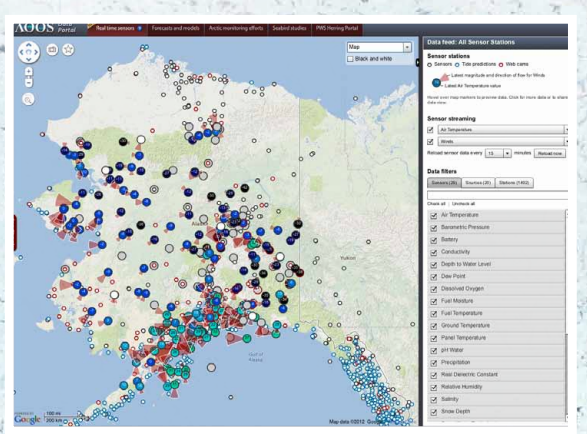
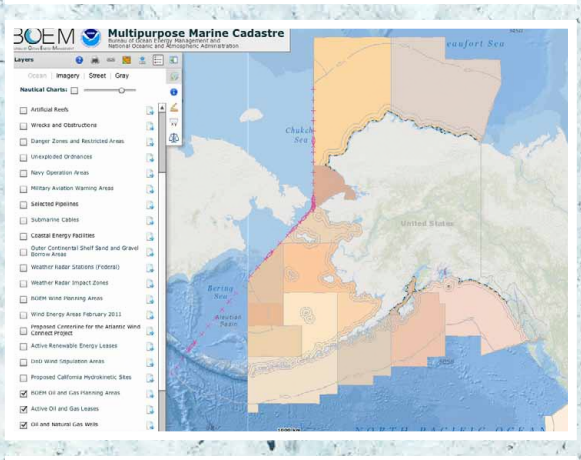
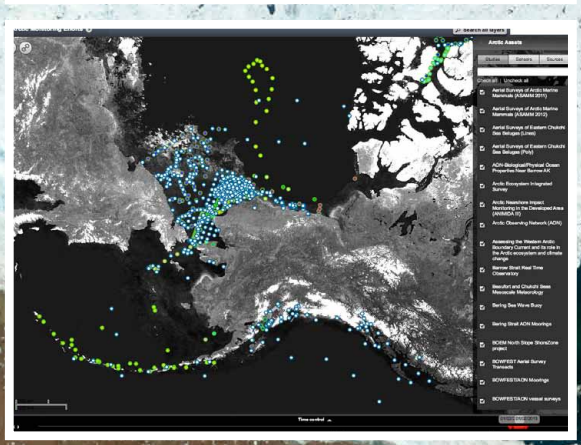
Spatial Tools for Arctic Mapping and Planning (STAMP): Decision Support Tool Use and Applicability Report







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EXECUTIVE SUMMARY

The purpose of this report is to evaluate online decision support tools for marine spatial planning for their applicability to the Spatial Tools for Arctic Mapping and Planning (STAMP) project.

The focus of the report is on web-based tools that include mapping functionality and serve as data clearinghouse/portal tools, visualization tools, or multiple objective planning tools. This report is not intended to be an exhaustive inventory but includes only tools that specifically address marine spatial planning in the U.S. and that meet many or all of STAMP's needs. We considered other tools, such as software packages that prioritize or zone marine space (i.e., MARXAN with Zones), but those tools did not directly address the needs of STAMP. Future iterations of this type of report should consider not only web-based mapping applications but other tools that generate or analyze information that could feed into future STAMP project needs.

Categorizing tools is important because it will help STAMP to determine the type of application to develop. Most tools that we evaluated are portals or data viewers that consolidate information. They do not include functionality to analyze the information or report on relationships between data layers; they only make data available in one place. Most of the tools focus on authoritative data and government-sourced information such as maritime boundaries and limits. There is a lack of tools with derived or synthesized data, and this type of information will be increasingly valuable when comparing multiple management objectives. This includes the synthesis of real-time data.

Other tools take the concept of visualization or data viewers and add communications information on the planning process around the tool. This was particularly evident with MARCO Marine Planner. This is an important enhancement to the web mapping world, where often the tool is a standalone product with inadequate ancillary information on why it was developed and what purpose it serves in the larger planning process. The Northeast Ocean Data website also provides this type of enhanced communications information in its newly redesigned version, which was released in November 2012.

While it could be argued that some of the portals and visualization tools address multiple objectives because data within them represent different sectors, we sought to strictly define the category of multiple objective planning tools. We limited the category to tools that not only represent different sectors, but that analyze and compare criteria and parameters within them. Limiting this category to scenario-building and in particular tradeoff-analysis tools meant that very few existing tools fall into this category. We recognize that it is difficult to develop multiple objective planning tools, and the two tools that we evaluated were prototypes (Washington Marine Planner and SeaSketch). The former was created in response to Washington state's marine spatial planning legislation to offer a sense of what is possible in tradeoff analyses; the latter is a generalized application that is not tied to a specific planning process. As of this writing, neither had been used to make marine spatial planning decisions, and it is unclear whether they will evolve to be true decision support tools in this regard. This is a function of the planning process, not limitations in tool functionality or technology.

This report concludes by providing some targeted recommendations on STAMP tool development, based on our evaluation of existing tools. These recommendations are intended to help ensure that the STAMP tool is effective in meeting user needs in support of marine spatial planning decisions. In our evaluation, we found that although no existing tool meets all of STAMP's needs, some are very useful as models or starting points for defining the functionality and requirements for a STAMP tool.

INTRODUCTION

STAMP Overview

Alaska's diverse oceans and expansive coast are home to a diversity of fish and wildlife and support a multitude of activities including commercial and recreational fishing, traditional subsistence hunting and gathering, oil and gas development, shipping, and tourism. As the boundaries for these activities expand and change over time due to climate change, sea ice retreat, resource discoveries, and socioeconomic and political changes, Alaska residents and resource managers need access to the most current information and decision-support tools to help make sound decisions for the future. In addition, most of the species in Alaska listed under the federal Endangered Species Act rely on Alaska's coastal and marine environments.

To help address these needs, the Alaska Ocean Observing System (AOOS) and its partners including The Nature Conservancy, Axiom Consulting and Design, University of Alaska's Institute for Social and Economic Research, and Alaska Center for Climate Assessment and Policy are developing data integration and visualization tools that could be used to enhance coastal planning and decision-making. The tools will build on the existing features and functionality provided by the AOOS Portal. The project, Spatial Tools for Arctic Mapping and Planning (STAMP), focuses on the Northern Bering and Chukchi Seas, especially related to the potential for expanded commercial fisheries in the future. The National Oceanic and Atmospheric Administration (NOAA) has funded STAMP from 2012 to 2013.

Purpose of this Report

In the United States and around the world, many tools have been developed recently or are currently being developed that offer data integration and visualization for ocean planning. The tools vary widely in their purposes, functionalities, technical frameworks, and other important attributes. Many of the newly developed spatial visualization and decision support tools have already been assessed by other entities, such as the Center for Ocean Solutions[1] and the UNESCO Coastal and Marine Spatial Planning Initiative. However, the tools have not been assessed for their applicability to STAMP. The purpose of this report is to assess a suite of existing data integration and visualization tools for their potential applicability to STAMP's goals in the North Bering and Chukchi Seas.

1 Coleman, H., M. Foley, E. Prahler, M. Armsby, and G. Shillinger. *Decision Guide: Selecting Decision Support Tools for Marine Spatial Planning*. Monterey: Center for Ocean Solutions, 2011.

NEED FOR DECISION SUPPORT TOOLS

Overview of Needs Assessment Process

The Nature Conservancy and AOOS conducted a needs assessment that provided important background information for this report. The needs assessment sought to identify:

- the highest-priority management issues in the northern Bering Sea and Chukchi Sea, including but not limited to the potential for fishing activity there in the future;
- potential applications of decision support tools; and
- the most important tool functionalities and characteristics.

Phase one of the needs assessment included a survey and interviews with members of the target audience. Phase two consisted of a two-day workshop in which project participants reviewed the findings from the survey and interviews, discussed in greater detail the potential needs and applications for a decision support tool, and identified priorities for tool development.

Needs Assessment Phase 1: Survey and Interviews

As an initial step toward STAMP's goals, The Nature Conservancy and AOOS conducted interviews and a survey with potential tool users in the spring and summer of 2012. The questions were designed to collect information that can be used to define the needs and specifications for new spatial tools. Thirty people participated in the survey, and 22 interviews were conducted. The participants were people involved in or affected by marine management decisions in the Chukchi Sea and northern Bering Sea. They represented a range of settings from remote villages to cities.

Key Findings

1. Marine resource management decisions are often made through processes that are not based explicitly on resource data.
2. Decision-making processes could be improved through increased access to data, and the use of tools to summarize, view and analyze that data.
3. The most important weaknesses in current decision-making processes involve two issues that spatial tools can help address: public participation and the availability of data and information.
4. Currently, the most commonly used data types are oceanographic, fish stock, ice cover, marine mammals and regulatory boundaries.
5. There is a demand for year-round data, and in the face of rapid change, current and real-time data.
6. The most pressing management decisions revolve around climate change and the associated changes in environmental conditions coupled with increasing industrial development and consequent human uses of the ocean and near shore environments.

Recommendations

1. Build a tool that fits into and complements an existing management decision-making process.
2. When defining the tool concept and requirements, focus on addressing the needs of the people who are involved in that decision-making process. Make a tool that helps achieve their goal.

3. Consider developing a comprehensive clearinghouse of data needed for the selected decision-making process, including high-quality data in a usable format and a variety of scales and resolutions. Develop strategies to ensure proper use of data (e.g., built-in warnings of data limitations).
4. Effectively meet one or a few well-defined management needs, while remaining open to the possibility that the tool could be useful for other purposes.
5. Consider developing a tool that helps people explore the potential effects of climate change on environmental conditions and human uses of the ocean, and that enables them to illustrate and analyze scenarios and management responses.
6. Make sure that the tool is extremely easy for the target audience to use. Involve the target audience in the tool development process from its earliest stages.
7. Consider limitations of internet speed and bandwidth, particularly in rural communities, on tool design and use.
8. Work with data providers, including subsistence users, and subsistence mapping projects to help determine appropriate protocols for displaying and providing access to subsistence use data.

Needs Assessment Phase 2: STAMP Advisory Committee Meeting

In September 2012, the STAMP Advisory Committee, principal investigators, and project partners convened in Anchorage for a two-day meeting. The meeting included a presentation of the Phase 1 findings, a demonstration of three existing decision support tools (Washington Marine Planner, Mid-Atlantic Ocean Data Portal, Coastal Resilience), presentations on STAMP data and modeling efforts, and group discussions of management issues, potential applications of tools, user needs, and desirable attributes for STAMP tools.

Key Points

1. Many datasets are patchy and do not cover the entire region, but they are still useful.
2. The tool needs to have a clear and effective way to incorporate caveats that describe the limitations of the data.
3. The tool needs to be developed so it can be easily updated with the latest data.
4. The tool should include as much fish data as possible, even if it is patchy.
5. The tool should make it easy for people to distinguish between synthetic or derived data and real-time or raw data.

6. The tool should provide access to as many types of data as is feasible while also being simple to use.
7. People liked the idea of being able to draw a shape on a map and generate a report summarizing the data within the boundaries of the shape.
8. The tools should allow users to easily and intuitively change the legend, scaling, and display.
9. In addition to data, the tool should connect people to experts and non-spatial contextual information related to the data.
10. The tool should allow people to download data in both Albers and polar projections.
11. The STAMP tool's primary function should be to provide access to and visualization of data, but it should also include special capabilities that provide "decision support" attributes.

Expanding on Key Point 11, the meeting participants discussed the potential for developing a tool that enables people to build and analyze scenarios related to vessel traffic corridors. Most Arctic issues involve vessels (e.g., fishermen use boats of varying sizes; commercial shipping includes barges, tankers, and other large vessels; offshore oil and gas operations rely extensively on boats to service rigs and other infrastructure). One idea was for a decision support tool that enables people to draw and analyze vessel traffic corridors based on potential impacts to endangered or threatened species, subsistence species, fuel costs, marine safety, navigational hazards, and other features. The scenarios could incorporate information from climate model forecasts. Scenario planning that involves walrus, ice seals, ice flows, mobile habitat, and shipping would be useful.

Study Area Issues, Processes, Needs and Limitations

To summarize, the following are important overarching findings of the needs assessment:

1. The most pressing management issues revolve around climate change and the associated changes in environmental conditions coupled with increasing industrial development and consequent human uses of the ocean and nearshore environments. Specific concerns are increased shipping, oil and gas development, and future potential for a commercial fishery.
2. Decision-making processes in the STAMP study area seek to be inclusive by using expert knowledge, internal, external, and public meetings, but the process is complex, and people often do not have enough information to make well-informed decisions.
3. User friendliness is a critical limiting factor in tool effectiveness. It is vital for tool developers to focus on usability and communications effectiveness from the perspective of the target audience in the STAMP study area.

Selection of Evaluation Criteria Based on Needs Assessment

Based on the needs assessment, we developed a set of evaluation criteria for determining the applicability of existing tools to the STAMP project including study area needs and parameters. We defined the evaluation criteria by reviewing the needs assessment findings and distilling them into a set of attributes that are either required or highly desirable for the STAMP tool.

General Tool Characteristics and Usability Requirements

- **Data clearinghouse:** A central clearinghouse that makes many types of data, including external web mapping services, easily accessible and downloadable. Includes readily accessible metadata.

- **User friendliness:** Very easy to use, with an intuitive interface, designed for people without special expertise
- **Performance:** Very responsive over the Web, even in remote areas with limited bandwidth, and contains both basic and specific functionality that is easy to use, understand, and interpret
- **Issue-specific data:** Contains data that is pertinent to the overall aim of the decision support tool, and clearly articulates spatially explicit relationships between data representing competing or compatible issues
- **High-quality data:** Data that are scientifically reliable, whether authoritative or from derived analyses
- **Real-time data:** Access to real-time or near real-time data on oceanography, weather, ice extent, vessel locations, and other features
- **Easily updated:** New data easily added and the tool is periodically refreshed
- **Other considerations:** Specific functionalities that seem to be highlighted and frequently used; features that seem redundant or useless given the context of the tool; overall organization of the data in finding specific datasets quickly and easily

Specific Data and Tool Requirements

- **Comprehensive fish data:** Capacity to provide many types of fish data, including patchy datasets
- **Scenario-building tools:** Ability to create and visualize "what if" or suitability scenarios using spatial data
- **Analysis tools:** The primary focus of this criterion is whether the tool contains tradeoff-analysis functionality. A secondary focus is whether the tool has the ability to draw shapes and generate reports/summaries on data within the shape.
- **Climate change:** Ability to visualize observed and predicted effects of climate change and to incorporate those effects into scenarios
- **Multiple access levels or interfaces:** Options to address the needs of both technical and less-technical users as well as casual users and stakeholders
- **Multiple map projections:** Ability to download data in more than one projection, such as Alaska Albers and polar

Categories of Decision Support Tools

Four general categories of decision support tools (DSTs) are relevant to marine planning:

1. non-spatial frameworks and decision trees,
2. participatory mapping (non-GIS),
3. GIS and other spatial software packages, and
4. web-based mapping applications.

As the initial step in evaluating tools for STAMP, we reviewed the needs assessment information and determined that web-based mapping applications were the only DST category that aligns with STAMP's needs. The other categories do not provide the types of frameworks or functionality that STAMP is seeking. Based on this initial criterion, we evaluated only web-based mapping applications. For this reason, some tools that are well known in the marine planning context were not included. One example is MARXAN, which is a GIS-style spatial software package that can be very useful in other contexts, but it does not provide the type of functionality that STAMP requires.

EVALUATION OF DECISION SUPPORT TOOLS

Introduction to Relevant Web-Based Mapping Applications

Using the criteria described above, we analyzed a range of tools that have been used in Alaska or other geographies, and we evaluated their applicability to STAMP. Through this process, we selected seven as examples of existing tools that are relevant to STAMP's goals and meet many of the evaluation criteria. The tools fall into three categories — data clearinghouse/portal tools, visualization tools, and multiple objective planning tools — that cover the three major functions that the STAMP tool is intended to serve.

Data Clearinghouse/Portal Tools

- **Alaska Ocean Observing System (AOOS) Portal** (p. 9)
  AOOS addresses regional and national needs for ocean information, gathers specific data on key coastal and ocean variables, and ensures timely and sustained dissemination and availability of these data.
  Applicability to STAMP: STAMP tool will build on the AOOS Portal, which provides data sets useful for addressing STAMP's priorities.

- **Northeast Ocean Data** (p. 12)
  Northeast Ocean Data provides access to data, interactive maps, tools, and other information needed for decision making by managers, planners, scientists, and stakeholders from the Gulf of Maine to Long Island Sound.
  Applicability to STAMP: Combination of data clearinghouse and visualization tool that is user friendly, aligned with many of STAMP's criteria, and playing an integral part in a regional planning process.

Visualization Tools

- **Multipurpose Marine Cadastre** (p. 14)
  The Multipurpose Marine Cadastre provides with an interactive map showing offshore boundaries, infrastructure, human uses, energy potential, and other data sets.
  Applicability to STAMP: Source of Arctic data sets useful for addressing STAMP's priorities.

- **Arctic Environmental Response Management Application (ERMA)** (p. 16)
  ERMA is an interactive map that assists emergency responders and environmental resource managers in dealing with incidents that may harm the environment. It enables quick visualization, communication, and coordination.
  Applicability to STAMP: Source of Arctic data sets useful for STAMP's priorities. Example of a user-friendly decision support tool being implemented in STAMP's geography.

- **MARCO Marine Planner** (p. 18)
  MARCO Marine Planner is a dynamic online tool to engage stakeholders in ocean planning in the five-state Mid-Atlantic region. Marine Planner allows state, federal, and local users to visualize, query, map, and analyze ocean and coastal data.
  Applicability to STAMP: Example of user-friendly data clearinghouse and visualization tool that meets many of STAMP's criteria and is increasingly integrated into the Mid-Atlantic regional planning process.

- **Northeast Ocean Data** (p. 12)
  Northeast Ocean Data provides access to data, interactive maps, tools, and other information needed for decision making by managers, planners, scientists, and stakeholders from the Gulf of Maine to Long Island Sound.
  Applicability to STAMP: Combination of data clearinghouse and communication/visualization tool that is user friendly, aligned with many of STAMP's criteria, and playing an integral part in a regional planning process.

Multiple Objective Planning Tools

- **Washington Marine Planner** (p. 20)
  The Marine Planner helps people identify scenarios for ocean uses including renewable energy and conservation, design areas for further analysis, and analyze areas for tradeoffs between conservation and energy objectives.
  Applicability to STAMP: Example of scenario-building and tradeoff-analysis tool across conservation and renewable energy management objectives.

- **SeaSketch** (p. 22)
  SeaSketch is a platform for collaborative ocean geodesign. Using SeaSketch, people can design management plans, including marine protected areas, transportation zones, renewable energy sites, and more.
  Applicability to STAMP: Scenario-building tool based on geodesign principles that may be suitable for customization to address STAMP's goals.

The next section of the report provides detailed descriptions and evaluations of each of these tools.

AOOS Data Portal

Data Clearinghouse • Visualization

Website: aoos.org/aoos-data-resources

Who Developed the Tool?

Alaska Ocean Observing System (AOOS)

Where Has It Been Used?

Alaska

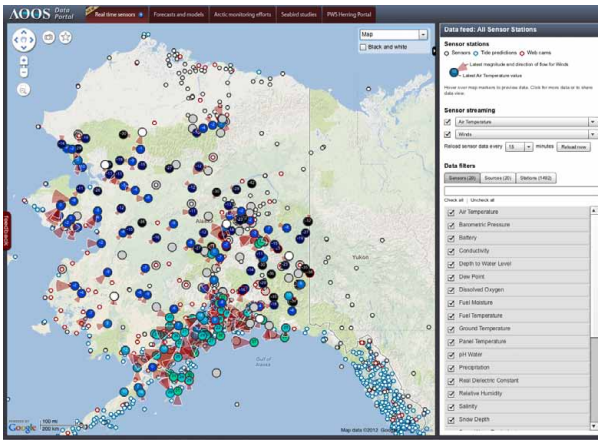
Why Was the Tool Developed?

The mission of AOOS is to address regional and national needs for ocean information, gather specific data on key coastal and ocean variables, and ensure timely and sustained dissemination and availability of these data. The Arctic is changing with the climate, bringing with it the potential for increased commercial activity and major habitat changes for its permanent residents. To meet these challenges, the AOOS Portal is increasing access to existing coastal and ocean data and packaging information and data in useful ways.

What Does It Do?

There are five distinct parts of the existing AOOS data portal, and four are relevant to the STAMP project area:

- A **real-time sensor map** assimilates real-time sensor feeds from multiple sources and delivers these data streams to users via a single Google-based map. Parameters include wind, waves, temperature, stream height, and other oceanographic and physical data. It does not include biological data at this time. Sensors can be filtered by station type, source, or name. The application connects to over 3,000 stations supported by 20 organizations and provides access to over 4,500 unique sensor feeds.
- A **model explorer** provides remote sensing products and forecast models for physical parameters such as wind, wave height, currents, air temperature, salinity, and sea ice. Data can be downloaded in spreadsheet format. There are time steps in the models to move forward and backward in time. Time series information can be extracted from point-specific locations using a "virtual sensor" tool. Increased functionality for extracting data from a polygon is under development.



- An **Arctic research assets map** displays information on biological and physical research instruments and monitoring sites in the Bering, Beaufort, and Chukchi seas between 2010 and the current field season. It is designed to help researchers collaborate and communicate prior to the field season. It includes information on instrument or transect locations, depth, sensor types, and who to contact for more information.
- The **North Pacific Seabird Data Portal** provides access to colony, species abundance, species distribution, diet, and boat-based observational data for approximately 250 species of seabirds. Users of the portal can filter data by species, data type, and temporal parameters. The data portal is tied directly to the North Pacific Seabird Data Management System providing an automated, end-to-end data management solution. As data are entered by contributors, they are made available in real time to other users seeking information.

General Tool Characteristics and Usability

Data clearinghouse: Data sets in the portal currently focus on the physical environment, except for the seabird portal and the research assets map. Most of the physical data are real time, and they cover ocean currents, sea surface temperatures, winds, sea ice, and other oceanic and physical variables. Some data sets have very good metadata, but in other cases metadata are difficult to find or may not be available.

User friendliness: Although there are some elements that clearly have ease of use in mind, the AOOS data portal overall seems oriented toward a relatively sophisticated user. For example, some of the language itself, such as in titles and help sections, may be intimidating and unclear to non-experts. The

web interface looks technical, and in some cases, small fonts on the map and legend make it more difficult to find useful information and explanatory text. The pop-up screens with introductory text improve the user friendliness. Some features of the model explorer are challenging for novice users to learn, and more easy-to-find instructions would be helpful. For example, a novice user testing the site found it difficult to load the layers and use the "going back in time" feature. Overall, the portal is moderately user friendly.

Performance: The tool performed well and was responsive during our testing.

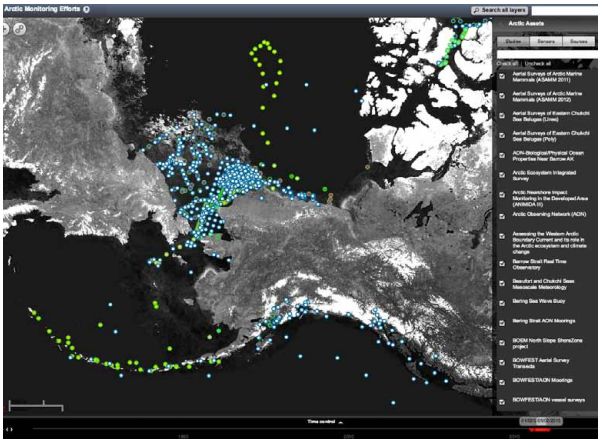
Issue-specific data: The portal is not intended to address specific issues. It is intended to serve as a general data clearinghouse for multiple stakeholder needs (including the scientific community).

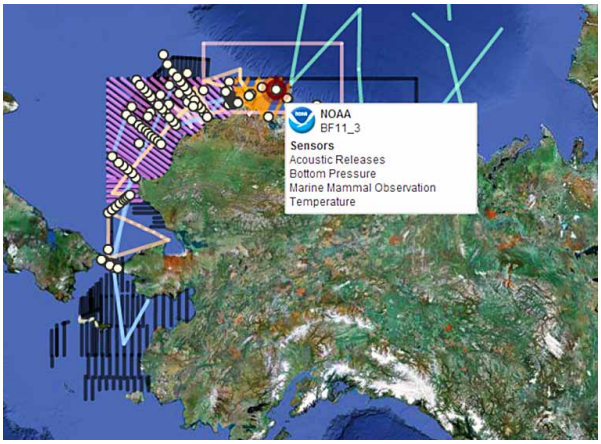
High-quality data: The portal clearly identifies data sources, which in many cases are federal and state agencies, academic institutions, and the private sector. In some cases, the metadata descriptions indicate that the data are of lower quality.

Real-time data: The portal includes a large amount of real-time data, including wind, waves, temperature, stream height, and other oceanographic and physical information. There is no real-time biological data included at this time.

Easily updated: Sensors for real-time data are updated regularly with the last updates within half an hour before our testing, with graphs clearly showing data trends by the minute over previous days. It appeared most data types were regularly updated or showed dates across the portals. It was not clear how easily updated the other data types were. The seabird portal appears to allow researchers to add their own data.

Other considerations: Retrieving sensor information is easy and is probably highly used. It is helpful that AOOS clearly shows data sources and the names and locations of the sensors. Enhanced help functions would be a useful addition. The map of research assets is useful and easy to use after becoming familiar with the site; the ability to obtain background research information including contact information and research period and general content of the study is very useful.





Specific Data and Tool Requirements

Comprehensive fish data: The only section of the portal that currently contains fish-related data is the Arctic research assets map, which describes at least one project studying fish. The portal developers will be releasing an Arctic-specific portal in January 2013 for the STAMP project that will include Arctic fish data.

Scenario-building tools: The portal does not currently include scenario-building tools.

Analysis tools: The "virtual sensor" tool in the Model Explorer application allows users to extract model output at a location of their choice and assess change over time in graph or chart form.

Climate change: The Model Explorer includes two climate change projection models produced by the University of Alaska's Scenarios Network for Alaska Planning (SNAP) project. With a time slider, users can advance the map display forward by day to 2100, showing predicted air temperature and precipitation on a two-by-two-kilometer grid. The

virtual sensor tool allows users to look at predicted changes in these parameters over time for a location of interest. Downscaled climate models for the northern Bering Sea and Chukchi Sea are under development and will be added in fall 2013.

Multiple access levels or interfaces: There is one level of access to the Portal with no password requirement. There is also a section for technical users with links to connect to data through interoperable web services. The Research Workspace is password protected and only accessible to approved members of various research work groups.

Multiple map projections: There is one projection option at this time. The Arctic portal is expected to include both polar and Albers projections.

Applicability to STAMP's Needs

Given that a critical need identified in the STAMP scoping process was for a data clearinghouse and that the AOOS Portal is a primary source of data for the ocean and coastal areas of Alaska, the AOOS Portal will provide an appropriate framework that can be extended through development of new functionality to address STAMP's needs. It provides many of the data sources such as ice, oceanographic, weather and real-time data identified as important to decision makers. The AOOS Portal would also help familiarize people with some of the relevant monitoring and research efforts currently under way and the locations of some of that information. Research covers biological and physical parameters, and a great range of national and international researchers. With a revised, user-friendly interface, increased range of data and functionality, it could be very effective in meeting STAMP's core needs.

Relevant Limitations of the Tool

- Usability level is currently suited for more advanced users and would need to be adjusted to be user-friendly for less technical users
- Does not currently provide higher-level scenario or analysis functions
- Also could be more relevant to STAMP needs with a broader range of data including biological data

Northeast Ocean Data

Data Clearinghouse • Visualization

Website: northeastoceandata.org

Who Developed the Tool?

The Northeast Ocean Data Working Group, which includes Applied Science Associates, Gulf of Maine Research Institute, The Nature Conservancy, NOAA Coastal Services Center, Northeast Regional Ocean Council, Northeastern Regional Association of Coastal Ocean Observing Systems, SeaPlan, and Waterview Consulting

Where Has It Been Used?

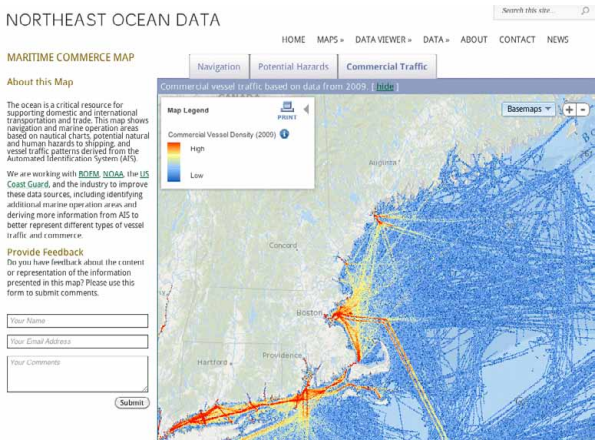
Northeast Ocean Data is playing a key role in ocean planning initiatives in the northeastern U.S.

Why Was the Tool Developed?

Northeast Ocean Data was developed to simplify and streamline access to data for ocean planning. Originally developed as a data clearinghouse, the website in November 2012 added user-friendly visualization features for less-technical users. Regional ocean planning is a collaborative process that depends on many groups of people having access to a wide range of data on environmental, socioeconomic, and regulatory parameters. Many of these data have been inaccessible, scattered among different providers, and not presented in a user-friendly way.

What Does It Do?

Northeast Ocean Data is a decision support and information system for managers, planners, scientists, and stakeholders involved in ocean planning in the region from the Gulf of Maine to Long Island Sound. This website provides access to interactive maps on key planning themes in the region, downloadable data, and a directory of external data sources and tools for decision making. When the site was originally developed in 2011, it was intended for a target audience of technical professionals. Subsequently, the tool has been used increasingly to support regional ocean planning initiatives involving broader, less-technical audiences. This role is set to expand dramatically beginning in November and December 2012, as the Northeast Regional Ocean Council's Ocean Planning Committee embarks on a major stakeholder engagement process. In anticipation of this role, the site has been undergoing a major redesign scheduled for release in late November 2012. The major emphasis of the redesign was on providing user-friendly data visualization tools that could be used easily by a wide variety of people engaged in ocean planning. A set of new, easy-to-use interactive maps on priority planning topics was developed as a key component of the redesigned site. These maps are simplified adaptations of the more complex, GIS-style data viewer on the site.



General Tool Characteristics and Usability

Data clearinghouse: While the functionality has since expanded beyond a data clearinghouse role, the tool continues to provide easy access to a wide variety of spatial data sets in six categories: administrative and regulatory; ocean uses; biology; physical oceanography; demographics; and cartography. Decisions about data priorities and specific types of data to include are made in consultation with the Northeast Regional Ocean Council (NROC). The data can be viewed online and/or downloaded for use in a desktop application. Detailed metadata are easily accessible for the data sets.

User friendliness: The user interface of the site is simple, uncluttered, and visually attractive, making it engaging and user friendly for less-technical users. All of the site's key features are readily accessible from the home page without being overwhelming. The new interactive maps are the primary tools for less-technical users. Unlike the GIS-style data viewer that was the original mapping tool on the site, each of the new maps presents only a limited number of data types, all of which relate to a specific planning topic, and the map controls are simplified like Google Maps, which most users are already familiar with. Next to each interactive map is a short descrip-

tion of what the map shows, and a form allows users to submit comments regarding the map. Some of the map language and symbology should be further simplified and clarified. The more technical Northeast Ocean Data Viewer is user friendly for its target audience of advanced users, although some aspects could be improved, such as the consistency, clarity, and completeness of the metadata.

Performance: The web pages and maps are very responsive, and large data files downloaded quickly during our testing.

Issue-specific data: The tool offers portfolios of data related to specific issues, and these data are being developed into an interactive atlas that so far includes aquaculture, energy, marine mammals, and maritime commerce.

High-quality data: The site provides the best available data for each data theme, which in most cases means the data are authoritative and/or have a very strong scientific basis. In some cases, data of lower quality, such as tidal energy potential data from a preliminary scientific model, are included because they are the best available to address a priority issue identified by the Northeast Regional Ocean Council.

Real-time data: The site provides access to real-time data, although users interested in that data would be better served by visiting the data providers' websites developed specifically for that type of data, such as neracoos.org. The site does feature several types of data derived from real-time data, such as time-averaged currents, sea surface temperature, and density of commercial shipping traffic.

Easily updated: Data sets behind the interactive maps and data viewer are continually being added and updated easily via ftp.

Other considerations: The Northeast Ocean Data Working Group is developing the site iteratively. New features and functionality are added continually to address the needs of NROC's regional planning process. In particular, the emphasis now is on expanding the simple interactive maps into a more comprehensive atlas; rather than providing all the data in a single map, such as the Northeast Ocean Data Viewer, the Working Group is focusing on providing simpler mapping applications targeted for specific purposes.

Specific Data and Tool Requirements

Comprehensive fish data: The site currently provides limited fish data: habitats of particular concern, essential fish habitat, and a few examples of seasonal distributions of selected fish species. More data can be added easily when needed for NROC's planning activities. NROC and Working Group are currently identifying needs for fish and other marine life data through a series of meetings and workshops with the fishing industry, scientists, conservation groups, and other stakeholders.

Scenario-building tools: The site includes a prototype demonstration version of a tidal energy screening tool. It allows users to select a region of interest, depth, and current speed threshold. Areas within a given distance of shipping lanes or heavy vessel traffic can be excluded. This prototype and other suitability/scenario tools are being developed to support NROC's planning process.

Analysis tools: The site does not currently include analytical tradeoff functions. They may be added if needed to support the NROC planning process.

Climate change: The site does not currently include data or functionality focused on climate change.

Multiple access levels or interfaces: The site does not require a log-in. All users have the same level of access. However, the site does provide a variety of interfaces intended for different audiences.

Multiple map projections: The site does not provide multiple map projections.

Applicability to STAMP's Needs

Northeast Ocean Data is a model for a data clearinghouse/portal tool and a visualization/communication tool for broad audience of users engaged in ocean planning. The site has proven helpful in integration and visualization of biophysical data, offshore energy development, marine mammals, and shipping lanes, all of which have applicability to the specific needs articulated for northwest Alaska. Integration of seasonal data on marine mammals provides a model for how a temporal variable for STAMP such as sea ice distribution could be integrated into a visualization tool.

Relevant Limitations of the Tool

- Does not cover STAMP's geographic area, although the same approach could be used there.
- Does not currently address climate change.
- Currently lacks the level of scenario building and tradeoff analysis that STAMP seeks.

Multipurpose Marine Cadastre

Data Clearinghouse • Visualization

Website: marinecadastre.gov

Who Developed the Tool?

NOAA Coastal Services Center and the Department of the Interior's Bureau of Ocean Energy Management

Where Has It Been Used?

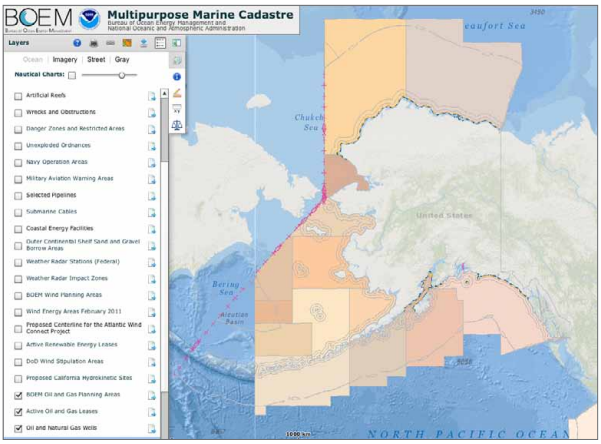
- In **North Carolina**, the Multipurpose Marine Cadastre has been used in support of wind energy planning to reduce conflicts in ocean use. Members of the North Carolina wind energy task force previously had access to the data only in the form of static maps.
- In **California**, the Habitat Conservation Division of NOAA has used the Multipurpose Marine Cadastre in reviewing applications for ocean energy licenses and preliminary permits. For example, the division has used the Marine Cadastre to evaluate the proximity of a proposed project to a range of marine species and habitats.
- Also in **California**, the NOAA Coastal Services Center, California Coastal Conservancy, and the California Ocean Protection Council collaborated on maps of proposed wave energy projects for the Federal Energy Regulatory Commission.
- In the **mid-Atlantic region**, federal data that are produced, maintained, and made available through the Marine Cadastre are included in the MARCO Marine Planner (see below).

Why Was the Tool Developed?

Created to comply with Section 388 of the Energy Policy Act of 2005, the Multipurpose Marine Cadastre was designed to support renewable siting on the U.S. Outer Continental Shelf. It is also being used in broader ocean planning efforts called for in the National Ocean Policy.

What Does It Do?

The Marine Cadastre provides the following products and services: a spatial data registry with over 140 authoritative data layers or web map services; the MarineCadastre.gov National Viewer for viewing and interacting with the data; a map gallery with custom



maps that users can view, modify, or enhance; technical support with guidance, best practices, and other helpful resources; and examples of how MarineCadastre.gov is being used in practice.

General Tool Characteristics and Usability

Data clearinghouse: The Multipurpose Marine Cadastre's primary role is to serve as a national data clearinghouse. It provides more than 140 data layers. However, the variety of layers is less than that number would suggest because several of the 140 layers focus on loggerhead turtles, several layers on sei whales, and so on for several other individual species, especially whales.

User friendliness: The website is easy to navigate and explanations are written for a non-technical audience. The maps use ArcGIS Explorer Online, and the user is presented with an interface that is not immediately intuitive to new users. It is not clear what can be done with the map or how to do it. It includes numerous options and functions that may be useful to an advanced user, but they are probably intimidating and not needed by most users. The functions are indicated with small icons whose meaning is not always obvious. Even users who are already reasonably comfortable using online mapping tools may find that they have to stumble around trying out various icons and buttons to figure out how to do things on the map. There is a learning curve from first arriving at the map to being able to do anything meaningful. That said, the map does seem to work well and be very useful once the user knows how to operate it. The site does provide a map gallery with ArcGIS Explorer Online maps preconfigured to focus on certain types of data relevant to particular topics in a particular geographic area. The preconfigured maps provide a

helpful "quick start", if the user is interested in the geographies and topics, but they suffer from the same usability issues as the general-purpose map.

Performance: The maps were slow to load during our testing with a high-speed internet connection. In some cases, there was also a delay when loading the legend. Given the complexity of the mapping interface and the functionality that is included, the map performs reasonably well, but ideally it would be faster without delays. The map performance may be a problem for people with slow internet connections.

Issue-specific data: The data in the MMC focus primarily on energy siting. Many relevant data sets are included that are specific to that issue.

High-quality data: The site has high-quality and authoritative data.

Real-time data: The site does not provide real-time data.

Easily updated: There is an Updates tab with announcements of updates have been made to the MMC. It is not clear how easy it is to update the site, or whether there is a schedule for doing so.

Other considerations: The site provides useful information about the data, as well as FAQs and other information that helps people use the MMC effectively.

Specific Data and Tool Requirements

Comprehensive fish data: The site does not contain comprehensive fish data.

Scenario-building tools: The site has a prototype tool for analyzing site suitability for offshore wind development.

Analysis tools: The site does not contain tradeoff-analysis tools.

Climate change: The site does not provide data or functionality specifically related to climate change.

Multiple access levels or interfaces: The site does not require a log-in for access, and it does not provide multiple interfaces for different audiences.

Multiple map projections: The MMC does not seem to provide multiple map projections.

Applicability to STAMP's Needs

The MMC is a source of some data sets covering STAMP's study area, and it was developed with a focus on offshore energy, which is one of the issues identified by the STAMP needs assessment. The utility of these data sets for site-specific planning (e.g., spatial resolution of data) would need to be evaluated further as part of STAMP's tool development process. Also, the MMC's mapping tools provide useful ideas for tool developers, despite some shortcomings in user friendliness and performance.

Relevant Limitations of the Tool

- Does not provide scenario-building and tradeoff-analysis functionality required by STAMP.
- Mapping application is only moderately user-friendly.
- Does not explicitly address climate change.

Arctic Environmental Response Management Application (ERMA)

Visualization

Website: erma.unh.edu/arctic

Who Developed the Tool?

NOAA Office of Response and Restoration, NOAA Office of Ocean and Coastal Resource Management, DOI Bureau of Safety and Environmental Enforcement, Oil Spill Recovery Institute, University of New Hampshire Coastal Response Research Center

Where Has It Been Used?

- Used effectively in other regions, there are now efforts underway to apply this tool in the Alaskan Arctic and include geographically specific issues, such as indigenous concerns.

Why Was the Tool Developed?

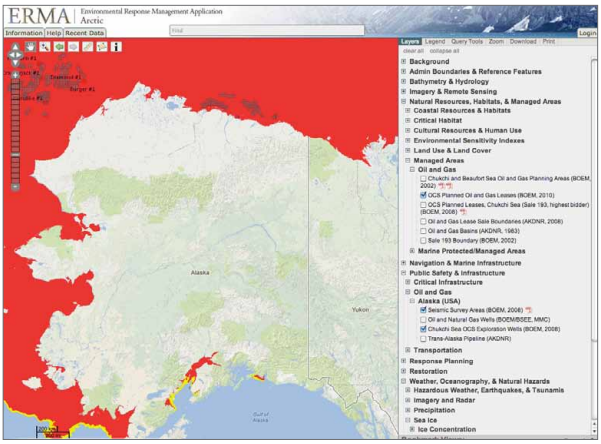
ERMA was developed to provide information for disaster response, particularly focused on oil spills. There are several geographically specific ERMA systems in place in the U.S., and ERMA played a critical role in the response to the Deepwater Horizon/BP oil spill in the Gulf of Mexico in 2010. ERMA is a well-tested and -implemented tool with a focused utility. As exploratory drilling expands in Arctic waters, there has been a priority to develop an ERMA system for northern Alaska.

What Does It Do?

ERMA is an online mapping tool that integrates both static and real-time data, such as Environmental Sensitivity Index (ESI) maps, ship locations, weather, and ocean currents, in a centralized, easy-to-use format for environmental responders and decision makers. ERMA enables a user to quickly and securely upload, manipulate, export, and display spatial data in a Geographic Information System (GIS) map.

General Tool Characteristics and Usability

Data clearinghouse: ERMA has a broad range of physical, biological, and human data. Examples of human data include infrastructure and subsistence areas. It includes at least one example of all the data types identified as priorities in the STAMP



scoping process: sea ice extent, oceanographic, fish, marine mammals, some critical habitat areas, vessel traffic, and some regulatory boundaries. ERMA has data from places outside of Alaska, such as northern Canada and Norway. The download tab is easy to find, and directions are easy to follow with suggested best practices included. Metadata is fairly easy to find, and links to the original data sources are provided. Limitations of the data are indicated clearly for some data layers but not for others.

User friendliness: Overall, this tool's ease of use is moderate to high. The site has an introductory box that immediately pops up when the user arrives, and it tells the user what the site is and what it is used for. The site has a relatively user-friendly interface, despite having so many data options. For basic use, it is fairly intuitive, but beyond that the site becomes challenging to use and requires more knowledge and skill. Some of the default settings are somewhat odd and take away from the user friendliness. For example, seasonal ice cover extent is displayed in a red color, the default base map is Google Streets, and seismic survey areas and Chukchi oil and gas wells appear by default.

Performance: The site performed adequately during testing with a high-speed internet connection, but it may not perform as well in places with less bandwidth. For example, accessing the metadata may be slower. It took approximately three minutes to download four layers over a high-speed connection.

Issue-specific data: ERMA includes oceanographic, marine mammal, vessel traffic, fish and regulatory boundary data.

High-quality data: Generally, the data sets appear to be of good quality, and information about data quality is provided in the metadata. Data limita-

tions could be more clearly spelled out up front. Some data sets are indicated as poor quality, such as biological data from the Audubon Arctic Atlas, but users need to read the metadata to know that.

Real-time data: There are real-time and near real-time data on the site. Information from NOAA's National Data Buoy Center, for example, is providing real-time and near real-time data from its northwest Alaska stations on wind, air temperature, and atmospheric pressure.

Easily updated: It is unclear when the site was last updated. Most of the data seems to be from 2012 with some layers from as early as 2004.

Other considerations: The help button is easy to find and easy to use. The large amount of data makes the site somewhat unwieldy. The site allows users to draw polygons and query the data within. ERMA has been customized with site-specific data for seven different geographic regions. Regional ERMA sites are currently secure-access only, but publicly available data can be accessed without a site login.

Specific Data and Tool Requirements

Comprehensive fish data: ERMA contains some fish data sets, including some with low-quality data, which are described in the metadata sections.

Scenario-building tools: The site did not appear to include scenario-building tools.

Analysis tools: ERMA allows for the creation and editing of polygons on the map. Data available for those areas is shown in report form and can then be analyzed.

Climate change: ERMA does not currently make it possible to visualize observed and predicted effects of climate change and to incorporate those effects into scenarios.

Multiple access levels or interfaces: There are at least two levels – password protected and not password protected, with the potential for a hierarchy within the password-protected category. Nearly all of ERMA's data layers are available to the public without a login or password. Password-protection seems to be built into the tool mostly so it is available if necessary in the event of an oil spill or other emergency in which a response team may need access to restricted information, or in the case of more sensitive data the provider does not want made completely public. There are also cases such as drills for response situations in which adding the full layers and features needed for the drill might overly clutter the interface. It should be noted that password protection seems to restrict only the data available and does not affect any analysis tool use or other functionality.

Multiple map projections: It appears there is only one available projection.

Applicability to STAMP's Needs

ERMA brings together available information needed for an effective emergency response in the Arctic's distinctive conditions, such as the extent and concentration of sea ice, locations of ports and pipelines, and vulnerable environmental resources. This information aligns closely with priorities identified in the STAMP needs assessment process, and the visualization tools provide a good model. In terms of overall applicability to the STAMP project, ERMA is user friendly, and at least one layer of each data types identified as priorities in the STAMP scoping and meetings are included in the tool: sea ice extent, oceanographic, fish marine mammals, some critical habitat areas, vessel traffic, and some regulatory boundaries. The breadth of data available is helpful in supporting the range of management issues identified in the scoping process that includes concerns with climate change, and increased vessel traffic development oil and gas development, and potential opening of a commercial fishery.

Relevant Limitations of the Tool

- Developed specifically for emergency response, limiting its relevance to STAMP's needs.
- Does not provide scenario-building and tradeoff-analysis functionality required by STAMP.
- Cannot extract or download data
- Although containing sea ice extent data, it does not explicitly address climate change.

MARCO Marine Planner

Visualization

Website: portal.midatlanticocean.org/planner

Who Developed the Tool?

The MARCO Portal Project Team includes Monmouth University Urban Coast Institute, Rutgers University's Edward J. Bloustein School and Center for Remote Sensing and Spatial Analysis, The Nature Conservancy, The University of Delaware's Gerard J. Mangone Center for Marine Policy, and Ecotrust

Where Has It Been Used?

Launched in September 2012, the MARCO Marine Planner is intended to support marine planning in the mid-Atlantic region of the United States.

Why Was the Tool Developed?

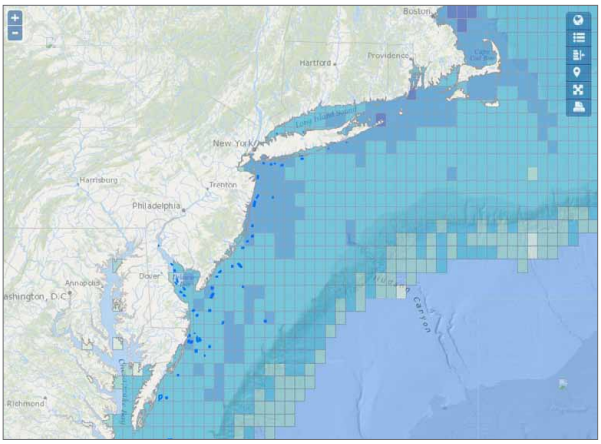
The MARCO Ocean Data Portal is an online toolkit and resource center that consolidates available data and enables state, federal and local users to visualize and analyze ocean resources and human use information such as fishing grounds, recreational areas, shipping lanes, habitat areas, and energy sites, among others. The Portal serves as a platform to engage all stakeholders in ocean planning from the five-state Mid-Atlantic region. MARCO Marine Planner is a key component of the MARCO Portal.

What Does It Do?

The Marine Planner was designed as an intuitive communication tool for accessing large amounts of information on sector-specific management objectives. Based the core functionality of MarineMap, a decision support tool for the Marine Life Protection Act process in California, users can visualize, query, map, and analyze ocean and coastal data. Map views can be shared at any time between users via built-in email and Twitter links. Users can add features to their map, find areas meeting certain users-defined criteria, and learn more about the traits and characteristics of their areas through analyses and reports. To encourage collaboration in decision and planning processes, user-generated designs based on selection criteria can be shared with other users through the tool's built-in sharing functionalities.

General Tool Characteristics and Usability

Data clearinghouse: Data on the site includes coastal



and offshore marine information alongside recreation, fishing, and renewable energy data. There is not a large amount of data on the site, but what is there is readily downloadable after clicking the "I" button to the left of the layer name.

User friendliness: Designed as a communications and planning tool, this application is very simple with only two tabs: Data and Active. The platform is a data viewer that is explicitly linked to an associated website on the MARCO planning process, allowing the user to readily go back and forth between mapping and communications. There is a Tour tab to help new users learn basic navigation. Located in the lower right, this tab is not intuitively placed but once recognized is a powerful way to learn how to navigate the map. The map itself could be bigger, and although the user can enlarge the map to full screen, layer visibility functions are limited in full-screen mode. The table of contents and legend (when visible) take up large areas of the browser window. The Hide Layers option, which helps to address that issue, is not immediately apparent to the user, and other functions are limited when Hide Layers is selected.

Performance: The mapping is very responsive. The available datasets, which are somewhat limited, draw quickly with no delays observed during our testing.

Issue-specific data: The data are specific to most of the issues being presented in the application. This is reinforced with the MARCO website being explicitly linked to the mapping.

High-quality data: The application includes scientifically reliable, authoritative and derived data relevant to the scale of the project.

Real-time data: The application wasn't designed to consume and process real-time data.

Easily updated: This application represents the second generation Marine Planner product focused on linking communications with mapping. Because this Marine Planner product was designed for the initial phase of the associated MARCO processes, data and functionality in the tool are likely to be updated in subsequent versions.

Other considerations: Currently, the tool does not include functionality for analyzing trade-offs or compatibility among planning objectives. Future iterations of this tool (by spring/summer 2013) are intended to have functionality similar to the Washington Marine Planner for scenario planning across management objectives. The tool provides unique logins for users, the ability to share selected areas of interest with others, and functions to create reports on data-driven metrics for specified areas.

Specific Data and Tool Requirements

Comprehensive fish data: The application is not intended to support comprehensive fish data, but it includes gear types and will include recreational fisheries.

Scenario-building tools: The application will soon allow the user to select specific management blocks based on a set of management-objective criteria for use in scenario planning. It is unclear at this time how in-depth tradeoff-analyses for compatible and incompatible marine uses will be developed given the sensitivities in the region.

Analysis tools: Although not currently available, the tool will allow users to draw unique shapes and generate summary reports within them as the application develops. Although these summary tools that issue specific reports will be generated, no trade-off functionality examining multiple shapes is being planned in this initial version of the tool (Washington Marine Planner was designed for this type of trade-off functionality). Other standard tools exist such as bookmarking specific map scenes and printing/exporting maps, but no analysis tools currently exist for calculating between or among data layers.

Climate change: The application does not include data or functionality specifically related to climate change.

Multiple access levels or interfaces: The tool provides two levels of access: (1) Without logging in, users can examine data in the map viewer. (2) Users who log in gain access to additional functionality such as creating and reporting on areas of interest, and summarizing specific metrics in the data.

Multiple map projections: Web map projection supported with download functionality.

Applicability to STAMP's Needs

Currently MARCO Marine Planner serves as a model for a tool with data clearinghouse, visualization, and communication functions. Scenario planning with specific design features will be incorporated into the tools in the next six months. MARCO Marine Planner and its precursor were developed to support specific multi-agency planning efforts. Should Alaska proceed with comparable planning processes, MARCO Marine Planner should be more deeply evaluated as its functionality develops.

Relevant Limitations of the Tool

- Does not cover STAMP's geographic area, although the same approach could be used there.
- Does not provide the specific tradeoff-analysis functions needed by STAMP.
- Does not address climate change.

Washington Marine Planner

Multiple Objective Planning

Website: washington.marineplanning.org

Who Developed the Tool?

The Nature Conservancy and Ecotrust

Where Has It Been Used?

Washington

Why Was the Tool Developed?

This is a pilot project intended to support the state's marine spatial planning process and the Pacific County Shoreline Master Plan (SMP) data and inventory characterization.

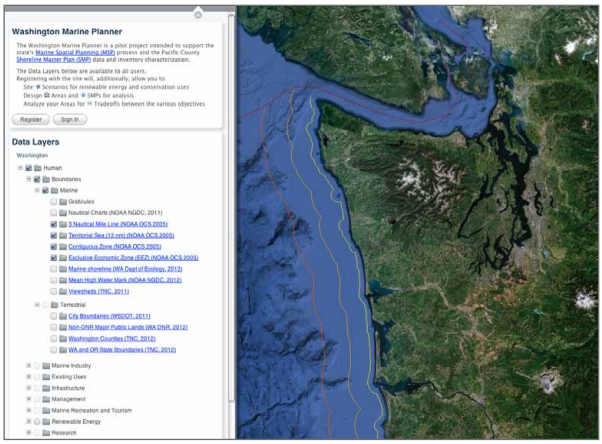
What Does It Do?

The Marine Planner extends the core functionality of MarineMap, a decision support tool for the Marine Life Protection Act process in California, enabling users to identify scenarios for oceanic use objectives that include renewable energy and conservation, draw areas of interest and receive summary reports of information within those areas —including sites specific to the SMP process—for further analysis, and analyze areas for tradeoffs between nearshore, benthic, and pelagic conservation and tidal, wind, and wave energy objectives. To encourage collaboration in decision and planning processes, user-generated designs based on selection criteria can be shared with other users through the tool's built-in sharing functionalities.

General Tool Characteristics and Usability

Data clearinghouse: The tool has information on the biophysical and ecological aspects of coastal and offshore marine environments as well as wind, wave, and tidal energy data.

User friendliness: It uses Google Earth, which means basic navigation is familiar to many users. The data viewer is well organized with clear call-out boxes that explain the information. A tab called My Shapes provides additional functions beyond the basic map viewer, although it is not readily intuitive. It does not take much time to become familiar with the most prominent functions, which are accessible through a few major icons at the top of the table of contents.



Performance: While Google Earth is fast and responsive, a major limitation is that it requires a browser plugin. Without the correct plugin, the application does not work. Some government agencies do not use Google applications, and therefore people at the agencies cannot use this tool.

Issue-specific data: The tool includes data that are specific to the issues on which the tool focuses.

High-quality data: The application includes scientifically reliable, authoritative and derived data relevant to the scale of the project.

Real-time data: The application was not designed to provide real-time data.

Easily updated: This application was the first generation of the Marine Planner product and will be updated to the second generation version (see MARCO Planner above). Because both Marine Planner products were designed for the initial phases of their associated regional planning processes, subsequent versions will likely be produced with updated data and functionality.

Other considerations: This decision support tool was one of the first to be designed for tradeoff-analyses between management objectives (conservation and renewable energy). With unique logins, the ability to share areas of interest with other users, and functionality to graph compatibility of management objectives in specified areas, this tool was a pioneering attempt at a local to state-scale stakeholder tool.

Specific Data and Tool Requirements

Comprehensive fish data: The application is not intended to support comprehensive fish data, but it does include data on some species.

Scenario-building tools: The application allows the user to select specific management objective criteria and visualize these places in marine space. This forms the baseline for identifying specific areas for either the state's marine planning or the Shoreline Master Planning process. Multiple scenarios can be saved if the user has set up an account within the application.

Analysis tools: The user can create unique shapes that represent areas of interest guided by the scenarios described above. Multiple shapes can be saved and graphed to illustrate compatibility and conflict areas between conservation and renewable energy objectives. This trade-off functionality is the primary analysis function in the application. Other standard tools exist such as measuring areas and bookmarking specific map scenes.

Climate change: The tool does not include data or functionalities that specifically address climate change.

Multiple access levels or interfaces: Two levels of access exist. (1) Without logging in, users can view data. (2) After logging in, users gain access to additional functionality, such as creating and reporting on areas of interest, and creating trade-off graphs for examining multiple areas across management objectives.

Multiple map projections: Web map projection supported, but with no download functionality it is unclear what local projections are supported.

Applicability to STAMP's Needs

Washington Marine Planner is a model for a tool that provides multiple-objective planning functions including scenario-building, area of interest custom designs, and tradeoff-analyses between sectors. This is the most sophisticated tool of those evaluated here in terms of generating and examining specific scenarios and tradeoffs. The functions that allow this have applicability to coastal infrastructure planning, shipping planning to reduce potential conflicts between uses (e.g., subsistence activities, commercial fisheries, barging supplies and fuel to communities). Although the level of fisheries information could be improved, this tool provides a strong example for how fisheries data might be integrated.

Relevant Limitations of the Tool

- Does not cover STAMP's geographic area, although the same approach could be applied there.
- Uses Google Earth, which imposes technical constraints that may not be acceptable for STAMP.
- Does not address climate change.
- Good example that illustrates the potential of scenario-building and tradeoff-analysis tools, but the issues differ from STAMP's priorities. However, this functionality could be replicated to address STAMP's purposes.

SeaSketch

Multiple Objective Planning

Website: seasketch.org

Who Developed the Tool?

Will McClintock (University of California, Santa Barbara) and collaborators

Where Has It Been Used?

Announced in July 2012, SeaSketch is intended for use anywhere around the world; to date, it has only been demonstrated using their Santa Barbara, California, example although there is a list of applications in early stage development on their website.

Why Was the Tool Developed?

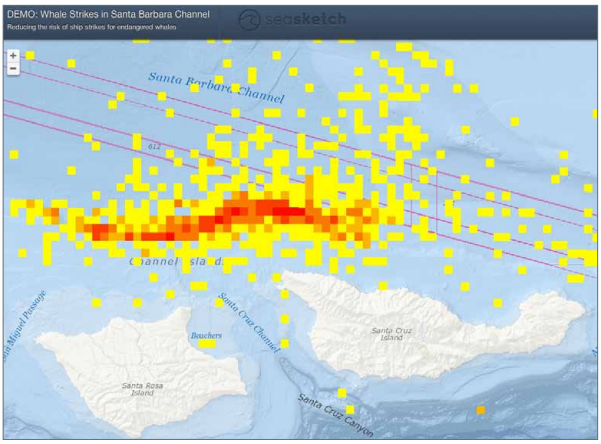
SeaSketch expands on the concept of the MarineMap tool, which provided users with an ability to quickly and easily draw different possible MPA scenarios on a map and immediately receive an analysis of whether the MPA design met planning objectives. MarineMap was an important tool for stakeholder engagement in the planning process in California. SeaSketch broadens this type of functionality so it can be applied in other planning contexts around the world, and it incorporates features for multi-objective planning and analysis.

What Does It Do?

SeaSketch is a platform for collaborative ocean geodesign. The geodesign approach examines relationships between different management sector interests and uses where users can alter spatial geometries and evaluate their effects on adjacent or overlapping information. In SeaSketch, users can (1) initiate a project by defining a study region, (2) upload map layers from existing web services, (3) define "sketch classes" such as prospective marine protected areas, transportation zones or renewable energy sites, (4) author sketches and receive automated feedback on those designs, such as the ecological value or the potential economic impacts of a marine protected area, and (5) share sketches and discuss them with other users in a map-based chat forum.

General Tool Characteristics and Usability

Data clearinghouse: Case examples in California have a good breadth of data, including external web



mapping services. Data are organized fairly well, but currently there is no way to collapse layers and simplify the data organization. SeaSketch is built as discrete applications that serve specific geographies and projects. Most of these applications are under development and seem to be placeholders with limited data. The Santa Barbara example application is the most fully developed, but even so it was set up as a demonstration and not intended to be facilitating a planning process.

User friendliness: The tab-driven format (layers, forum) is intuitive and simple. Some functionality is found by right clicking on the data layers, or clicking on the map (i.e., zoom to layer), but this is not apparent to novice users. One particular function, moving layers up and down, is not readily intuitive because it alters the drawing order, or overlap, on the map but not in the table of contents.

Performance: Generally, the tool performs well, but at the time of our evaluation it contained bugs, such as dialogue boxes that cannot be closed, and there is a delay in identifying features on the map. Once logged in, the user can draw and save shapes on the server. This performs well, but it seems the user still cannot take advantage of the forum for discussing the shape with others. Because this is a prototype system, some features may not be available yet.

Issue-specific data: For most of the applications the tool includes data specific to most of the issues being addressed, but in some it is unclear how the data relate to the overall aims of the project.

High-quality data: The prototype applications include scientifically reliable or authoritative data relevant to the scale of the project.

Real-time data: The applications do not seem to be designed to provide real-time data.

Easily updated: Because SeaSketch was released very recently, the update cycle is not yet known.

Other considerations: The most unique features of SeaSketch are the sketches and forum tabs, which require the user to have an account and log-in. Though the functionality is currently limited, these are powerful ideas that will certainly evolve. It is unclear how these functions will be used in real planning processes.

Specific Data and Tool Requirements

Comprehensive fish data: Most of the prototype SeaSketch applications are not intended to support comprehensive fish data.

Scenario-building tools: The prototype application for the Channel Islands off of Santa Barbara in California includes functions for scenario planning. The user can create new shipping lanes and see how they may interact with whale habitat and marine protected areas. This geodesign functionality is powerful, but it is unknown whether users will find real applicability when applied to a planning process.

Analysis tools: While the scenario example above is a good basis for examining tradeoffs, the ability to draw and propose new shipping lanes could have dramatic consequences, especially because it would involve proposed alteration of authoritative data. Drawing sketches and calculating these shapes as they interact with other data seems to be a primary analysis function. This is only available in one application; all other applications have only data lists, and the ocean acidification example contains analyses done elsewhere. The applications are therefore primarily data viewers with no analysis functionality, although reporting functions do exist.

Climate change: The NOAA Habitat Blueprint application in SeaSketch mentions "resilient coastal communities" as an outcome, but it is unclear what data in the application support this outcome. No other SeaSketch application addresses climate change.

Multiple access levels or interfaces: Two levels of access exist. Without logging in, users can examine data in a viewer. After logging in, users gain access to additional functionality, such as sketches and forums.

Multiple map projections: Web map projection is supported, but with no download functionality it is unclear what local projections are supported.

Applicability to STAMP's Needs

SeaSketch offers scenario-building and compatible/incompatible marine use functionality that may be applicable in Alaska. The tool can be used by resource managers and stakeholders to easily design a variety of scenarios for allocating and distributing uses in the marine environment. This ability to develop scenarios to reduce competing uses and evaluate tradeoffs between shipping, energy development, subsistence, and commercial fishing can be a powerful tool for stakeholder involvement in planning. However, STAMP has not identified any geodesign or spatial discussion forum needs and therefore this tool primarily addresses only needs around visualization.

Relevant Limitations of the Tool

- Does not provide the data clearinghouse functionality that STAMP needs.
- Provides a general platform that would require customization for STAMP's purposes.
- Because SeaSketch is brand new, it is not yet clear how well it will perform in practice.
- While geodesign and spatial discussion forum functionality is potentially powerful for marine planning, this concept has not been fleshed out in actual planning processes and therefore may not be practical or needed.

Summary Matrix: Tools vs. Evaluation Criteria

This matrix provides a summary of how the tools described in this report align with the requirements identified during the STAMP needs assessment. For explanations of the evaluation criteria, please refer to "Selection of Evaluation Criteria Based on Needs Assessment" on page 5.

		AOOS Portal	Northeast Ocean Data	Marine Cadastre	Arctic ERMA	MARCO Marine Planner	Washington Marine Planner	SeaSketch
Category of Decision Support Tool	Web-based mapping application	✓	✓	✓	✓	✓	✓	✓
	Non-spatial framework and/or decision tree							
	Participatory mapping (non-GIS)							
	GIS or other spatial software packages							
Primary Role of Tool	Data clearinghouse	✓	✓	✓	✓	✓		
	Visualization	✓	✓	✓	✓	✓		
	Multiple-objective planning						✓	✓
STAMP Evaluation Criteria	User friendly	✓	✓	✓	✓	✓	✓	✓
	Performance	✓	✓	✓	✓	✓	✓	✓
	Issue-specific data	✓	✓		✓	✓	✓	✓
	High-quality data	✓	✓	✓	✓	✓	✓	✓
	Real-time data	✓	✓		✓			
	Easily updated	✓	✓	✓	✓	✓		✓
	Comprehensive fish data							
	Scenario-building tools		✓	✓		✓	✓	✓
	Analysis tools (tradeoffs)						✓	✓
	Focus on climate change	✓						
	Multiple access levels or interfaces		✓		✓	✓	✓	✓
	Multiple map projections	✓						

CONCLUSION

At the time of this review, there is not a single tool that adequately addresses all the categories of tools or criteria that STAMP needs. Neither are there tools in use today that meet all of the diverse needs in the area of marine spatial planning. Instead, there are multiple tools for multiple needs and sectors. This poses both a challenge and an opportunity for STAMP, which can both draw from the existing tools, and forge a new path forward.

Key Findings and Recommendations for STAMP Tool Development

STAMP PRIORITIES: Data clearinghouse; Range of data with comprehensive fish data; Climate change

FINDINGS: The AOOS Portal already provides most of the data clearinghouse functionality needed by STAMP. While none of the other tools that we evaluated currently provide comprehensive fish data, the AOOS Portal will soon be adding Arctic fish data. Few other tools provide data in a form that is useful for addressing climate change and its impacts on the marine ecosystem and human uses of the ocean, but the AOOS Portal is currently developing climate-related data products.

RECOMMENDATIONS: Use the AOOS Portal as the STAMP data clearinghouse, supplementing its existing data with a broader range of data including biological and comprehensive fish data as well as data related to climate change. Use the AOOS Portal as the foundation for building new functionality (visualization, multiple objective planning). As climate-related data products are developed, ensure that they are directly relevant to top concerns raised in the STAMP needs assessments, including loss of sea ice, increased shipping traffic, and increased oil and gas development; for ideas, evaluate tools that focus on climate change and coastal hazards (e.g. Coastal Resilience, NOAA's Sea Level Rise viewer). Consider integrating specific climate change scenarios for the region (e.g., use scenario outputs from the UAF's SNAP).

STAMP PRIORITY: User-friendliness

FINDINGS: Each of the tools is user friendly in some ways. For STAMP's purposes, the best models are the MARCO Marine Planner and Northeast Ocean Data.

RECOMMENDATIONS: Use the AOOS Portal as the STAMP data clearinghouse, supplementing its existing data with a broader range of data including biological and comprehensive fish data as well as data related to climate change. Use the AOOS Portal as the foundation for building new functionality (visualization, multiple objective planning). As climate-related data products are developed, ensure that they are directly relevant to top concerns raised in the STAMP needs assessments, including loss of sea ice, increased shipping traffic, and increased oil and gas development; for ideas, evaluate tools that focus on climate change and coastal hazards (e.g. Coastal Resilience, NOAA's Sea Level Rise viewer). Consider integrating specific climate change scenarios for the region (e.g., use scenario outputs from the UAF's SNAP).

STAMP PRIORITY: Visualization

FINDINGS: Many tools do not provide enough information or context for people who are not already up to speed on the relevant issues, how and why the tool is useful, and how the tool fits into existing planning processes. The MARCO Marine Planner and Northeast Ocean Data Portal provide good communication and visualization features that could be adapted to STAMP.

RECOMMENDATIONS: Investigate in detail the communication features of the Northeast Ocean Data and MARCO Marine Planner. Identify how these tools could be used in their current form or modified to facilitate communication about specific issues among stakeholders. Engage with the developers of these tools regarding potential for implementation. Develop similar maps on specific aspects of climate change, sea ice, marine mammals, shipping, fishing, energy development, and other priority issues. Consider ways to provide information and context around the tool itself, such as embedding a web mapping application within a web page that also has content on the relevant issues or important results viewable in the tool. In addition, visualization tools need to be augmented with clear graphical displays suitable for public presentations.

CROSS-CUTTING PRIORITY: Multiple objective planning

FINDINGS: Washington Marine Planner and SeaSketch are good examples of how tools may be developed to support multiple-objective planning.

RECOMMENDATIONS: Using Washington Marine Planner as a conceptual framework, define how priority issues for tradeoff analysis and multi-objective planning in STAMP's study area would be represented in a decision-support tool, if that functionality is determined to be appropriate for the STAMP region and stakeholders. Clearly define the decision-making process and criteria; tool functionality required to represent the process and criteria; and data requirements and feasibility. If scenario development is desired, examine whether SeaSketch is needed for scenario development using geodesign, and stakeholder engagement using the spatial discussion forum, in the STAMP study area. We recognize that the political climate in Alaska may not yet be ripe for a planning process that involves stakeholders in this way. However, if scenario planning may be desired in the not-too-distant future, it would be valuable to build the STAMP tool such that it is amenable to adding that functionality.

CROSS-CUTTING PRIORITY: Accessing data from other sites

FINDINGS: Many of the tools that we evaluated did not access and use data from other sites. They only used data that they hosted. Despite the importance of sharing data among decision support tools, the technology to do so is still lacking, especially in cases that would require interfacing between open source and proprietary software. This is an important function that needs more attention, as tools need to access data from other sources.

RECOMMENDATIONS: Develop mechanisms for AOOS to access data from other sources, such as the Marine Cadastre, so that it can provide many types of up-to-date, accurate information at many spatial scales without having to host all of the data.

CROSS-CUTTING PRIORITY: Effective support for marine planning

FINDINGS: Many of the general challenges of tool development have been dealt with already in other geographies. The most important challenge now is to ensure that tools effectively support marine planning processes and contribute to enhanced decision making.

RECOMMENDATIONS: Engage with the developers of the tools described in this report to potentially apply their expertise and approaches to STAMP's specific needs and context, reducing the need for STAMP to reinvent the wheel and duplicate effort. At the same time, recognize that region-specific needs and applications for the tool should drive the tool development process (i.e., the need to address both multiple management objectives and climate-related issues) and that local knowledge is critical for the success of the tool, including the knowledge and expertise associated with the AOOS Portal.