Developing Ecological Decision Support Tools for Long Island Sound Seafloor Habitats: 2024 Workshop Report

Mixed shell substrate featuring sparse macroalgae, including *Gracilaria*

LONG ISLAND SOUND HABITAT MAPPING INITIATIVE REPORT PREPARED BY:

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Boring sponge *Cliona* towers host mixed bryozoan and hydrozoan colonies in the Phase 2 area.

Introduction

This report provides a summary of the recorded feedback provided by spatial data users throughout Long Island Sound during a workshop at UConn Avery Point on April 4, 2024. The workshop served as a critical step in the Long Island Sound Seafloor Habitat Mapping Initiative's multi-step process to improve decision support tools (DSTs) for facilitating informed decision-making throughout the Sound. For the purpose of this workshop and report, a DST was defined as a program or website that assists users with data and information transfer, analysis, or storage and includes DSTs ranging from online data warehouses to map-based visualizers and scenario modelers (see summary of DSTs in Appendix 1). The workshop structure and targeted outcomes were designed to address data user needs and preferences identified through a survey process.

The survey was completed by 282 respondents representing the various user groups and geographic extent of Long Island Sound (see survey summary in Appendix 2). Respondents answered fifteen questions that helped identify where users are accessing data; preferred data formats; the big picture uses of data; and the biggest challenges to using the data. The survey results suggest the most common use for geospatial data across user groups (planners and policy makers, researchers and scientists, engineers and consultants) is for decision-making and qualitative assessments. Of the twelve DSTs named in the survey, respondents said they regularly used all to acquire data and achieve their goals and included additional tools in an open-ended "other" category. The survey results indicated that data accessibility, followed by availability, were the biggest challenges users faced when using DSTs. Details about decisions being made and the data needed to make those decisions; reasons for choosing one DST over another for a given purpose and types of data being accessed from each required further evaluation.

In addition to the current challenges, needs and preferences identified by data users, future decisions and data needs also required consideration. Across all user groups, respondents identified stakeholder engagement and outreach as the second most common use of geospatial data, a process that could be facilitated by a well-designed DST. Hence, the following key goals were identified for the workshop:

1. Identify decisions being made in LIS and the data or data products needed to inform those decisions
2. Examine the qualities that make a DST accessible, user-friendly, and useful
3. Determine what future considerations decision-makers foresee needing to address
4. Explore how a DST could facilitate stakeholder engagement and outreach.

Each of these goals was addressed throughout the in-person workshop through plenary talks, small-group discussions, and a moderated full-group discussion. The following sections detail the workshop planning and structure; describe the ideas generated throughout the day relating to each of the four goals; and summarize the key takeaways.

Workshop Planning, Structure and Program

Guided by the information gaps and goals identified through the survey process, the workshop structure was carefully designed and refined to achieve the overarching goal of informing the improvement of marine geospatial DSTs for Long Island Sound (see Workshop Program below). An overview of the survey findings and existing DSTs for LIS and lists of identified gaps to address and questions for discussion were distributed one week ahead of the workshop (see Appendices 1 & 2). The workshop physical space was lined with posters describing the existing data and data products from the LIS Seafloor Habitat Mapping Project so that participants could explore and discuss their benefits and limitations throughout the day.

The workshop began with a welcome and introduction to the day and goals by Jim O'Donnell and a broad introduction to the long-standing, large-scale Long Island Sound Seafloor Habitat Mapping Initiative by Kevin O'Brien (manager of the CT National Estuarine Research Reserve and former project lead for the LIS Seafloor Habitat Mapping Initiative at CT DEEP) and Mark Tedesco (director of EPA Long Island Sound Office). To inform the day's discussions, two speakers agreed to provide plenary talks based in their extensive experience in marine spatial planning and policy and the use of data for informed decision-making. Jennifer McCann, director of U.S. Coastal Programs at the Coastal Resources Center at the University of Rhode Island Graduate School of Oceanography and Director of Extension Programs for Rhode Island Sea Grant, was integral to the development of the Rhode Island Special Area Management Plan, the first formally adopted Ocean Spatial Plan in the United States. Todd Callaghan, coastal and marine ecologist with the Massachusetts Office of Coastal Zone Management, serves on the Northeast Regional Ocean Council's Habitat Classification and Ocean Mapping Subcommittee. McCann and Callaghan shared their extensive experience in translating data into action in nearby Rhode Island and the Gulf of Maine, respectively, with case studies elucidating the data needed, steps taken, tools used, and best practices for planning for different types of uses while balancing diverse social and ecological concerns.

Immediately following the plenary talks, attendees were divided into small breakout groups (see Participant Perspectives section) to provide input on the identified goals (see Appendix 3 for breakout group goals and prompts). The first session was aimed at identifying the decisions being made, the data required to inform those decisions, and the DSTs being used. The second session focused on determining the pros and cons of existing DSTs (e.g., features that helped or hindered utility and decision-making); envisioning qualities of an idealized DST; identifying ways for DSTs to be used to address future needs; and use of DSTs to facilitate stakeholder engagement. A summary of the information recorded within the breakout groups and the full-group moderated discussion for each of the workshop goals is included below.

Boulder pile featuring ghost anemonmes *Diadumene leucolena* and mixed sponge colonies, including *Cliona* and *Halisarca*

Workshop Program

8:30 – 9:00	**Arrival and Coffee, Tea & Light Breakfast**
9:00 – 9:35	**Introduction and Background** • Welcome, Introductions, and Goals of the LIS Seafloor Habitat Mapping Workshop (Jim O'Donnell) • Brief introduction to LIS Seafloor Habitat Mapping Initiative (Kevin O'Brien)
9:35 – 10:10	**Plenary One: "Using data and local knowledge for coastal planning: Cable Laying in Narragansett Bay"** with **Jennifer McCann**, director of U.S. Coastal Programs at the Coastal Resources Center at University of Rhode Island Graduate School of Oceanography & director of Extension Programs for Rhode Island Sea Grant
10:10 – 10:20	**Break**
10:20 – 10:55	**Plenary Two: "Seafloor Mapping–Data Translated to Action" with Todd Callaghan**, coastal and marine scientist at the Massachusetts Office of Coastal Zone Management
10:55 – 11:10	**Breakout Groups Assignments and Topics**
11:10 – 12:10	**Breakout Session One**–Decisions, data, and DSTs in use in Long Island Sound
12:10 – 1:20	**Lunch by Chef Sherry Pocknett and Sly Fox Den (Branford House)** Fish Tacos with Three Sisters Succotash; Chef Sherry's Slaw and Fry Bread sides; Corn Cakes and Three Sisters Rice; Cranberry Lemonade and Sassafras Tea. Indian Pudding and Pear Crisp for dessert.
1:20 – 2:20	**Breakout Session Two**–Ideal DST features, future considerations, stakeholder engagement
2:20 – 2:35	**Break and Transition to Seminar Room**
2:35 – 3:45	**Moderated Discussion and Consensus Building Activities**
3:45 – 4:15	**Closing out the meeting** • Summary and Recommendations • Next Steps • Ideas and requests for future workshops

Participant Perspectives on Workshop Goals

According to the survey results, all user groups across roles and organizations throughout the Sound are using geospatial data to inform the decisions they make in the region. To ensure that the wide variety of users were well represented at the workshop, hundreds of prospective participants working around the Sound were contacted with a request to participate. Seventy (the maximum number of participants) registered and fifty-six attended. The participants represented a broad range of organizations and interests including:

- **Federal organizations:** Environmental Protection Agency, National Oceanic and Atmospheric Administration, U.S. Army Corps of Engineers, U.S. Department of Agriculture's Natural Resources Conservation Service, U.S. Geological Survey, U.S. Fish and Wildlife Service
- **Regional planning collaborations:** New England Interstate Water Pollution Control Commission
- **State agencies:** CT Dept. of Energy & Environmental Protection, CT State Historic Preservation Office, MA Office of Coastal Zone Management, NY State Dept. of Environmental Conservation
- **Research and Scientific groups:** CT Institute for Resilience and Climate Adaptation, CT Sea Grant, CT National Estuarine Research Reserve, Long Island Sound Study, Northeast Ocean Data Portal, Northeast Regional Ocean Council, Rhode Island Sea Grant
- **Engineering and Consulting firms:** Inspire Environmental, WSP
- **Academic institutions:** Lamont-Doherty Earth Observatory at Columbia University, Stony Brook University, University of Connecticut, University of New Haven, University of Rhode Island
- **Tribal government and representatives:** Golden Hill Paugussett Tribal Nation
- **Nonprofit organizations**: Mystic Aquarium, Save the Sound

Participants were distributed among eight breakout groups to allow for focused conversation and optimization of idea capture. Groups were assigned to enhance diversity in role and organization, to enrich discussion and broaden perspective. Participant responses to each prompt were recorded on flipchart pages, which were then transcribed and collated into the summary below by tallying repeated or similar phrases to identify recurring issues and common points of interest. The feedback gathered during the workshop and summarized below will inform the design and development of DSTs to support decision-making in Long Island Sound and the surrounding areas and communities.

Goal 1: Identify the decisions being made in LIS and the data or data products needed to inform those decisions

Common decisions being made fell within fifteen topics, with seven of those mentioned by multiple breakout groups. The first and the most frequently identified were decisions associated with **laying seafloor cables**. Decision-making pertaining to **aquaculture**, including permitting, siting, evaluating habitat quality, assessing impacts, and quantifying interactions with wastewater or pollution was the second-most mentioned. Similarly, decisions pertaining to **shallow water development** (including dock operations), **dredging** (siting, disposal, reuse), **water quality** (assessment, tracking contaminants, mitigating wastewater and pollution, and updating/siting treatment facilities), **restoration efforts,** and **identification of paleo landscapes and shorelines** were commonly identified.

A main takeaway was the breadth of data required to make informed decisions and take action. More than thirty types of data were identified as necessary for informed decision-making across the breakout groups (Table 1). A common theme across data types was the need and preference for interpreted data products (e.g., maps or graphs) for quick assessments. However, users also identified the importance of access to raw or low-level data for subsequent, detailed analyses and evaluation. Among the data types identified, the following emerged as consistently important: detailed sediment characterization; nearshore data to integrate with offshore data; fisheries and species-level distribution; habitats, and sociocultural data (fishermen and stakeholder perspectives, Tribal interests, shipwrecks, and submerged cultural landscapes) (Table 1).

Table 1. Participant-identified information needs for decision-making in Long Island Sound, generated during breakout group sessions. Category groupings determined by report authors.

Data Category	Data Needs
Oceanography	Sea level changes, pelagic processes, tidal data, water column light, currents, dissolved oxygen, wave height, wind speed
Bathymetry & Imagery	Bathymetry, historical imagery, orthophotographs, LiDAR for shallow water characterization
Water Quality	Temperature, water quality, sewage outflows
Sediment Characterization	Sediment type, sediment cores, dredging data, contaminants (not just metals), 3D characterization of sediment stratification, grain size, sand, temperature, porosity, magnetic properties, bulk density, transference, thermal conductivity, stability, potential hypoxic areas, climate change impacts
Habitat	Essential fish habitat (EFH), habitat characterization and quality, submerged aquatic vegetation
Biological Communities	Coastal and marine ecological classification scheme (CMECS), benthic communities, ecological data, shellfish beds, species distribution maps, wildlife agencies areas of concern, sand lance data & spawning areas, climate change impacts
Restoration	Location of sites, case studies, StoryMaps
Sociocultural	Archaeological sites, fishermen's opinions and insight, cultural data, tribal interests, shipwrecks, stakeholders in a given area, recreational uses/areas, legal enforcement
Fish and Fisheries	Fisheries datasets, preferred habitats, seasonal locales, species distributions, kept catch and biomass heatmaps
Energy and Infrastructure	Cable landfalls, windfarm infrastructure
Nearshore	Land use changes, agriculture, tidal marsh data, potential cable landfall sites, topography
Aquaculture	Presence/location, details about aquaculture projects, past permits, gear types

Goal 2: Examine the qualities that make a DST accessible, user-friendly, and useful

The overabundance of DSTs:

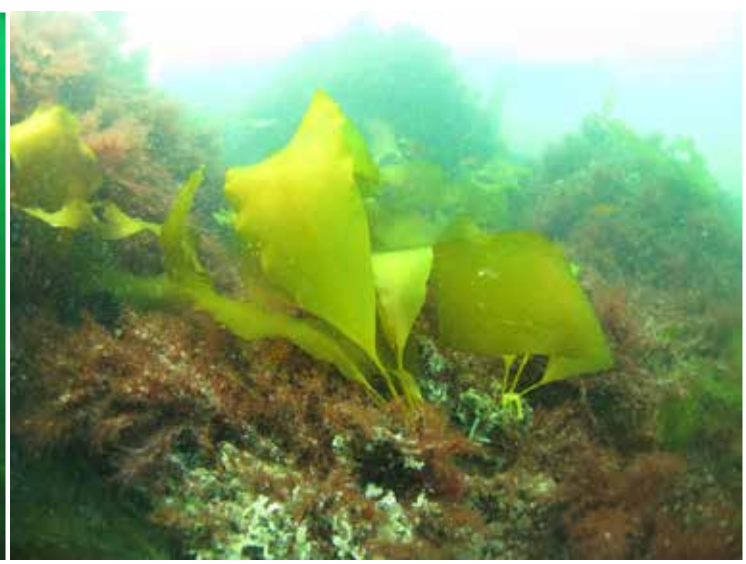
Workshop participants described using more than thirty DSTs for Long Island Sound (Table 2). The most common refrain heard was the challenge of data being distributed across so many DSTs, each with its own interface and access requirements. Rather than producing a new DST with another subset of data, it became clear that a queryable directory of available data to serve as a central guide connecting users with existing DSTs would be helpful to the community. Several participants cited findability–lacking awareness of the existence of data or a DST–as a major impediment to accessibility.

Data quality and accessibility concerns:

Participants also discussed the importance of quality assurance and completeness of data and data products being provided for the Sound and emphasized the need for data standardization. Many identified issues with the "inconsistency" of data across platforms, viewers, and sources. While the nature of the inconsistencies were not defined explicitly in this process, we interpret this to mean that various platforms and DSTs supply different types of data, formats, or methods to transform raw data into data products. An effective DST would provide quality assurance for the data; standardized metadata with a detailed description of processing from raw data to product (e.g., thresholds used or assumptions made); quantification of uncertainty; and a point of contact for the dataset.

Participants also emphasized the need for increased data sharing. Incongruent data sharing policies across agencies and organizations are seen to hinder data quality and availability, with larger consequences for decision-making at smaller agencies and organizations with more limited resources. While a new DST cannot compel organizations to share data, it is a major concern of the workshop participants and worth addressing through policy at higher levels of organization.

Fostering communication and collaboration was repeatedly voiced as an important quality of a DST and a priority for future consideration as a means to cooperatively determining priorities and achieving public outreach and engagement (discussed further in Goal 4).

Left: Chris Conroy (UNewHaven) takes scaled orthogonal images of boring sponge *Cliona* and northern star corals *Astrangia poculata* at Ellis Reef in Fishers Island Sound during Phase 2. [photo by Peter Auster]; Right: sugar kelp *Saccharina latissimi* surrounded by other algae and epifauna at Black Ledge in Fishers Island Sound during Phase 2. [photo by Peter Auster]

Preferred technical aspects of DSTs:

Workshop attendees strongly voiced their preference for an interactive mapping interface for accessing data and data products with the option of exporting static maps for dissemination and raw data for additional analyses. Preferred features include a toggle-on or off for viewing multiple data layers to suit specific project needs and a mechanism for defining an area of interest. DSTs requiring an account (paid or free) or advanced technical skills and knowledge to operate (e.g., ESRI/ArcGIS license and skillset) were strongly discouraged, since many organizations lack access or staff dedicated to those software systems. Instead, increasing user-friendliness by including clear communication, accessible language, and a built-in glossary for technical and scientific terms was strongly encouraged.

Table 2. DSTs identified and discussed by participants.	
Aquaculture siting atlas (CT)	NCCA
Aquaculture mapping atlas	NCCOOS/LISICOOS/NERACOOS
CLEAR	Northeast Ocean Data Portal
CT Blue Plan	Northeast Pacific Regional Climatology on NCEI
CT Eco	NYC DEEP
EFH Mapper	Recreational Fishing Tool (RI)
ERDDAP	SediMatch
Fisheries portal	Shellfast (MA)
Internal agency data	Storm Tools
MARCO	Tides and Currents
Marine Traffic	U.S. Army Corps of Engineers
MyCoast	USFWS
National Agriculture Imagery Program	USGS
National Park Service	Web soil survey

Goal 3: Identify future considerations decision-makers foresee needing to address

Increasing the temporal coverage of data:

Discussion among the participants centered around the temporal and spatial resolution and coverage of data; they seek to understand trends in data and to identify cumulative impacts. Access to historical imagery and previously unshared data will aid in those efforts. They emphasized the importance of long-term datasets and sustained monitoring for the successful future management of LIS. Such monitoring requires many years of planning to accomplish and should therefore be planned for now. Given the costs and time required to implement data collection, the tradeoff between investment and completeness (spatial and temporal resolution and coverage) of the data acquired in the future should be carefully considered.

Identifying and reducing vulnerabilities for biodiversity:

Given global and local trends and predicted future conditions, conserving biodiversity and fostering habitat health was identified as a priority. Participants identified the critical need for vulnerability indices for species in the Sound. Data in hand may be insufficient for developing effective indices, so future improvement in the temporal resolution of data in the region was identified as a priority. Participants also emphasized the importance of assessing habitat fragmentation and identifying the potential for fostering wildlife corridors; in identifying current biodiversity hotspots and informing the design of marine protected areas; and in prioritizing areas that would most benefit from restoration.

Economic considerations:

Blue carbon management and an anticipated increase in aquaculture were identified as a growing future focus for decision-makers. Both would require increased water quality monitoring and habitat assessment. Participants predicted well-planned restoration and mitigation projects to increase in importance, bringing additional economic and ecological gains. Participants also foresaw issues that would carry economic costs, including increasing coastal erosion and shallow water development projects. Hence, future DSTs need to be effective at performing cost-benefit analyses for a given proposed action or scenario to inform permitting, mitigation or compensation.

Goal 4: Explore ways a DST could facilitate stakeholder engagement and outreach

Participants identified facilitation of stakeholder engagement as the second most common use for geospatial data. DSTs can offer enhanced communication throughout the Long Island Sound community. Participants encouraged increased cooperation and partnership among organizations. Consensus among multiple perspectives and agendas and improvement in the quality of data collected with pooled resources results in increased public trust. There was an interest in facilitated communication among DST users for identifying opportunities to share expertise and coordinate data collection.

Emphasis was placed on the value of enhanced communication both from and to stakeholders. Stakeholder participation is a key tenet in marine spatial planning and adaptive co-management; a DST should be developed to facilitate this reciprocal stakeholder engagement, rather than one-way communication. Participants did identify the use of StoryMaps as a helpful tool for summarizing complex geospatial data into accessible and engaging spatial stories that convey important information about the status of marine systems. Sharing underwater imagery of marine habitats, often done within StoryMaps, could increase connection with and understanding of the significance of the data being collected. Communication with stakeholders could be enhanced by facilitating the export of high quality customizable summary outputs of data or trends for use in presentations and reports.


Left: The underside of a boulder and mixed gravel host ghost anemones *Diadumene leucolena* interspersed with breadcrumb sponge *Halichondria panicea*; Right: Roman Zajac and Chris Conroy (UNewHaven) guide the USGS SEABOSS during launch operations aboard the R/V Connecticut during Phase 2.

Conclusions

There is a wide variety of complex decisions to be made throughout the Sound and unique collections of data and data products are needed to inform each decision-making process. For the Long Island Sound Seafloor Habitat Mapping Initiative and other organizations looking to improve DSTs for the Sound, the participant perspectives presented here thoroughly described many avenues for success through minor adjustments to or major advances in existing DSTs. We see (i) three tractable elements that inform the development of a user-friendly, useful DST and (ii) approaches for advancing research of and decision-making for Sound seafloor habitats.

(i) Data findability and accessibility are the biggest roadblocks to data-driven decision-making in the Sound. Therefore, DST development should focus on:

1. ***making data findable across organizations***
2. ***designing DSTs to be easily used and understood by all***
3. ***increasing communication from, to, and among users and organizations.***

A wealth of data is currently distributed across an unwieldy array of DSTs. An ideal solution would be to integrate available data into a single, high functioning DST that serves as a one-stop shop for all data needs. Organizations collect and store their own data to meet their mandates and serve their respective communities, therefore a single DST is unlikely to emerge anytime soon. The USGS has been working towards developing a mapper with all available Long Island Sound data, offering great potential to solve multiple purposes. Currently, their mapper is limited to a few data sources and will require several years before all data is incorporated. As a near-term solution, participants identified a need for a DST that takes the form of a queryable directory that could point and connect users to where data can be retrieved and identify the organizations generating that data. Such a directory would help to reveal data gaps and areas of data abundance for informing decision-making.

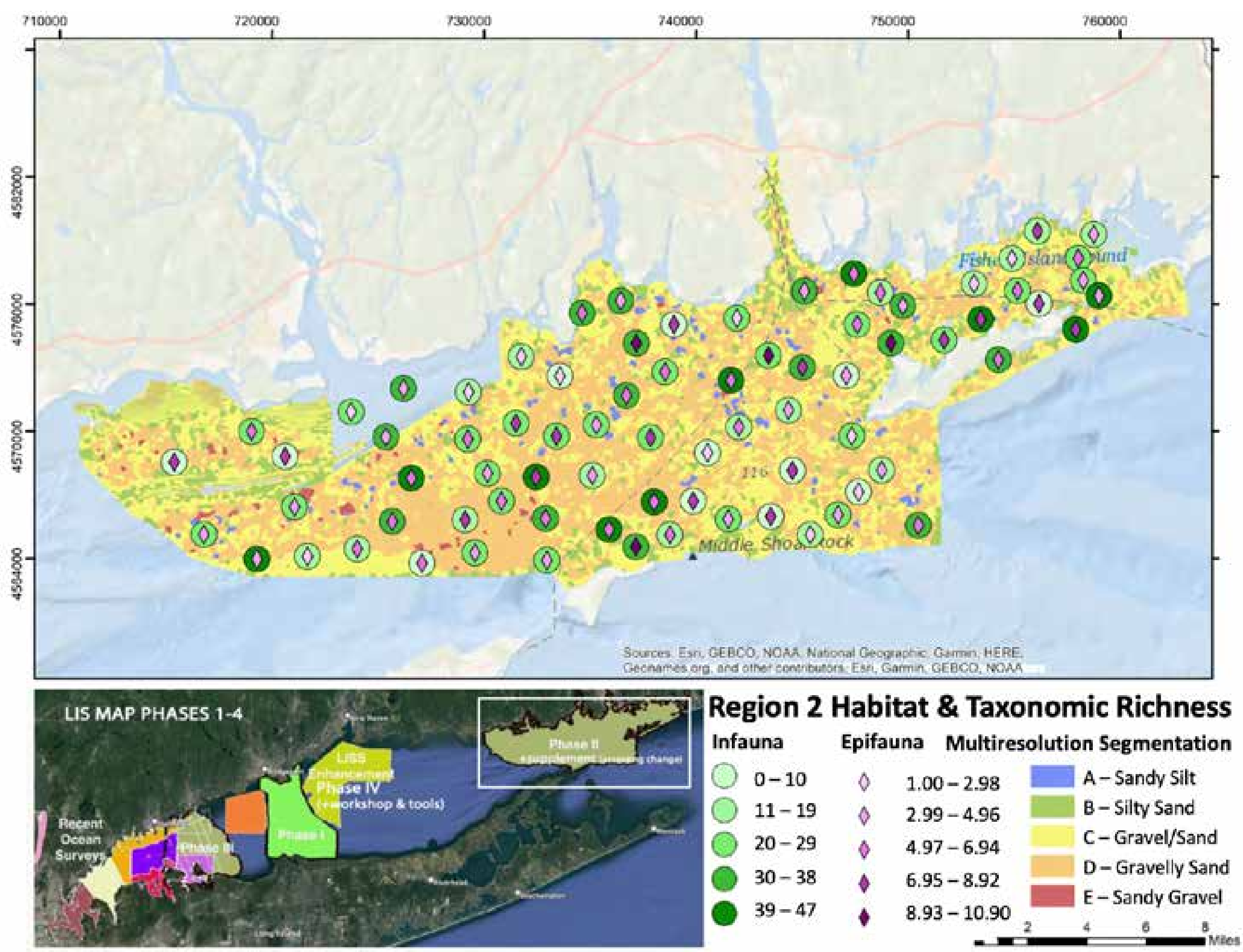
Key features that improve the user-friendliness and usefulness of DSTs for decision-making include the use of clear language and an accessible glossary; availability of summary products (e.g., maps or graphs rather than raw data); inclusion of data quality metrics; and an area-of-interest functionality. Participants indicated that the raw data should be easily accessible through the DST and called for the development of data standards and increased transparency so that data are consistent across viewers and the assumptions used to translate data into products are known. Emphasis was placed on enhancing communication among decision-makers, across organizations, and with stakeholders. A DST could be helpful in coordinating data collection and improving analyses. A DST that facilitates data sharing allows for resources to be pooled and more effectively used. The ability to export high-quality maps, figures and images that are readily interpretated and integrated into other platforms (e.g., StoryMaps) would serve to enhance communication between decision-makers and stakeholders.

(ii) To meet future needs for decision-making in Long Island Sound, additional data must be collected and/or made available, temporal resolution needs to be increased, and vulnerability indices prioritized.

Participants identified current and future data gaps in focal areas including seafloor cables, aquaculture, water quality, shallow water development, and restoration. The most pressing data needs are in water quality, sediment characterization, habitat and biodiversity assessment, and high spatial resolution shallow water data that can be integrated with offshore data. Participants identified the need for improved temporal resolution of data and for long-term monitoring to enable detection of trends in abiotic and biotic variables. Improved temporal and spatial resolution and coverage would aid in the development of vulnerability assessments. Planning to achieve these goals is a five-year process. While the needs cannot be fulfilled in the immediate term, organizations can begin to identify collaborators, apply for funding, and plan the data collection and sharing efforts envisioned to incrementally improve decision-making capacity.

Next steps for the Long Island Sound Habitat Mapping Initiative and DST Development

The Long Island Sound Seafloor Habitat Mapping Initiative 2024 workshop for informing decision-making in Long Island Sound and improving the usability and accessibility of the data and data products generated by the project (https://lismap.uconn.edu/) was very productive. Informed by the outcomes of this workshop, the Initiative plans to improve accessibility and findability of products from this project and other data collection efforts throughout the Sound by developing a web-based data-navigator hosted on a redesigned and modernized Initiative website. The project team will work to make LIS Seafloor Habitat Mapping Initiative data findable in the other data portals and DSTs identified by workshop participants. We will revise the language used and explanations provided to optimize accessibility. Approaches to future data collection efforts will be informed by the needs and priorities identified in this process.



Top: Phase 2 habitat map depicting sample infaunal and epifaunal diversity; Inset: Map of Long Island Sound featuring planned and completed seafloor mapping project areas.

Acknowledgments

The Long Island Sound Seafloor Habitat Mapping Initiative wishes to thank all of the participants who contributed their time and thoughts to this workshop, despite the challenging weather. We wish to thank Katie Lund (CT NERR) for facilitating the conversation, and Kevin O'Brien (CT NERR) and Mark Tedesco (EPA, LIS Office) for introducing the LIS Seafloor Habitat Mapping Project. We thank Jennifer McCann and Todd Callaghan for providing valuable regional context and DeAva Lambert for describing the work ahead. We thank Chef Sherry Pocknett, Jade Galvin and the Sly Fox Den family for a beautiful lunch. Finally, our thanks to Judy Benson, communications coordinator at CT Sea Grant, for her expert review of this report and to John Lucas and the UConn Research Communications team for designing its form.

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Clockwise from Upper Left: Sean Ryan and Riley Pena (UConn) are joined by Roman Zajac (center, UNewHaven) as they sieve sediments collected during Phase 4 USGS SEABOSS operations aboard the R/V Connecticut; Riley Pena (UConn), Nyrobi Whitfield (Oberlin College/UConn REU), and Benjamin Odoh (UNewHaven) inspect the Boxfish ROV prior to launch aboard the R/V Connecticut during Phase 4; Courtney Schneeberger and Olivia Walton (UNewHaven) sieve sediments collected during Phase 2 USGS SEABOSS operations aboard the R/V Connecticut; Carson Hill and Carlee Dunn (UConn) prepare to launch the Boxfish ROV aboard the R/V Weicker during Phase 3.

Appendices

Appendix 1. Pre-workshop Materials: Summary of Decision Support Tools

Decision Support Tools

Definitions

Decision Support Tools (DSTs) can take many forms—from dashboards providing access to real-time data; to map-based interfaces that display information from multiple datasets; to applications that allow users to adjust parameters via 'knobs and levers' for exploring a range of possible outcomes associated with specific decisions (Stoltz et al. 2023). They are intended to support users with various tasks, including data and information transfer, analysis, or storage (Punarbasi et al. 2017).

Data products, unlike raw data, fall under the umbrella of DSTs because they translate underlying raw data into more interpretable and actionable information. For example, raw abundance counts of any given species can be used to generate predicted species distributions with estimated uncertainty and presented as maps showing the probability of a species occurrence across a given area. This data can be combined with other species abundance data to model the spatial distribution of various taxonomic levels (e.g., seabirds or all birds) which can be used to map the spatial distribution of bird diversity indices. An alternative example is the translating of gigabytes of raw sensor data into a more useful product such as current speed and direction into bottom stress or hourly pH levels into trends in ocean acidity or ocean health indicators. As such, data products are one of many useful types of DSTs.

How DSTs are used

DSTs are intended to facilitate decision-making and resource management by providing actionable information for each step of the management process. Described below are six tool function categories and the step(s) of the marine spatial planning (MSP) process that the function supports. Also included are links to explore tools providing the identified functionality.

> **Tool function: Data management**–provide access to raw data needed to characterize the social-ecological system where the decision is being made.
Helps with: Step 2—gathering data
Examples: all data portals (e.g., USGS)

> **Tool function: Mapping and visualization of data**–interpreting the raw underlying data into either spatial (maps) or nonspatial (graphs) summaries of conditions and communities within the system. Whether spatial or nonspatial, these summaries can be interactive (users can change included data) or static (preset data).
Helps with: All steps
Examples: Northeast Ocean Data Portal

Seven Steps of Marine Spatial Planning

1. **Define management goals and objectives**
2. **Gather data & define current conditions**
3. **Identify issues, constraints, and future conditions**
4. **Develop alternative management actions**
5. **Evaluate alternative management actions**
6. **Monitor and evaluate effectiveness of implemented management actions**
7. **Refine goals and objective**

- **Tool function:** Alternative scenario development and analysis–these tools can be designed to perform various functions that help determine management options such as ecosystem service valuation, impact assessments, tradeoff assessments, forecasting of conditions, and providing visual context to management options.
  Helps with: Steps 3 through 5
  Examples: TNC's Marine Mapping Tool or Coastal Resilience Tool (functions for Connecticut and allows you to model different sea level rise scenarios)

- **Tool function:** Proposing and analyzing options for a given management action–can help determine the location where management actions can be implemented based on site conditions, permitting, mitigation measures required, or compatibility with other ecosystem uses.
  Helps with: Steps 4 and 5 – developing and evaluating management options
  Examples: Marxan Mapp

- **Tool function:** Stakeholder and community engagement and outreach–can allow users of all levels to explore, query and visualize data, can incorporate local and traditional knowledge, and can allow stakeholders to comment on proposed plans or actions.
  Helps with: All steps
  Examples: Sea Sketch (formerly Marine Map)

- **Tool function:** Support of adaptive management by assessing whether objectives were met–compare conditions post management action to initial conditions either spatially or by generating reports and graphs.
  Helps with: Steps 5 though 7 – evaluating effectiveness of actions and refining plans
  Examples: ARIES (ARtificial Intelligence for Ecosystem Services)

Example DSTs and tool function

Tools included are Connecticut Blue Plan, Connecticut Environmental Conditions Online (CT ECO), the Integrated Ocean Observing System (IOOS), Long Island Sound (LIS) Seafloor Habitat Mapping Initiative, Marine Geospatial Data System (MGDS), Mid-Atlantic Ocean Data Portal (MARCO), Northeast Ocean Data Portal (NODP), and New York State Geographic Information Gateway.

Decision Support Tool	Data Management	Mapping & Visualization	Alternative Scenarios	Determining Options	Stakeholder Engagement	Management Reassessment
CT Blue Plan	X	X			X	X
CT ECO	X	X		X		X
IOOS	X	X	X	X		X
LIS Seafloor Habitat Mapping	X	X			X	X
MGDS	X					X
MARCO	X	X	X	X	X	X
NODP	X	X			X	X
NY State GIS portal	X	X				X

NOTES: While all freely available data portals and visualizers facilitate stakeholder engagement to some degree, the marked sites offer StoryMaps or other visualizers that are easily interpreted by individuals across experience levels. Similarly, most tools can facilitate management reassessment as long as the conditions pre-intervention or management action are available in a form that can be directly compared post-action. Alternative scenario investigation can be achieved through most tools, but those highlighted here allow forecasting of conditions.

How you can help us create a DST

- What are common management goals and objectives for LIS decision-makers? What data or data products are needed to achieve those goals and objectives?
- Would connecting to other decision-makers through the DST be of help in determining goals, objectives, and available management options? What about easy access to case studies or examples of how other decision-makers apply the data?
- Who are the stakeholders in your area of responsibility? What information would they like to explore? What information do you wish they had ready access to that could improve how you communicate with them?
- What do you like or dislike about the DSTs for Long Island Sound? What do you wish you had?
- What makes a DST useful and user-friendly to you? What existing guides or help pages have been effective for you?
- Are there DSTs from other regions that you think would be effective for LIS?

DST resources and references

Center for Ocean Solutions (2011) Decision Guide: Selecting Decision Support Tools for Marine Spatial Planning. Stanford, CA: The Woods Institute for the Environment, Stanford University, 56pp. DOI: http://dx.doi.org/10.25607/OBP-44

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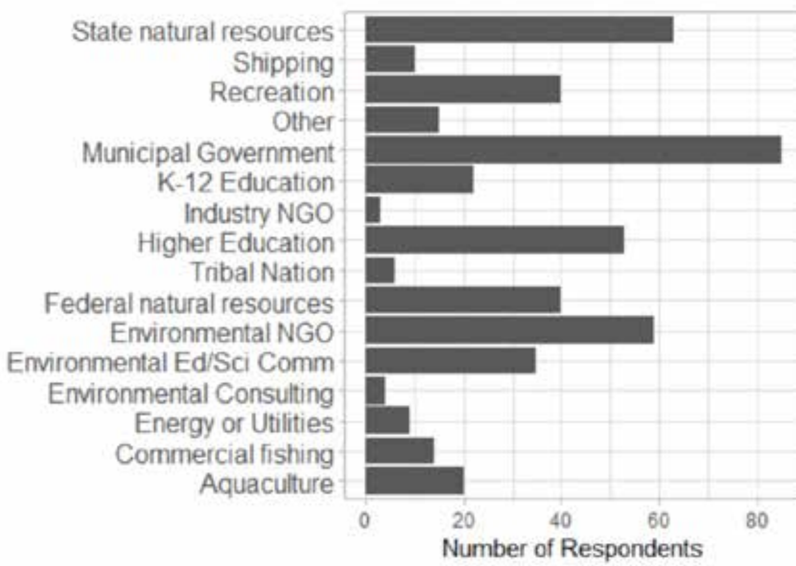
Appendix 2. Pre-workshop materials: Long Island Sound geospatial data survey report

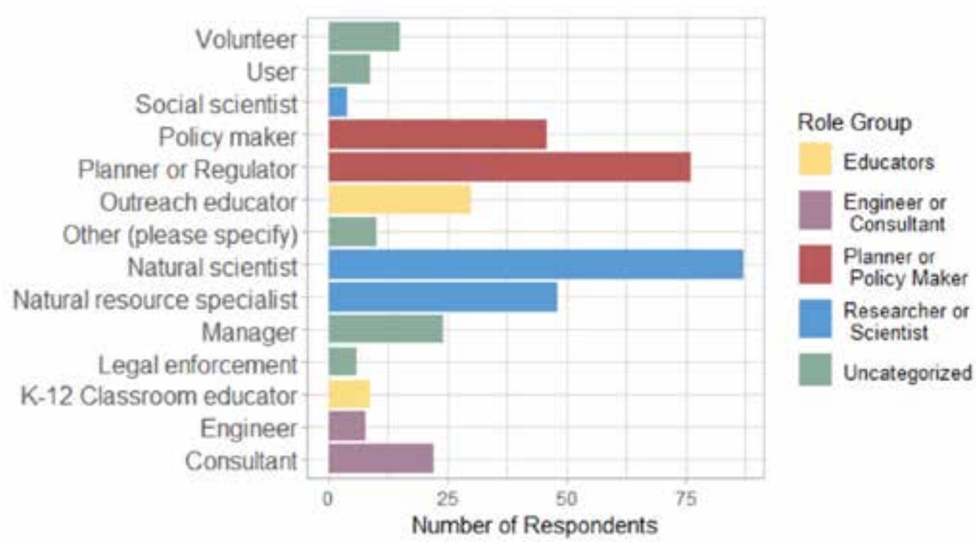
Geospatial data users in Long Island Sound

Where have survey respondents worked (top) and in what roles (bottom)?

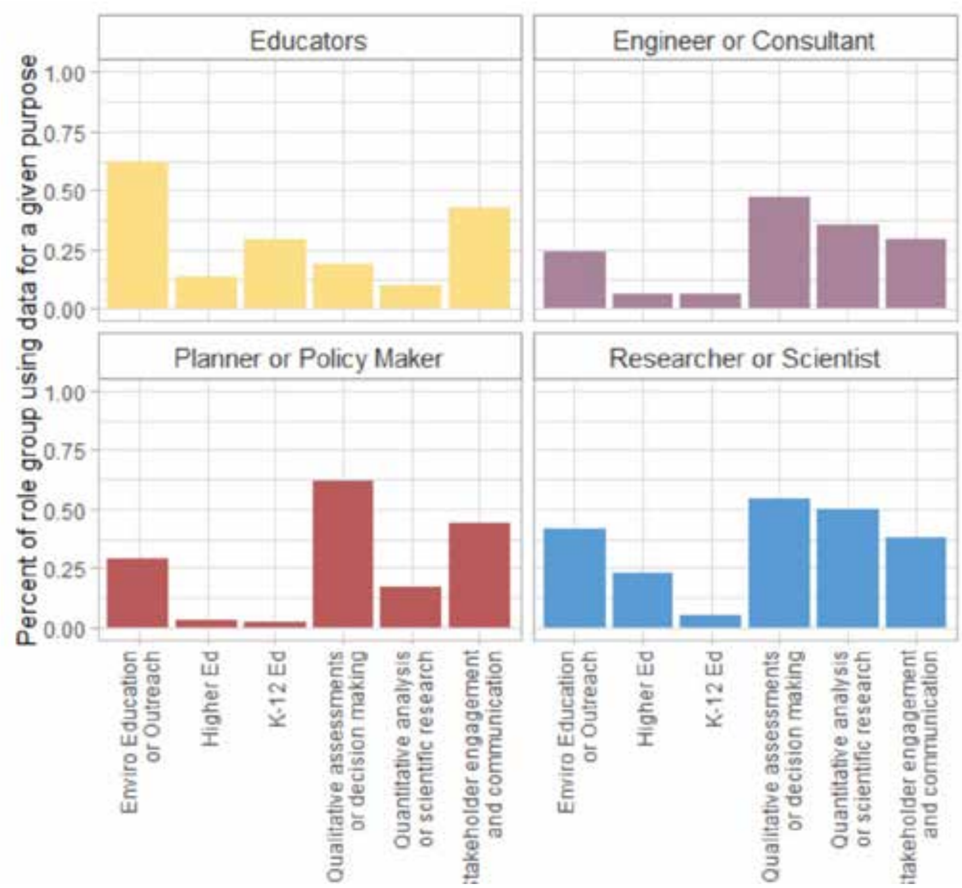
A total of **282 individuals**, representing a wide variety of organizations (top figure) and roles (bottom figure), responded to LIS Seafloor Habitat Mapping Initiative survey request. In their response, individuals listed all organizations within which they had worked in the past five years. For roles, individuals only listed their current role(s). Roles were categorized into four key groups (see legend), including **Educators (n = 21), Engineers and Consultants (n = 17), Planners and Policymakers (n = 106), or Researchers and Scientists (n = 78).**

*NOTE: Individuals that listed "Manager" as their role were distributed among four groups based on their other responses. Those that listed more than one role were included in a single category based on their other responses and in the following order: Engineer or Consultant, Planner or Policymaker, then Scientist or Researcher.



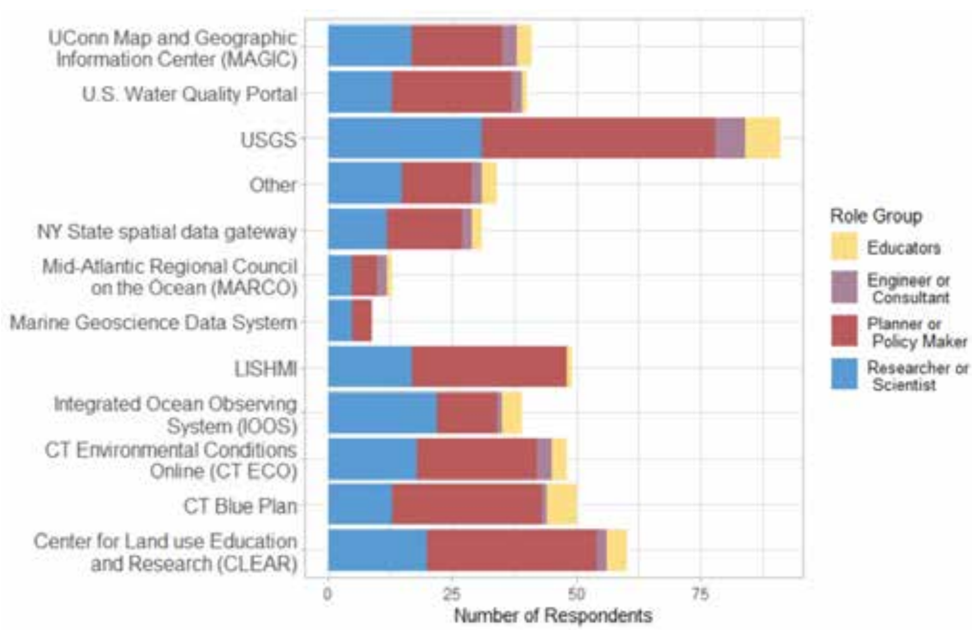


What are people using LIS geospatial data for and where do they go to get it?



For each role category (e.g., Educators, Engineer or Consultant, Planner or Policymaker, and Researcher or Scientist), bars represent the percentage of time data is used for that purpose. Qualitative assessments are the most common use of data for every role except for Educators. Stakeholder communication is a common purpose for all user groups. While to a lesser degree than qualitative products, all groups are performing quantitative analyses, especially Researchers and Engineers and Consultants.

Regardless of role category, most users are primarily retrieving data from USGS. The ten other DSTs explicitly included in the survey are also heavily used. Approximately 30% of respondents selected "Other." Some listed additional data sources, including Northeast Ocean Data Portal, NOAA, and colleagues.



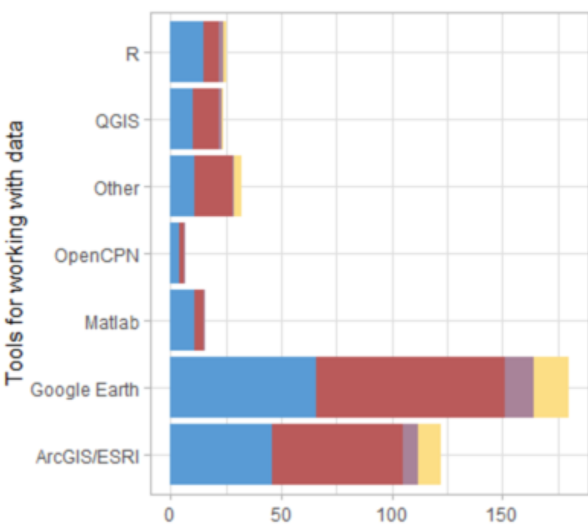
Questions you can help us to answer

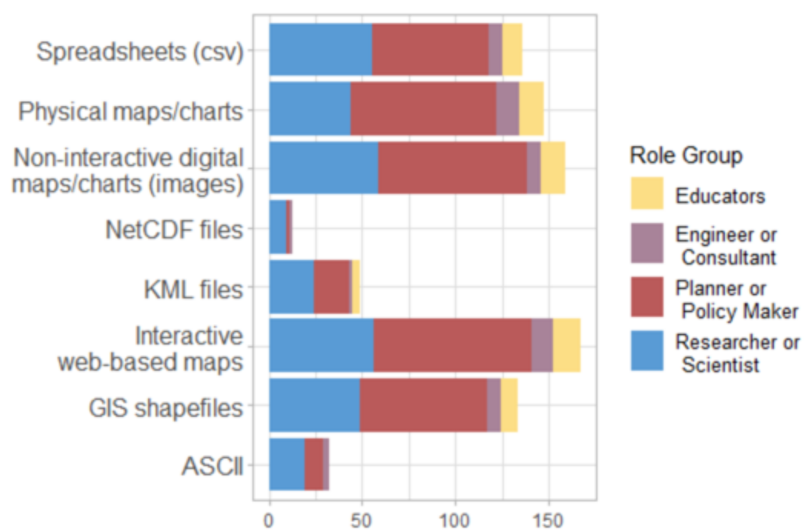
- What decisions, research or communication are you trying to inform?
- What data or data products are you accessing from the sources available to you?
- What data or data products do you access together to meet your needs?
- What steps do you take to find data within existing sources? Do you know in advance or does it require exploration?
- What data or data products for Long Island Sound are missing and need to be added or to be made more accessible to increase your ability to achieve your goals?

Identify the important qualities for making data useable

What tools are used to process LIS data and what file formats are preferred?

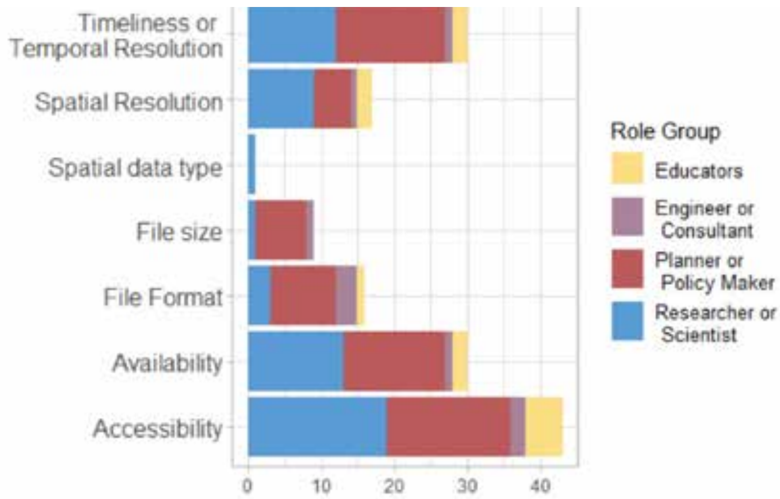
Survey respondents typically work with data in Google Earth and ESRI/ArcGIS, indicating the importance of data having a spatial quality/interpretability. Respondents equally prefer working with static images or physical maps and interactive maps or manipulable shapefiles. Spreadsheets emerged as a preferred method of working with data.





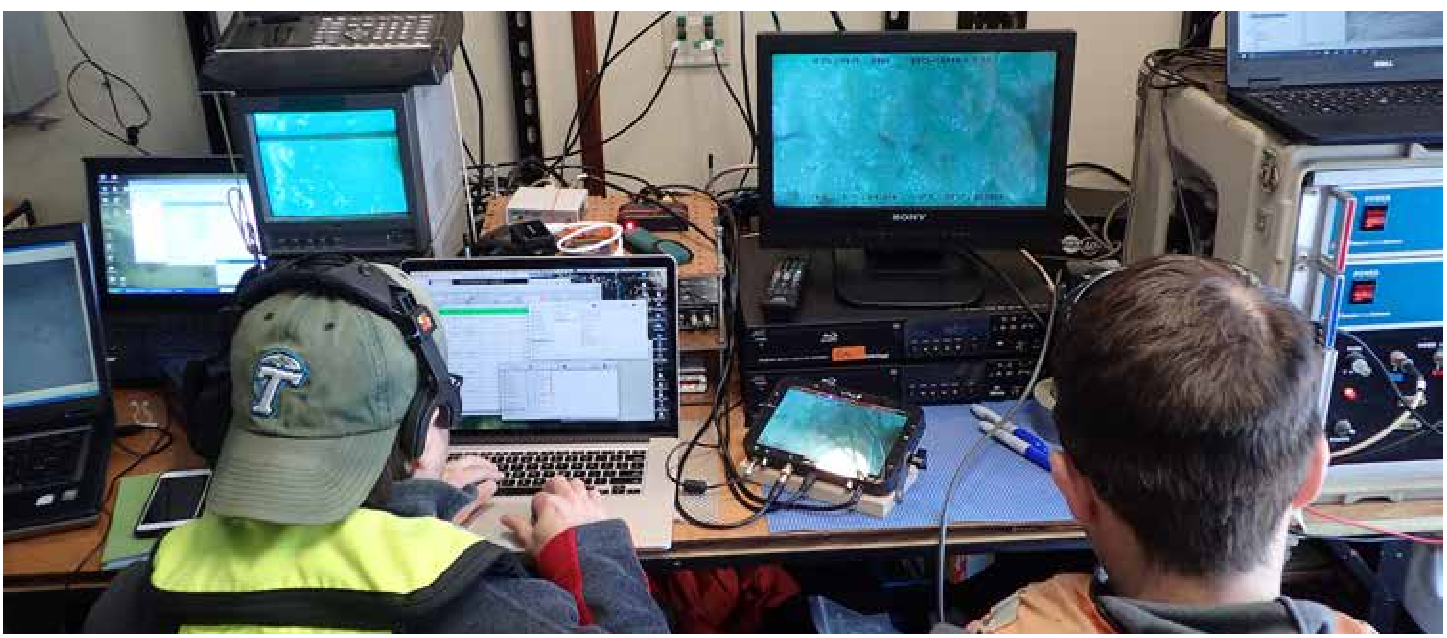
What are the biggest challenges to using geospatial data, products, or tools?

Accessibility (the steps required to use data and products once they've been located) was identified as the biggest challenge to using data, data products and tools across role categories, followed by availability and timeliness or temporal resolution.



Questions you can help us to answer

- Among the data types identified, what format(s) do you prefer?
- What features make your preferred format(s) better to work with?
- What details about spatial resolution are important for you?
- What are the qualifications of data that is "available" to you?
- What steps do you take to process data into actionable information?
- What steps would you like to see built into a portal to make data more readily usable?



Seth Ackerman (USGS) and Chris Conroy (UNewHaven) remotely monitor USGS SEABOSS from the R/V Connecticut during Phase 2 seafloor operations aboard the R/V Connecticut.

Appendix 3. Breakout session goals and prompts

Session One (11:15 – 12:15)

Focal Question: What decisions or issues need to be address and what data are needed to inform those efforts?

1. 10-15min: Introductions/Perspectives: Each participant introduces themselves, describes their role and organization and offers one or two examples of decisions or issues they are working on in Long Island Sound.

2. 20-25min: For each issue/decision, identify the data needed to support decision-making or address issues (Note: review working definitions of data, data product, decision support tool:
    a. What data (physical, ecological, chemical, etc.), data products (e.g., integrated products or maps), or decision support tools (e.g., GIS layering)
        i. are you currently using to address this issue?
        ii. do you wish you had?

        Definitions for this conversation:
        - **Data** are the raw (calibrated) data recorded
        - **Data products** integrate one or more raw datasets and/or provide an interpretation of data. Typically, data products translate raw data into more easily interpretable and actionable information (e.g., data figures, raw species counts translated into species distribution maps, integrated habitat maps, lengthy time series translated into trends)
        - **Decision support tools** are programs or interfaces that help users access, interpret, and analyze data. They can take on many forms, such as portals where data is stored for access; map-based interfaces that facilitate visualization; or applications that model scenarios or summarize data based on user input
    b. Describe where and how you access data, data products, and tools including
        i. your preferred sources and formats for each data type. (This can help us identify if, for certain decisions, people are having to go to multiple DSTs/data sources.)
        ii. elaboration on whether you need raw data or a data product (i.e., processed or interpreted information).
    c. Identify challenges to finding, obtaining and using data including those related to
        i. findability.
        ii. data access (ownership, utility, format, etc.).
    d. Additional suggestions for conversation include requesting that participants
        i. elaborate on their needs for raw data or a processed or interpreted data product.
        ii. identify data that is often supplied in raw form but that they would prefer to obtain as a product or vice versa.
        iii. identify preferred data formats (e.g., spreadsheet, map image, interactive map) for various data and data product types.

3. Final 15min: Synthesis
    a. What patterns, commonalities and consensus arose in the discussion?
    b. What types of data, data products and DSTs support a wide range of issues, decisions?
    c. What strong preferences emerged for data types, locations, and formats?
    d. What common challenges or obstacles exist across decisions and data types?
    e. What are the processes generally followed for using data to inform decisions?

Session Two (1:25 – 2:25)

Focal Questions: How can we improve data and data product delivery and usefulness for Long Island Sound? What challenges impede current workflows? What should we consider for informing future decision-making in Long Island Sound?

1. 20-30 min: Identify the pros and cons of various existing DSTs as sources for data and products
    a. Identify features you like or dislike about a given DST, including
        i. the type of data or data products you typically access there.
        ii. the degree of user-friendliness and accessibility of the DST.
    b. Describe the steps in your workflow from raw data to decision or action.
        i. Which DST(s) do you use to accomplish those steps?
        ii. What steps would you like to complete but cannot with current offerings?

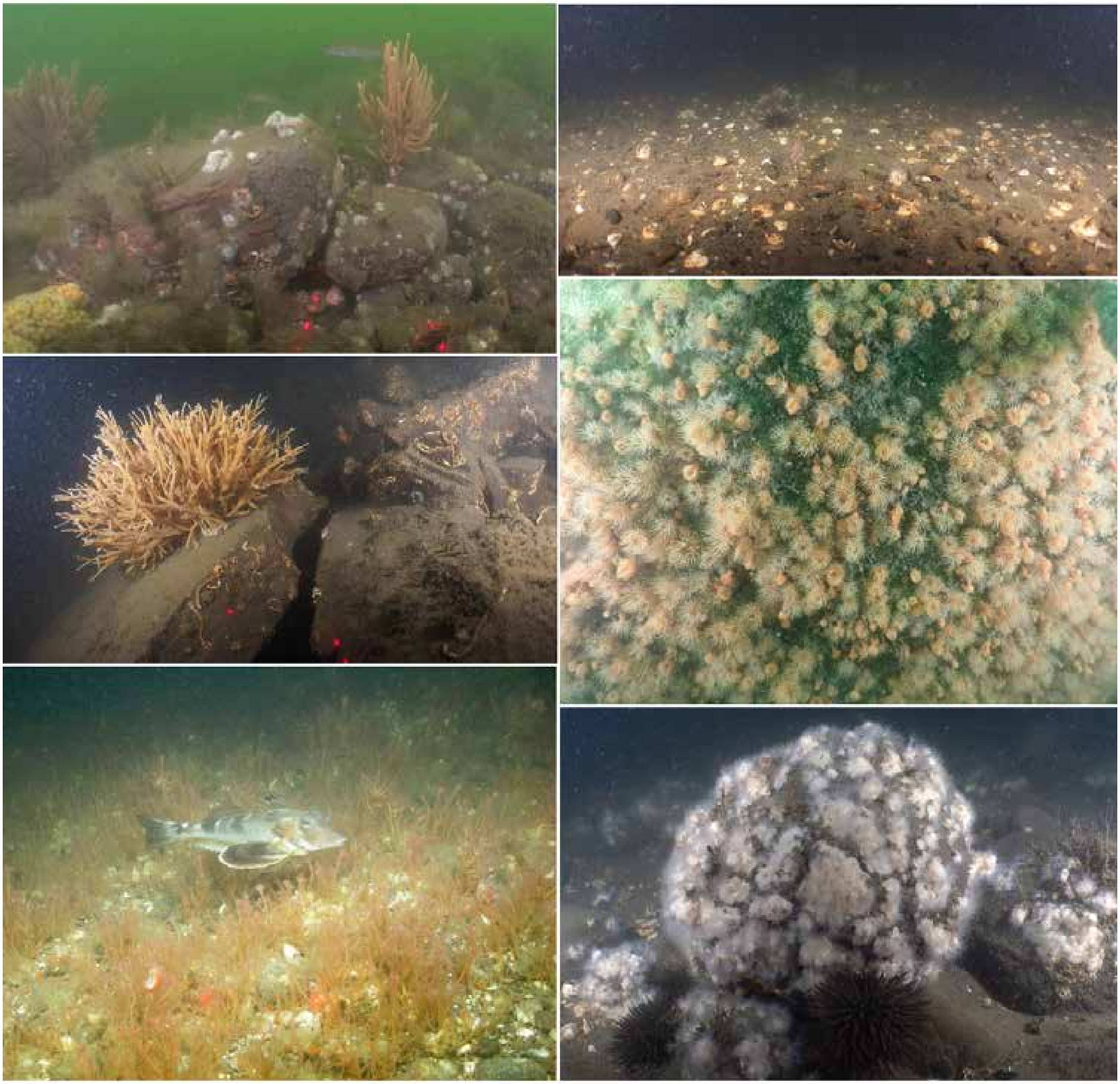
    It may help to review some of the functionality a DST can provide, including
    - data management,
    - mapping and visualization,
    - scenario development and analysis, proposing and analyzing management options,
    - stakeholder engagement,
    - informing adaptive management by allowing for reassessment of management action success.

    d. Do any DSTs have particularly useful help pages, tutorials, case studies or examples of their use? Would those features be helpful?
    e. Would communicating with other decision makers and users within the DST be useful?
    f. What else do you wish you had in a DST for Long Island Sound?

2. 5-10 min: Discuss future concerns for Long Island Sound and the use of a DST to address those concerns
    a. Extend the time scale of consideration to 20 years.
        i. Identify issues you may not be facing now, but are likely to be either increasingly present or pressing in the future.
        ii. What data will you need to address those issues and concerns?

3. 5-10 min: Discuss how a DST could facilitate stakeholder engagement, since stakeholder engagement was identified in the survey process as one of the most common uses of data and data products for Long Island Sound.
    a. Who are the stakeholders within your area of responsibility?
        i. What data do you currently share with them?
        ii. What data have they indicated are of interest them?
        iii. What format for the data or data products best conveys the information to those stakeholders?

4. Final 10-15 min: Synthesize
    a. What are some of the common downsides to DSTs?
    b. What are the functions most frequently identified as lacking in the DSTs available in LIS?
    c. What are some of the most helpful features of DSTs?
    d. What are the most pressing future concerns that a DST should plan for now?
    e. What were commonly identified features that facilitate stakeholder engagement?



Clockwise from Upper Left: Small boulder pile hosting boring sponge *Cliona* sp., branching sponge *Haliclona occulata*, and northern star corals *Astrangia poculata* in the Phase 3 area; mixed soft sediment and shell bottom hosting epifauna in the Phase 2 area; ghost anemones *Diadumene leucolena* inhabiting the vertical face of a boulder in the Phase 2 area; Atlantic purple sea urchins *Arbacia punctulata* surrounded by northern star corals *Astrangia poculata* in the Phase 2 area; a striped sea robin *Prionatus evolans* swims above mixed gravel and cobble sediments covered with *Tubularia indivisa* and scattered red-finger aeolis nudibranchs *Coryphella verrucosa* in the Phase 2 area; branching sponge *Haliclona occulata* and calcerous worm tubes *Serpula* sp. grow on angular boulders in the Phase 3 area.

Branching sponge *Haliclona occulata* and several patches of northern star coral *Astrangia poculata* in the Phase 4 area. [photo by Peter Auster]