, a Secondary Justification of Benthic Exploration, and a Tertiary Justification of None (**Table 7**) the Benthic Exploration number for that cell would be two (2), the Water Column Exploration number for that cell would be two (2) and the Scientific Research number for that cell would be one (1) (**Table 8**).

This indicates that two (2) organizations selected a Justification for this cell of Benthic Exploration, two (2) selected a Justification of Water Column Exploration, and one (1) selected a Justification of Scientific Research. This indicator can help identify where organizations have shared reasons for mapping need.

Table 7. Sample justification entries for two organizations with interests in the same grid cell.

	Office 1	Office 2
Primary Justification	Benthic Exploration	Water Column Exploration
Secondary Justification	Water Column Exploration	Benthic Exploration
Tertiary Justification	Scientific Research	None

Table 8. The summation of sample justification entries for two organizations with interests in the same grid cell.

Justification	Sum
Benthic Exploration	2
Water Column Exploration	2
Scientific Research	1

2.6.2.1 Unique Justifications

The number of unique justifications per cell was summarized to determine which areas had the most varied reasons for why organizations wanted mapping data there. To determine this, a geospatial tool asked the following for each justification criterion:

1. Was Justification J_a entered for this cell?
    a. If so, add one (1) to the unique justification total.
    b. If not, add zero (0).

If a specific justification was entered multiple times for that cell—for example, if multiple organizations put the justification Scientific Research in a given cell—it was only counted once.

Taking the sample cell from above (see **Table 9** below), the calculation would run as follows:

Table 9. Sample justification entries for two organizations with interests in the same grid cell.

	Office 1	Office 2
Primary Justification	Benthic Exploration	Water Column Exploration
Secondary Justification	Water Column Exploration	Benthic Exploration
Tertiary Justification	Scientific Research	None

In this cell, two (2) organizations entered the following justifications: Benthic Exploration, Water Column Exploration, and Scientific Research. Thus, the number of unique justifications would be three (3): Benthic Exploration, Water Column Exploration, and Scientific Research. Note that Benthic Exploration and Water Column Exploration are not counted twice, even though they were entered twice, because the tool is only checking for unique justifications in order to assess where there is varied mapping interest.

2.6.3 Map Product

Respondents were allowed to enter up to three (3) map products in each cell to identify *what* data products they wanted in a given location. **Table 3** identifies each of the drop-down options for map product.

For the analysis, each map product was summed across organizations for each cell. For a given map product P_a, all entries of P_a in a given cell—whether P_a was entered for the Primary, Secondary, or Tertiary Map Product—were summed to gain an understanding of how many organizations had the same map product in that cell.

For example, if one organization gave Cell A a Primary Map Product of Elevation, a Secondary Map Product of Backscatter Intensity, and a Tertiary Map Product of Nautical Map and Chart Products, and a second organization gave Cell A a Primary Map Product of Backscatter Intensity, a Secondary Map Product of Elevation, and a Tertiary Map Product of None (**Table 10**) the Elevation number for that cell would be two (2), the Backscatter Intensity number for that cell would be two (2) and the Nautical Map and Chart Products number for that cell would be one (1) (**Table 11**).

This indicates that two (2) organizations selected a Map Product for this cell to be Elevation, two (2) selected a Map Product of Backscatter Intensity, and one (1) selected a Map Product of Nautical Map and Chart Products. This indicator can help identify where organizations have shared data needs.

Table 10. Sample map product entries for two organizations with interests in the same grid cell.

	Office 1	**Office 2**
Primary Map Product	Elevation	Backscatter Intensity
Secondary Map Product	Backscatter Intensity	Elevation
Tertiary Map Product	Nautical Map and Chart Products	None

Table 11. The summation of sample map product entries for two organizations with interests in the same grid cell.

Map Products	**Sum**
Elevation	2
Backscatter Intensity	2
Nautical Map and Chart Products	1

2.6.3.1 Unique Map Products

The number of unique map products per cell was analyzed in order to determine which areas had the most diverse data needs, with the most varied data products requested. To determine this, a geospatial tool was run that asked the following for each map product criterion:

1. Was Map Product P_a entered for this cell?
    a. If so, add one (1) to the unique map product total.
    b. If not, add zero (0).

If a specific map product was entered multiple times for that cell—for example, if multiple organizations put the Map Product Elevation in a given cell—it was only counted once.

Taking the sample cell from above (see **Table 12** below), the calculation would run as follows:

Table 12. Sample map product entries for two organizations with interests in the same grid cell.

	Office 1	**Office 2**
Primary Justification	Elevation	Backscatter Intensity
Secondary Justification	Backscatter Intensity	Elevation
Tertiary Justification	Nautical Map and Chart Products	None

In this cell, two (2) organizations entered the following map products: Elevation, Backscatter Intensity, and Nautical Map and Chart Products. Thus, the number of unique map products would be three (3): Elevation, Backscatter Intensity, and Nautical Map and Chart Products. Note that Elevation and Backscatter Intensity are not counted twice, even though they were entered twice, because the tool is only checking for unique map products in order to assess where there are varied data needs.

3. RESULTS

The study sought to answer questions about where multiple organizations had mapping needs, and to identify areas of highest interest among multiple organizations. The goal of the analysis was to summarize this information in an easy, straightforward way that would allow people from multiple backgrounds to be able to recognize where there were areas of high interest.

The study required approximately nine (9) months to complete. Timeframes involved in each step were as follows: widget customization (June - July, 2020), Outreach (January then August - September 2020), stakeholder participation (October 2020 - January 2021), data merging and analysis (February - March 2021).

Guided by the questions described in **Section 1.1**, participant results were analyzed in ArcGIS using a variety of geospatial tools that were developed in May 2020 using ModelBuilder. These results are below:

3.1 Priority

The following maps demonstrate priority interest across Great Lakes mapping stakeholders surveyed as a part of this study.

3.1.1 High Priority

High priority areas (representing mapping needs within 1-2 years) were concentrated coastally (**Figure 3**), particularly along the southern and eastern coasts of **Lake Erie** and **Lake Ontario**. In **Lake Superior** and **Lake Huron**, priorities were concentrated in St. Joseph Channel and Whitefish Bay, and in the St. Mary's River. Areas where four or more organizations identified high priority interests were in Green Bay in **Lake Michigan** and along the northern coast of Wisconsin, including Chequamegon Bay and Bayfield Peninsula, in **Lake Superior**.

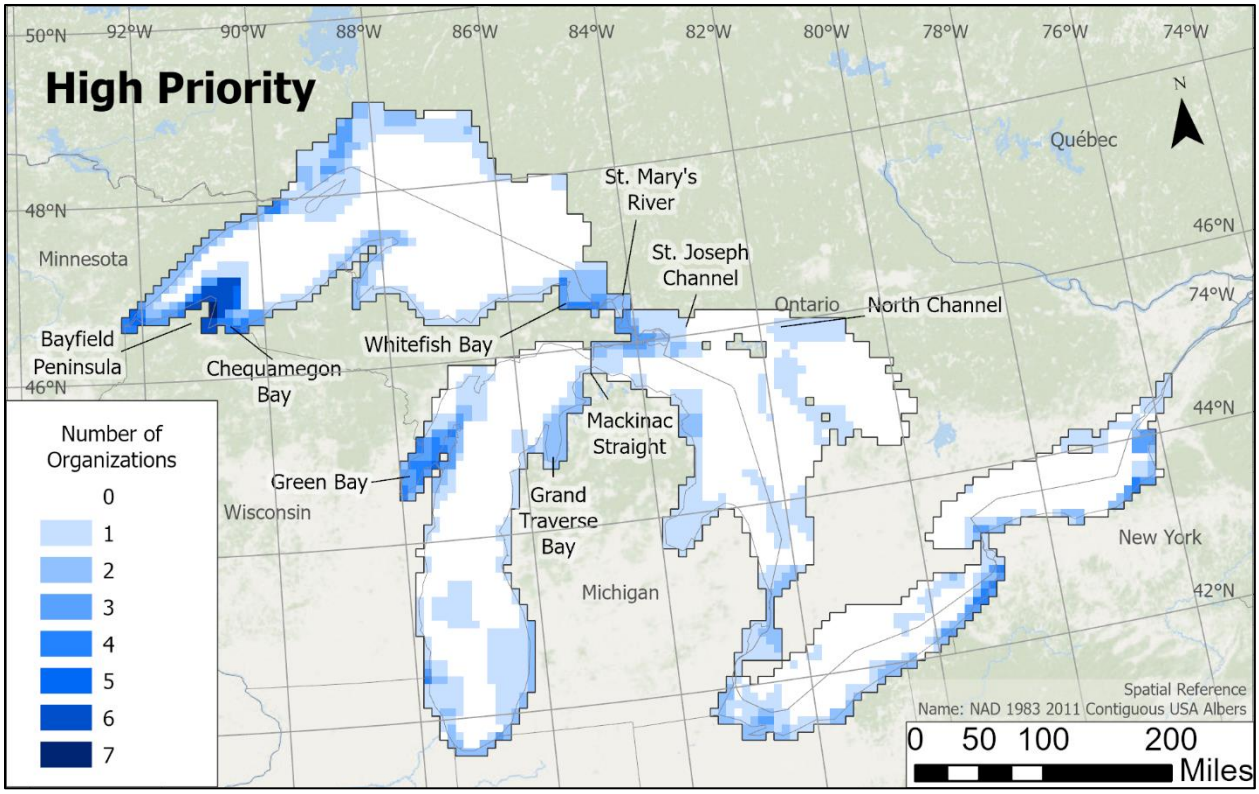

Figure 3. Number of organizations selecting cells as High Priority, representing mapping needs within 1-2 years.

3.1.2 Medium Priority

Medium priority areas (representing mapping needs within 3-5 years) were more evenly distributed throughout the Great Lakes (**Figure 4**), with large portions of **Lake Erie**, **Lake Ontario**, and **Lake Huron** identified as a medium priority by multiple organizations even beyond coastal areas (here defined by the 30-m isobath). Medium priority interests were also concentrated along the northern shore of **Lake Huron**, while there were reduced medium priority interests in St. Joseph Channel, Whitefish Bay, and the St. Mary's River; this is a contrast to the high priority distribution results, where these areas represented significant interest. However, there were some similarities with the high priority distribution results. As with the high priority distribution results, areas where four or more organizations identified medium priority interests were in Green Bay in **Lake Michigan** and along the northern coastal of Wisconsin, including Chequamegon Bay, in **Lake Superior**.

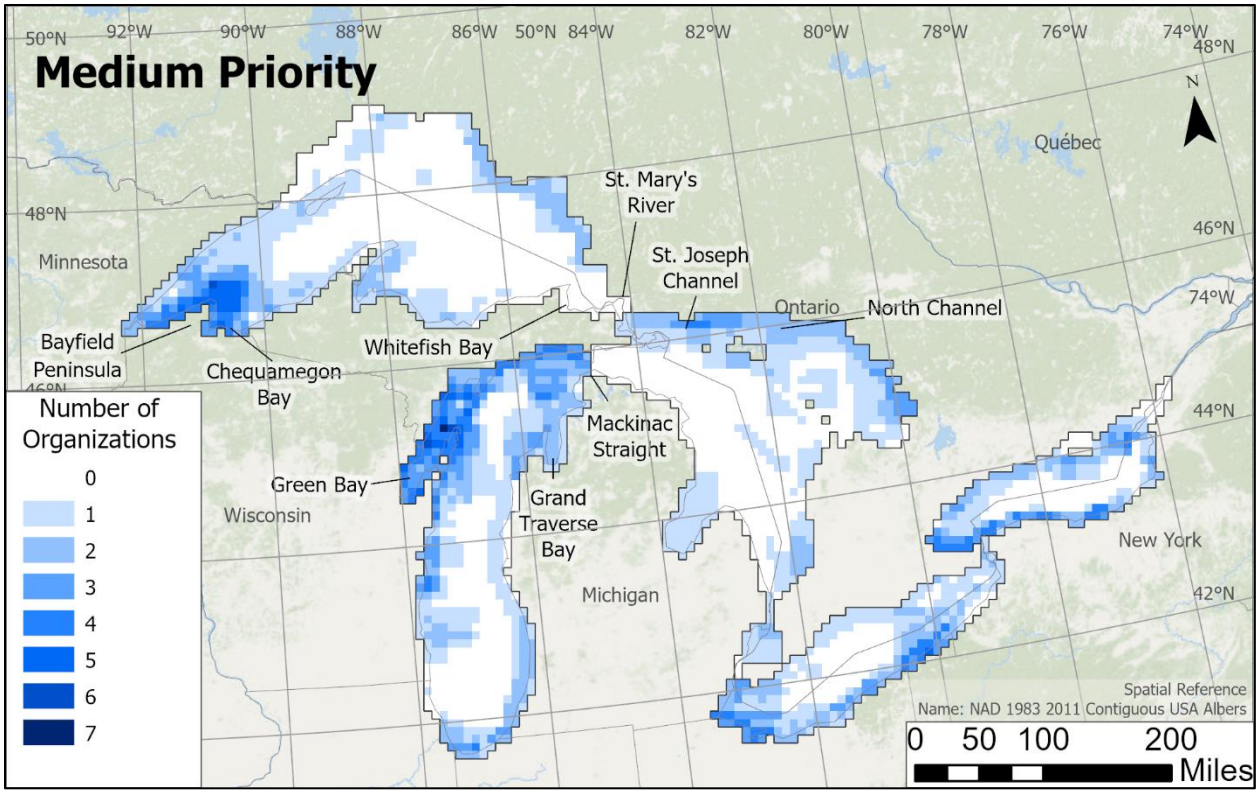

Figure 4. Number of organizations selecting cells as Medium Priority, representing mapping needs within 3-5 years.

3.1.3 Low Priority

Low priority areas (representing mapping needs within 6-10 years) were distributed in many offshore locations (>30 m depth) (**Figure 5**). Of particular low priority interest were **Lake Erie** and **Lake Ontario**¸ where significant offshore interests were identified by multiple organizations. Offshore low priority interests were also identified in southern **Lake Superior** and in western **Lake Michigan** outside of Green Bay. Up to four (4) organizations identified any given area as a shared low priority interest.

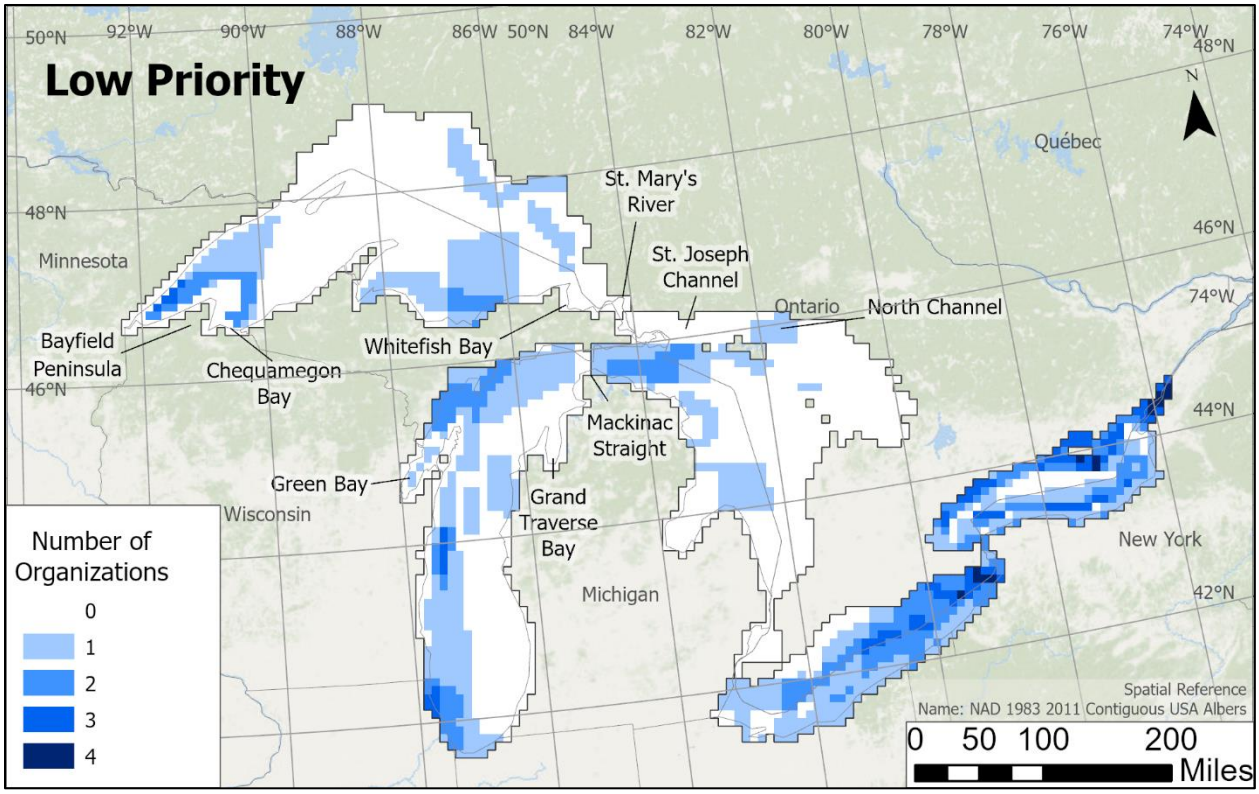

Figure 5. Number of organizations selecting cells as Low Priority, representing mapping needs within 6-10 years.

3.1.4 Any Priority

Many organizations identified priorities across the Great Lakes, whether they were high, medium, or low (**Figure 6**). Coastal areas were popular, with the entire coastline of **Lake Ontario** identified as a priority among multiple organizations, along with much of the southern, eastern, and western coastlines of **Lake Erie**. Although **Lake Huron** appears to have less interest than the other lakes, this is partially due to the fact that fewer organizations responded with priorities for Lake Huron with nine (9) organizations responding versus thirteen (13) for several other lakes. Acknowledging this, there was high relative interest in St. Joseph Channel, Whitefish Bay, the St. Mary's River, and the North Channel. There was also strong general priority interest in the Straits of Mackinac in **Lake Michigan** and **Lake Huron**. In **Lake Michigan**, general priority interest also covered much of the southern extent of the lake along the Illinois and Indiana coastlines. There was also significant mapping interest in Green Bay, with at least five (5) organizations identifying some kind of mapping interest in this region, and as many as eight (8) organizations identifying specific areas in and around Green Bay. In **Lake Superior**, much of the northern Wisconsin coastline was a priority, including Chequamegon Bay.

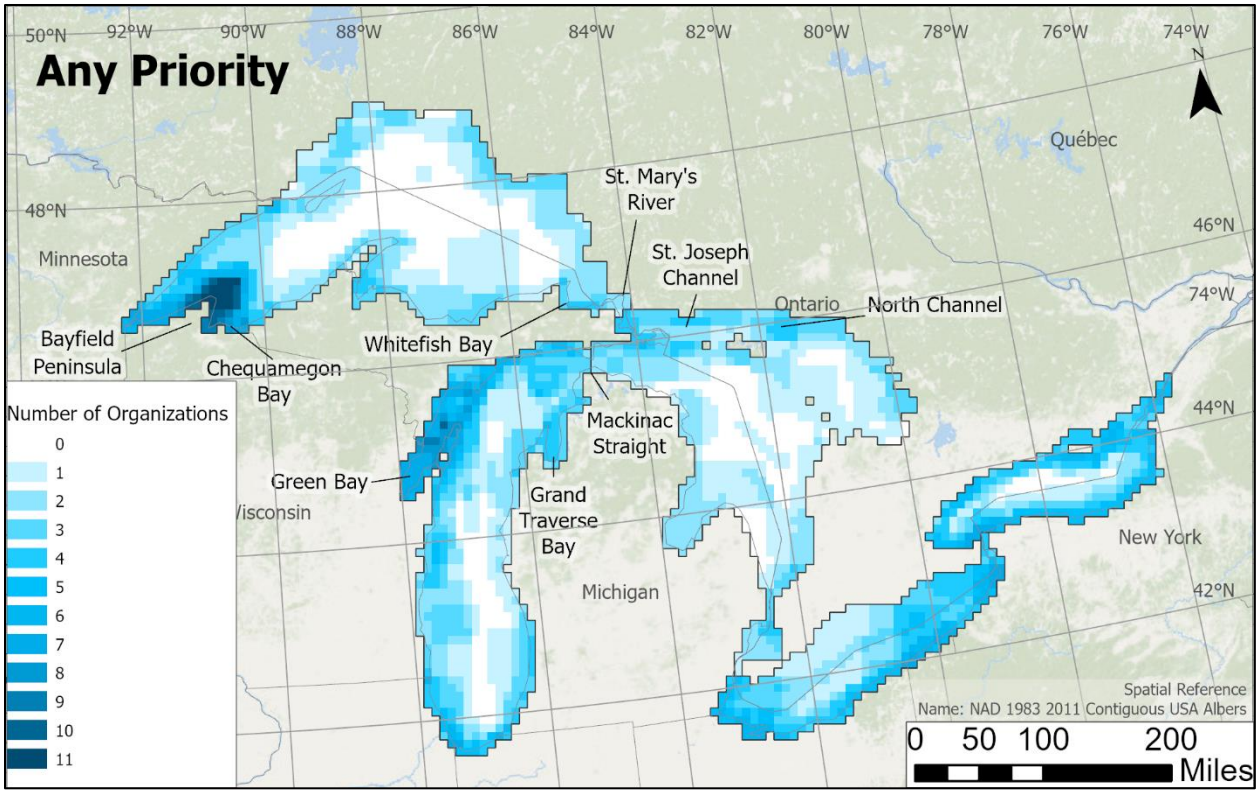

Figure 6. Number of organizations with high, medium, and low priority interests. Areas of this map with a value of "0" were not selected as a priority for any participants of this study, which expressed strong interest in habitat mapping (see Justification results).

3.1.5 Weighted Priority

Weighted priority areas were concentrated coastally, particularly along the southern and eastern coasts of **Lake Erie** and **Lake Ontario**. In **Lake Superior** and **Lake Huron**, weighted priorities were high in St. Joseph Channel and Whitefish Bay, and in the St. Mary's River. The highest weighted priority areas across the Great Lakes were in Green Bay in **Lake Michigan** and along the northern coast of Wisconsin, including Chequamegon Bay, in **Lake Superior**. Significant priority areas were also identified along the Michigan coastline, particularly in Grand Traverse Bay, and along the southern extent of the lake along the Illinois and Indiana coastlines.

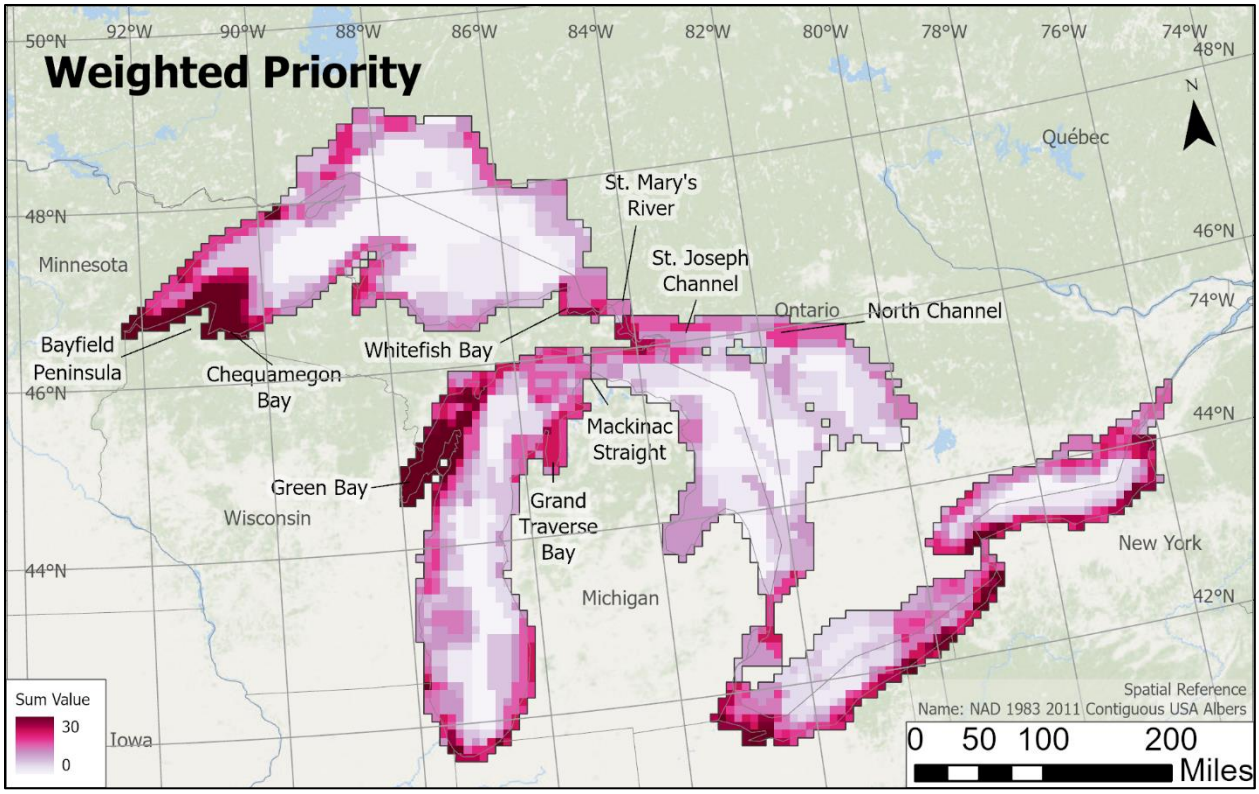

Figure 7. Geographic distribution of weighted priorities, where the high, medium, and low priorities for each cell were assigned numerical values of 3, 2, and 1, respectively, and participant priorities were summed to visualize areas of highest interest among all study participants.

3.2 Justification

For all lakes, the top justification was Habitat/biota/natural area (**Figure 8**), with varied distribution across the Great Lakes. Interest in habitat, biota, and natural areas was particularly high along the entire coastline of **Lake Ontario**, and throughout all of **Lake Erie**, with at least one or two organizations choosing this justification throughout these lakes. Interests in habitat mapping were also concentrated in St. Joseph Channel and Whitefish Bay, and in the St. Mary's River, in **Lake Superior** and **Lake Huron**. Areas where four (4) or more organizations identified habitat mapping interests were in Green Bay in **Lake Michigan** and along the northern coast of Wisconsin, including Chequamegon Bay, in **Lake Superior**. In northern Wisconsin, as many as ten (10) different organizations expressed interest in habitat mapping.

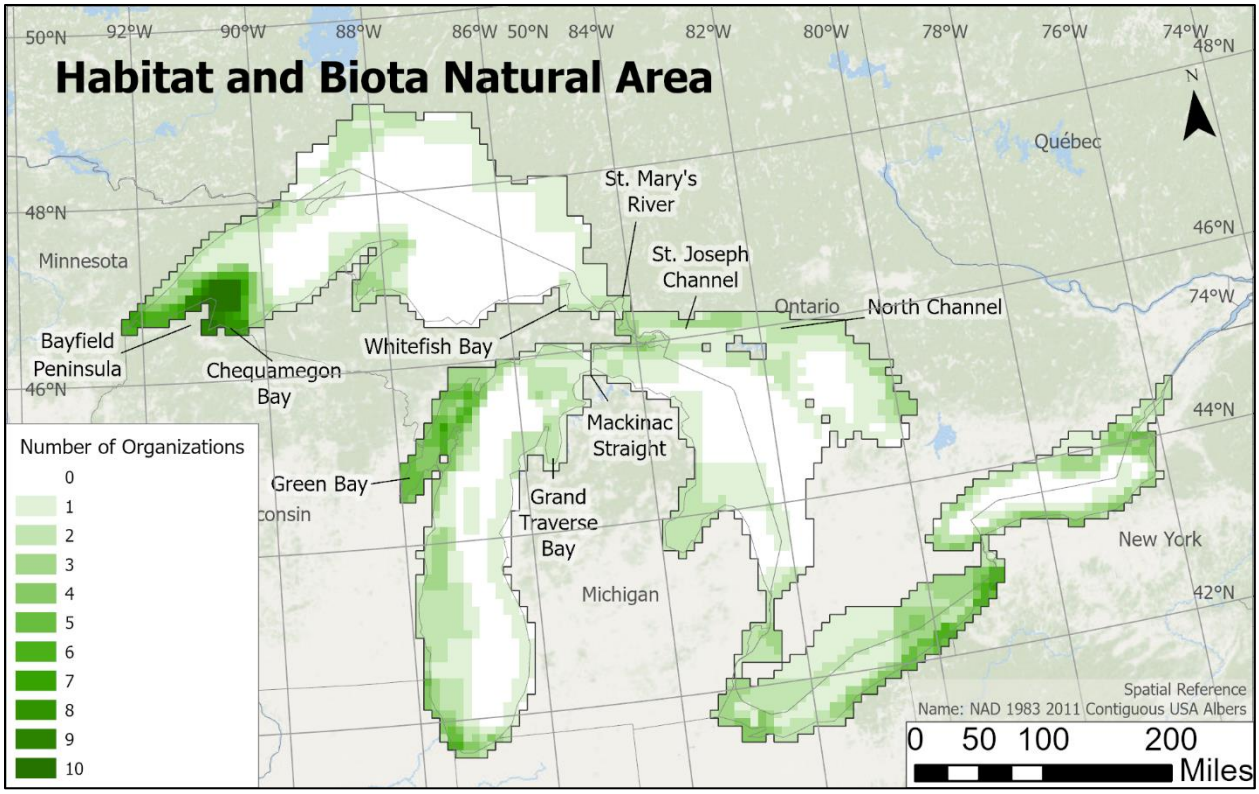

Figure 8. Map showing the number of organizations that selected Habitat/biota/natural area as their justification for participants in this study.

3.2.1 Unique Justifications

High richness of mapping justifications tended to occur in coastal areas (**Figure 9**), though in some places, like **Lake Erie** and **Lake Michigan**, unique and diverse mapping interests extended far offshore. In **Lake Superior** and **Lake Huron**, there were over five (5) unique justifications in St. Joseph Channel and Whitefish Bay, and in the St. Mary's River. The most varied justifications across the Great Lakes were along the coastline of **Lake Ontario**, in Green Bay in **Lake Michigan**, and along the northern coast of Wisconsin, including Chequamegon Bay, in **Lake Superior**. However, mapping justifications were diverse and varied in many locations throughout the Great Lakes.

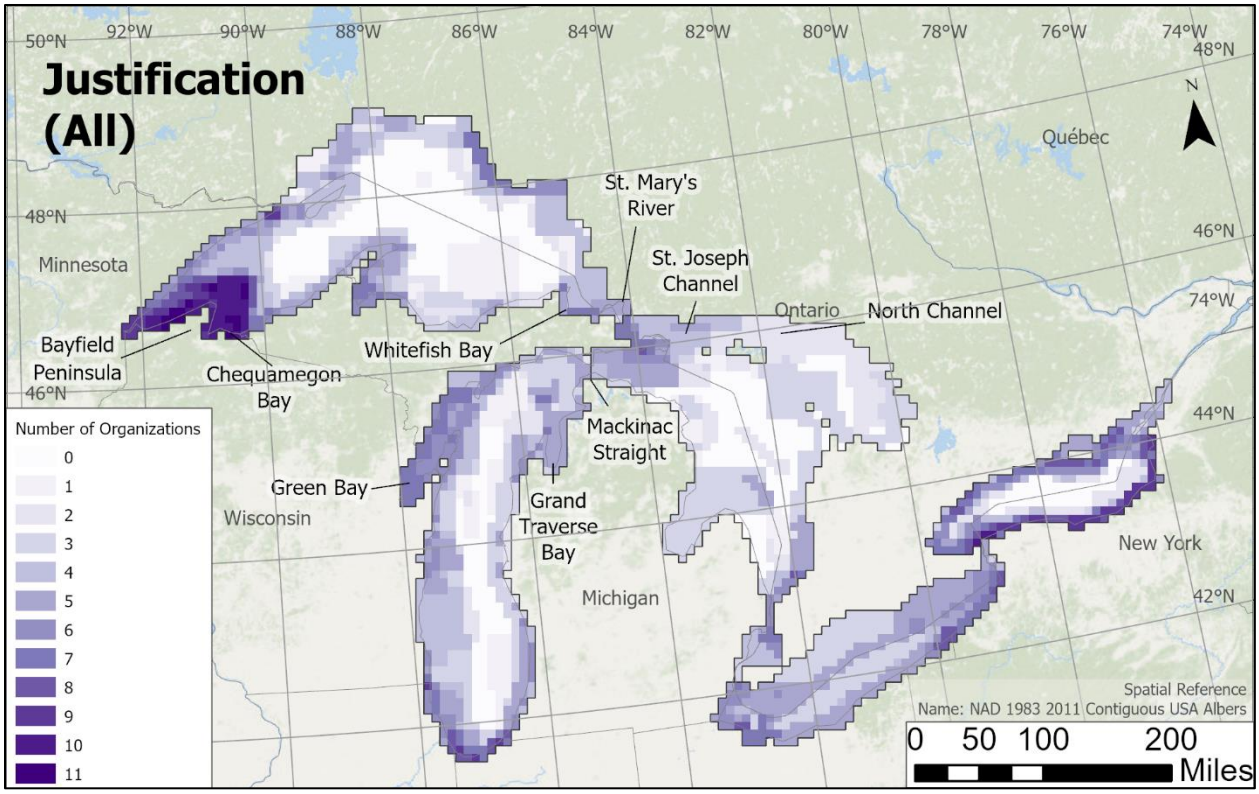

Figure 9. Geographic distribution of unique justifications. Coastal areas tended to have more participants expressing mapping data needs in the same areas for different reasons.

3.2.2 Frequency by Region

A frequency plot was generated that identified the most common justifications for each of the five (5) lakes, and for the Great Lakes as a whole. The frequency plot incorporated all justifications regardless of whether they were Primary, Secondary, or Tertiary. Justifications not included in this plot were General Knowledge Gap (the default for Primary Justification) and None.

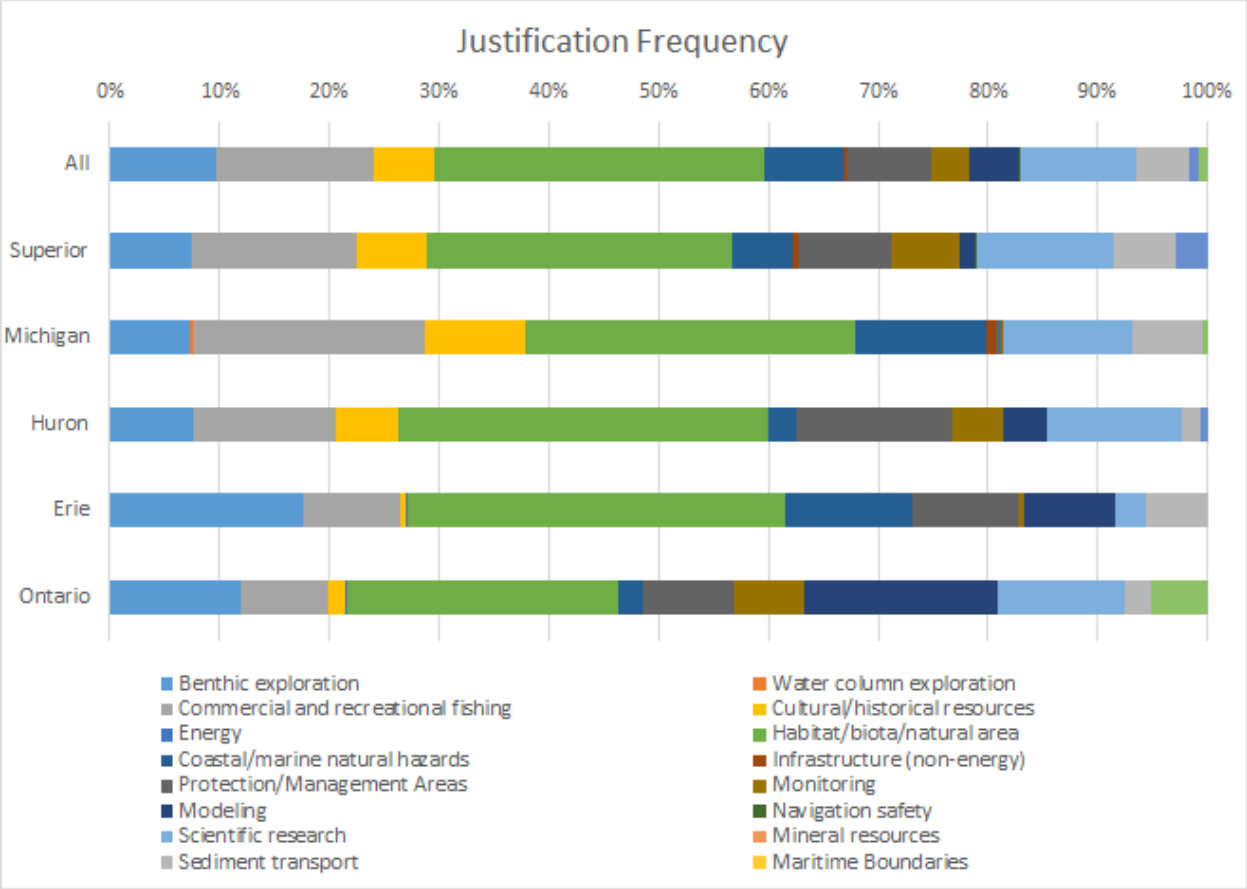

Figure 10. A chart showing, by lake, the frequency by which participants justified their mapping needs among 18 different options. As shown in green, study participants frequently cited habitat/biota/natural area as their primary reason for needing mapping data.

Figure 10 reveals a number of interesting trends. Throughout the Great Lakes, the most commonly selected justification was Habitat/biota/natural area, with almost 30% of the region given this reason for mapping. Other popular justifications included Benthic exploration, Commercial and recreational fishing, and Scientific research. However, there was variation in justifications selected across all five lakes.

Lake Huron closely matched the Great Lakes as a whole, with justification frequencies similar to those of the entire Great Lakes. In **Lake Ontario**, there was markedly reduced interest in Cultural/historical resources (less than 3% of justifications selected) compared to the whole Great Lakes (around 5%), but much higher interest in Modeling (around 15%) compared to the whole Great Lakes (less than 5%). **Lake Michigan** saw much higher interest in Commercial and recreational fishing than the Great Lakes as a whole, and much higher interest in Coastal/marine natural hazards; however, there was less interest in **Lake Michigan** for justifications such as Protection/Management Areas and Monitoring, which were selected as such low frequencies as to

not be easily discerned in **Figure 10**. **Lake Erie** reflected lower interest in Cultural/historical resources (<2%) than the Great Lakes as a whole (around 5%), but had higher interest in Benthic exploration (>15%), compared to the Great Lakes as a whole (~10%). Finally, **Lake Superior** had varied mapping interests that reflected those of the Great Lakes as a whole, but with somewhat higher interest in Monitoring as measured by justification frequency.

3.3 Map Product

Across the Great Lakes as a whole, the most frequently-selected map product was Habitat map characterization (**Figure 11**), which follows from the high interest in the justification Habitat/biota/natural area. Demand for habitat map products was particularly high along the entire coastline of **Lake Ontario**, and throughout all of **Lake Erie**, with at least 1-2 organizations choosing this map product throughout these lakes. Interests in habitat mapping were also concentrated in St. Joseph Channel and Whitefish Bay, and in the St. Mary's River, in **Lake Superior** and **Lake Huron**. Areas where four (4) or more organizations identified habitat map characterization as a requested map product were in Green Bay in **Lake Michigan** and along the northern coast of Wisconsin, including Chequamegon Bay, in **Lake Superior**. In northern Wisconsin, as many as seven (7) different organizations requested this map product.

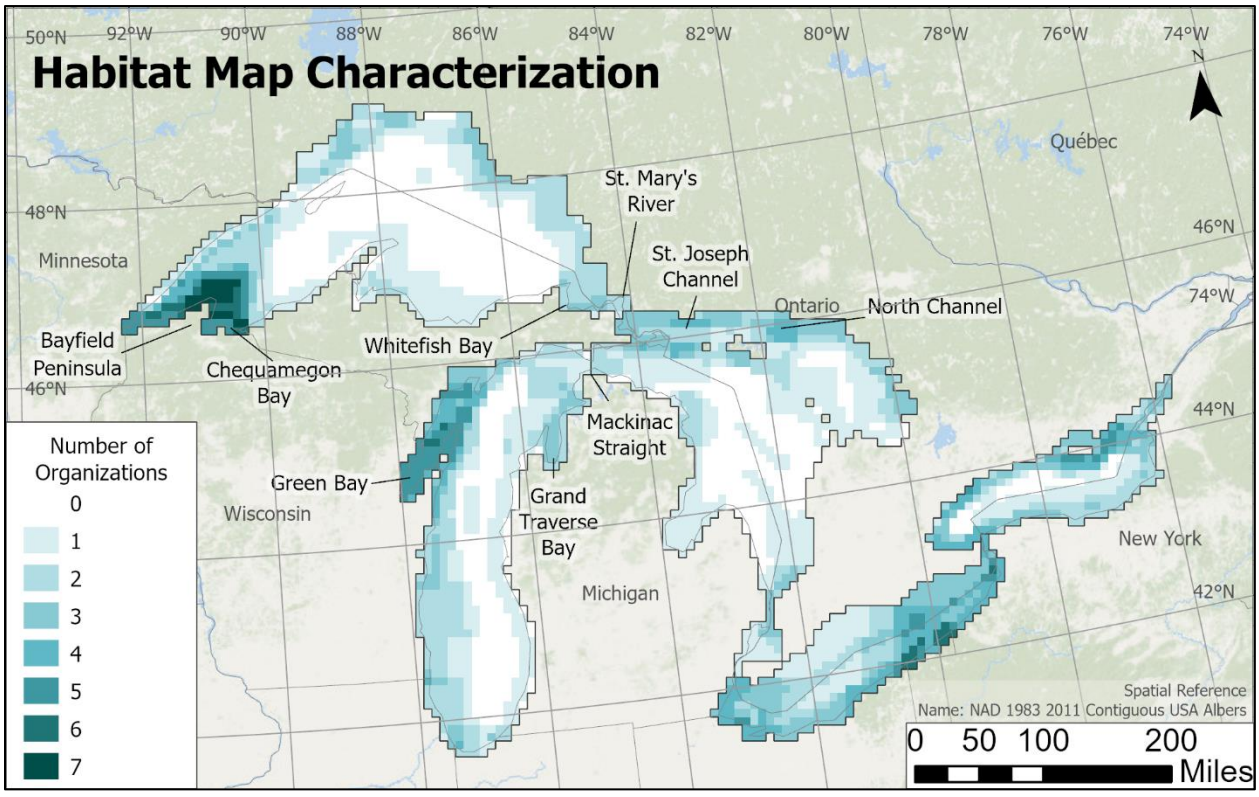

Figure 11. Map showing the number of organizations in the study that selected Habitat Map Characterization as their desired map product.

3.2.1 Unique Map Products

Unique map products were highest in a number of locations (**Figure 12**). In some locations, the number of unique map products rose alongside the number of unique justifications, which is not surprising, as more variation in reasons for mapping means there will likely be more variation in which map products are requested. In **Lake Ontario**, **Lake Erie**, and **Lake Michigan**, diverse map products were requested far offshore, and in the case of **Lake Erie**, across the entire lake. In **Lake Superior** and **Lake Huron**, there was a high number of unique map products in St. Joseph Channel and Whitefish Bay, and in the St. Mary's River. The most varied map products across the Great Lakes were along the coastlines of **Lake Ontario** and **Lake Erie**, in Green Bay in **Lake Michigan**, and along the northern coast of Wisconsin, including Chequamegon Bay, in **Lake Superior**.

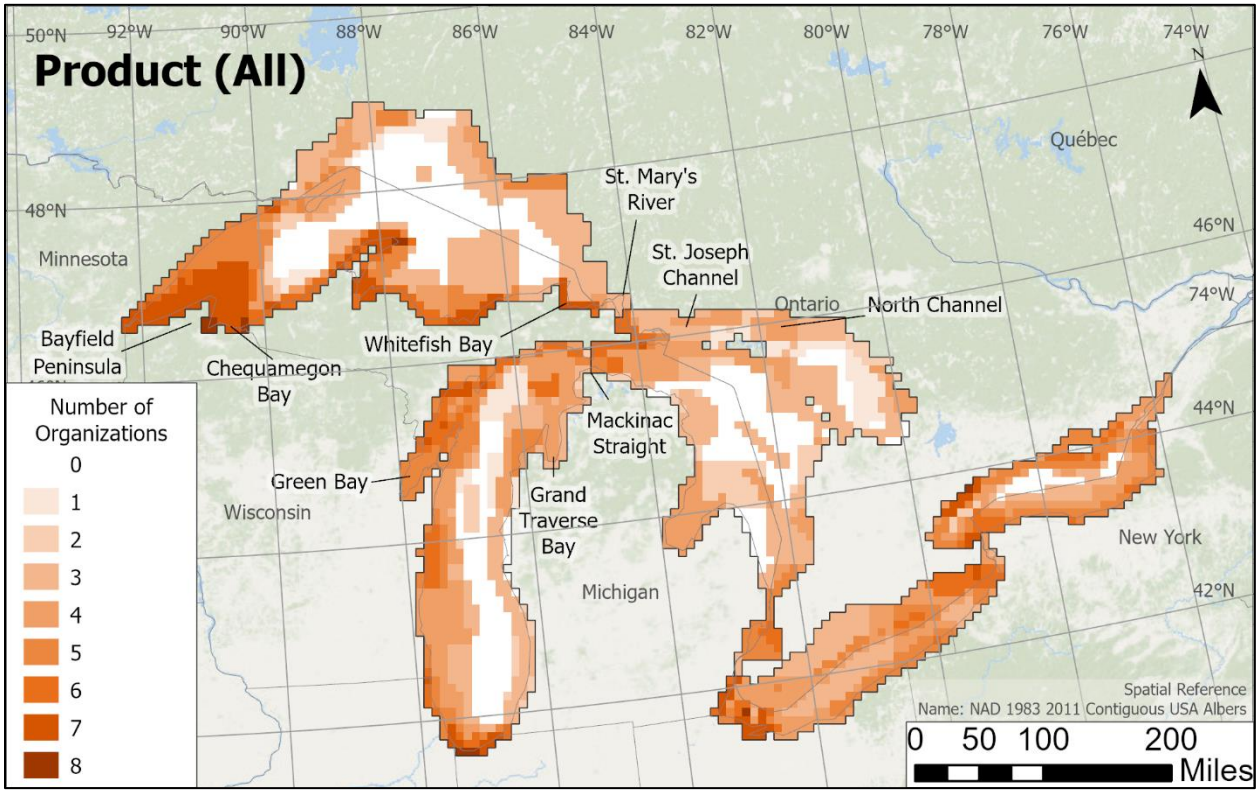

Figure 12. Geographic distribution of unique map products requested. Coastal areas tended to have more participants requesting different map products in the same areas.

3.3.2 Frequency by Region

A frequency plot was generated that identified the most common map products for each of the five (5) lakes, and for the entire Great Lakes as a whole. The frequency plot incorporated all map

products regardless of whether they were Primary, Secondary, or Tertiary. The Map Product option None was not included in this graph.

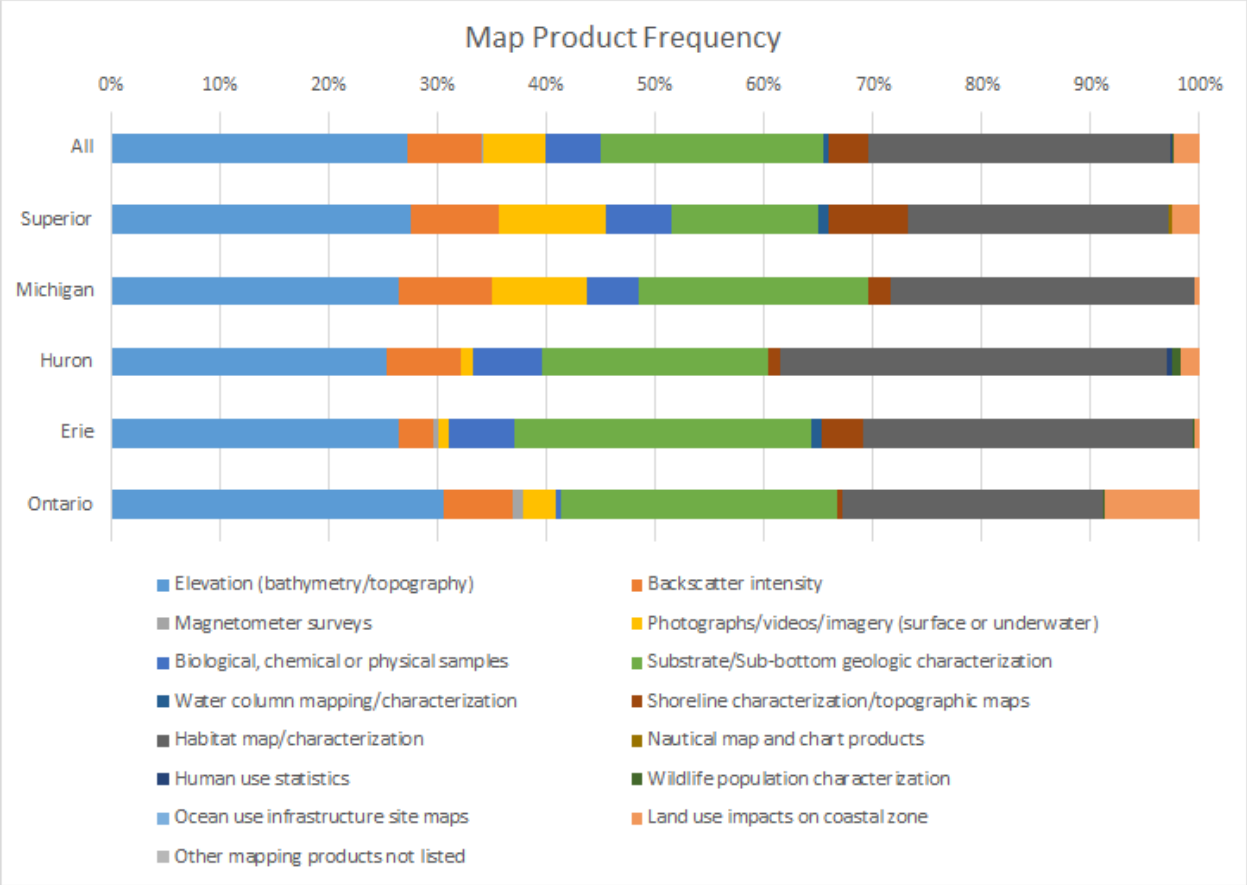

Figure 13. A chart showing, by lake, the frequency by which participants identified map product needs among 15 different options. Study participants frequently cited elevation data (light blue), substrate/sub-bottom geologic characterization (green), and habitat map/characterization (grey) as their desired map products.

Figure 13 reveals a number of interesting trends. Throughout the Great Lakes as a whole, the most-requested map products by frequency included Elevation, Substrate/sub-bottom geologic characterization, and Habitat map/characterization, and these three represented the majority of all responses. In **Lake Huron**, requested map products were similar to those of the Great Lakes as a whole, with some variation: there was less interest in Photographs/videos/imagery (<2% compared to ~5% for the Great Lakes as a whole), and more interest in Habitat map/characterization (over 30% compared to under 30% for the Great Lakes as a whole). **Lake Ontario** had markedly higher interest in Land use impacts on coastal zone than the Great Lakes as a whole, with nearly 10% of requested map products in **Lake Ontario** going to Land use impacts compared to ~3% for the Great Lakes as a whole. **Lake Michigan** saw higher interest in Backscatter intensity and

Photographs/videos/imagery than the Great Lakes as a whole, which was reversed in **Lake Erie**, where these map products were represented at a lower frequency. However, **Lake Erie** saw much higher interest in Substrate/sub-bottom geologic characterization compared to the Great Lakes as a whole (around 25% compared to 20%). Finally, **Lake Superior** saw higher interest in Backscatter intensity and Photographs/videos/imagery than the Great Lakes as a whole, but lower interest in Substrate/sub-bottom geologic characterization.

3.4 Overlap Analysis

One of the main purposes of this study was to make it easier for mapping partners to find each other throughout the Great Lakes. Potential partners can browse through the priority, justification, and map product results described in previous sections and identify shared areas of interest; however, the process is somewhat laborious and involves toggling on/off many layers. To streamline this partner discovery process, the study results were consolidated into a final data product called the "overlap analysis."

The overlap analysis is a simplified view of the study results. The analysis layer is created by merging and dissolving the submission grids for each organization that participated in the study. The layer contains the geospatial extent of the prioritized area(s) for each organization; the primary, secondary, and tertiary map products desired; and the name of the organization. The polygons in this layer have overlapping geometries.

The overlap analysis layer is accessible as a web map service, which may be viewed and queried through desktop or online GIS applications. With the layer displayed on a map, a user can pan to different locations, and select an area of interest. The overlap analysis will display the organizations that are interested in mapping in that location as well as the mapping data products they desire.

Figure 14 illustrates how a user might query the overlap analysis layer via the interagency U.S. Mapping Coordination Site. In this example, a user selects an area of the overlap analysis in the northern portion of Lake Michigan, and a pop-up window appears. The window displays the records within the overlap analysis that are co-located with the user's selection. Each record represents an organization. The "1 of 4" on the top bar of the pop-up window denotes four (4) organizations that share mapping interests at this location. By clicking on the white triangle adjacent to the "1 of 4" notation, the user may scroll through each of the four records. For each record, the window displays the name of the organization (under "Office") and the primary, secondary, and tertiary map products requested by that organization. In this example, the window is showing that the Michigan Department of Natural Resources is seeking habitat map/characterization, backscatter intensity, and elevation data at this location.

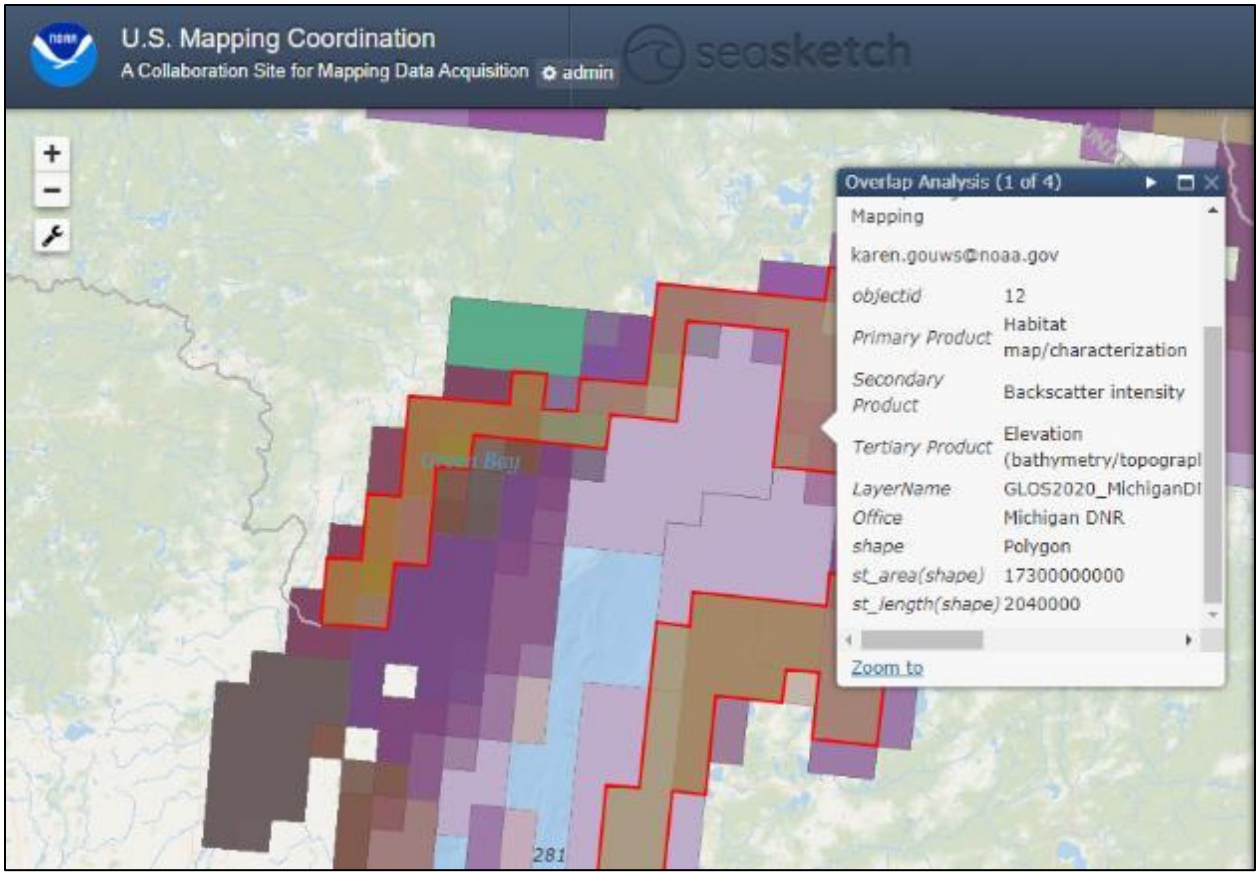

Figure 14. Screenshot of overlap analysis layer on U.S. Mapping Coordination Site.

4. CONCLUSION

The Great Lakes Spatial Priorities Study was conducted from June 2020 to March 2021. The study explored priority mapping areas among different Great Lakes mapping organizations with a primary interest in benthic habitat mapping throughout the U.S. and Canada. Study results helped to identify where there were shared mapping interests across the region among the surveyed organizations and individuals. It is hoped that the study results lead to enhanced collaborations around shared mapping needs by allowing study participants and other interested parties to see where overlapping geographic and thematic interests occur.

The discovery and exploration of overlapping interests is made possible through the U.S. Mapping Coordination Site, where results can be viewed and interacted with. The U.S. Mapping Coordination Site also provides the boundaries of completed and planned mapping efforts to allowing for discovery of data within needed geographies. Finally, the spatial prioritization study results provide acquisition planners with a new resource to assist with targeting their limited data acquisition resources (e.g., funding, ship time, etc.) to places with the greatest number of potential end users, and the specific desired end products and resolutions.

The analysis revealed a number of trends. High interest among multiple organizations was concentrated in places like the Minnesota and Wisconsin coasts of Lake Superior, Green Bay in Lake Michigan, and coastlines of Lake Erie and Lake Ontario. But multiple organizations reported interests throughout all lakes, with several lakes (particularly Lake Erie, Lake Ontario, and Lake Michigan) having mapping interests throughout the entire lake, from the coastline to far offshore.

Perhaps not surprising given the organizations selected to participate in the study, the analysis also identified that top mapping justifications were Habitat/biota/natural area, Benthic exploration, Commercial and recreational fishing, and Scientific research, though there was some variation. Likewise, the top map products requested were Elevation, Substrate/sub-bottom geologic characterization, and Habitat map/characterization, although some lakes also noted specific high interest in other map products, such as Land use impacts (e.g., Lake Ontario).

To enable further work on a broad scale mapping plan of action in support of Lakebed 2030, data from this study will be merged with other priorities submitted by additional NOAA offices and its federal partners. These results will be shared publicly on the interagency U.S. Mapping Coordination Site to assist in planning and coordination activities across additional stakeholders. NOAA will continually seek to improve and expand on the analysis to include more organizations. NOAA intends to repeat the mapping priority survey every three to five years to ensure relevance of these study results for ongoing data acquisitions.

5. DATA ACCESS

Data from this study can be accessed through the following methods:

Online Maps

Results layers, the original submission grids submitted by each organization, and the overlap analysis layer can be viewed on the interagency U.S. Mapping Coordination Site (URL: https://www.seasketch.org/#projecthomepage/5272840f6ec5f42d210016e4) under the subheading **Spatial Priorities Study: Great Lakes**.

Data Download

File geodatabases of the results layers, the original submission grids submitted by each organization, and the overlap analysis layer can be acquired by emailing IWG-OCM Staff at iwgocm.staff@noaa.gov.

GIS File Attribute Descriptions

Below are descriptions of what data can be found in each field (column) of each results layer. Each results layer is a raster file with the following three (3) field names. **Table 13** shows the field names and descriptions for results layers.

Table 13. Field names and descriptions for results layers.

Field Name	Description
OBJECTID	A unique ID for each row in the table
Value	For Justification_All: The number of unique justifications entered for that cell For Product_All: The number of unique map products entered for that cell For Priority_Weighted: The weighted priority value (High = 3, Medium = 2, Low = 1, None = 0), for that cell For all other layers: The number of organizations that entered that cell as a given priority, justification, or map product; for example, in Justification_BenthicExploration, this represents the number of organizations that entered a justification of "Benthic Exploration" for that cell.
Count	The count of cells in the raster layer that share the same value. When summed across all rows, it should add up to 3,029, the total number of cells in the grid.

Table 14 shows the field names, aliases, and descriptions for submission layers.

Table 14. Field names, aliases, and descriptions for submission layers.

Field Name	Field Alias	Description
OBJECTID	OBJECTID	A unique ID for each row in the table
Priority	Priority	Priority level (High, Medium, Low, or None)
Coins	Coins	Coin value. *All coin values are zero because this study did not use the coin method.* Instead, this study used the High/Medium/Low method (above). This column is a holdover from prior spatial priorities studies.
Justification1	Primary Justification	Justification selection. Full drop-down menu list is available in **Table 2**.
Justification2	Secondary Justification	Justification selection. Full drop-down menu list is available in **Table 2**.
Justification3	Tertiary Justification	Justification selection. Full drop-down menu list is available in **Table 2**.
Product1	Primary Map Product	Map product selection. Full drop-down menu list is available in **Table 3**.
Product2	Secondary Map Product	Map product selection. Full drop-down menu list is available in **Table 3**.
Product3	Tertiary Map Product	Map product selection. Full drop-down menu list is available in **Table 3**.
Driver	Driver	Driver (legislative, executive, program, etc.) selection. Full drop-down menu list is available in **Table 4**.
Resolution	Horizontal Resolution	Horizontal resolution selection. This describes the desired spatial resolution of the output data. Full drop-down menu list is available in **Table 5**.
Reg_Ocea	Reg_Ocea	Region codes for Ocean: **0** = Non-ocean (aka terrestrial) cell **1** = Ocean cell These codes were used as filtering methods within the application, filtering all the cells in the grid so that *only* ocean cells display in the application.
Grid_ID	Grid_ID	A unique six-digit identifier for each grid cell, in text format. Each cell will have the same Grid_ID and Cell_ID.

Field Name	Field Alias	Description
Cell_ID	Cell_ID	A unique six-digit identifier for each grid cell, in number format. Each cell will have the same Grid_ID and Cell_ID.
Lake_ID	Lake_ID	Identifies which lake a cell falls into: Superior, Michigan, Huron, Erie, and Ontario.
LayerName	LayerName	The name of the submission layer. This will be in the following format: GLOS2020_OrganizationName.

Table 15 shows the field names, aliases, and descriptions for the overlap analysis layer.

Table 15. Field names, aliases, and descriptions for the overlap analysis layer.

Field Name	Field Alias	Description
OBJECTID	OBJECTID	A unique ID for each row in the table
Product1	Primary Map Product	Map product selection. Full drop-down menu list is available in **Table 3**.
Product2	Secondary Map Product	Map product selection. Full drop-down menu list is available in **Table 3**.
Product3	Tertiary Map Product	Map product selection. Full drop-down menu list is available in **Table 3**.
LayerName	LayerName	The name of the submission layer. This will be in the following format: GLOS2020_OrganizationName.
Office	Office	The name of the submitting office/organization: Penn State University, Grand River Conservation Authority, etc.

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