Data Sharing for the Development of an Atlantic Canada Marine Atlas

WORKSHOP DISCUSSION PAPER

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About COINAtlantic

The Coastal and Ocean Information Network Atlantic (COINAtlantic) is a longstanding non-governmental organization based in Halifax that promotes and facilitates coastal and ocean data and information exchange across Atlantic Canada in support of integrated management. COINAtlantic has been contracted by Fisheries and Oceans Canada to prepare and circulate a Discussion Paper and provide facilitation of a Data Sharing workshop.

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Executive Summary

Fisheries and Oceans Canada (DFO) is leading a Marine Spatial Planning (MSP) process that brings together relevant authorities, stakeholders and rightsholders to better coordinate how we use and manage marine spaces to achieve ecological, economic and social objectives. In support of the MSP program, an atlas for Atlantic Canada's three bioregions (Scotian Shelf, Gulf of St. Lawrence, Newfoundland and Labrador) will be developed by March 2022. This Atlantic Canada-wide compilation of data and information will be a web-based, public platform with interactive maps of ocean ecosystems, human uses and management areas.

Marine atlases have played key roles in supporting marine spatial planning in Canada and around the world. Atlases built on data that are up-to-date, objective, reliable, relevant and easily compared can help to visualise competing demands on space and resources and assess the implications of new uses or new management measures on both the environment and on existing users. By improving access to information on the spatial and temporal presence of vulnerable assets and the intensity of human activities, a marine atlas can increase awareness and understanding of ecological and socio-economic conflicts and opportunities, enable better risk management and guide proactive decision making.[1]

The responsibility for mapping coastal and ocean zones typically lies with many federal, provincial, and local agencies, each with their own unique mission or geographic area.[2] Aggregating and integrating data from these different sources to support the development of an atlas can be a complex and time-consuming process; key to the success of this undertaking is a well-developed data infrastructure, commonly known as spatial data infrastructure (SDI). An SDI brings together data under adequate licencing terms, with consistent technical and quality standards, and with accompanying metadata.

Themes are used to organize data layers in online marine atlases and commonly include topography, bathymetry, areas of conservation or other significance, and human use data, including fishing, shipping, energy, mineral extraction, recreation, telecommunications, heritage, military, and socio-economic data. Specialized functions that accompany a marine atlas – such as measuring or reporting tools – are driven by the kinds of decisions that the platform is required to support, the users, and the technological resources available.

The question of what data and information is relevant and required for an atlas is strongly dependent on the type of planning the atlas is intended to support, as well as who its intended users are. There are a multitude of federal, provincial and municipal government departments, Indigenous organizations, non-governmental organizations, research institutions, and private-sector companies that collect coastal and marine data in Atlantic Canada and who could potentially benefit from an online marine atlas for Atlantic Canada. In order to identify relevant and available data, multiple data collection approaches should be used from targeted workshops with federal, provincial, and municipal governments, to data collection workshops with industry associations, NGOs and local knowledge holders. An inclusive and transparent process will help overcome data sharing impediments, address data sensitivity issues and ensure the atlas development is driven by the needs and expertise of regional stakeholders, rightsholders and relevant authorities.

Introduction

Fisheries and Oceans Canada (DFO) is leading a Marine Spatial Planning (MSP) process that brings together relevant authorities, stakeholders and rightsholders to better coordinate how we use and manage marine spaces to achieve ecological, economic and social objectives. Planning processes are underway in five areas across Canada: Pacific North Coast, Salish Sea, Bay of Fundy/Scotian Shelf, Newfoundland-Labrador Shelves and Gulf of St. Lawrence. These processes will produce marine spatial plans for each area by March 2024. Key elements to the MSP process include:

- Governance (internal governance; federal, provincial, Indigenous and stakeholder mechanisms)
- Bioregional marine atlas/data portal (data sharing; related applications including interactive marine atlas)
- Decision-support tools (integration of relevant federal initiatives and application of tools for multiple use planning and decision making)
- Bioregional marine spatial plan (long-term direction and guidance with shared/distributed accountabilities for implementation)

This Discussion Paper will focus on only one element of the MSP process: the bioregional marine atlas/data portal. In support of the MSP program, an atlas for Atlantic Canada's three bioregions (Scotian Shelf, Gulf of St. Lawrence, Newfoundland and Labrador) will be developed by March 2022. This Atlantic Canada-wide compilation of data and information will be a web-based, public platform with interactive maps of ocean ecosystems, human uses and management areas.

Marine atlases have played key roles in supporting marine spatial planning in Canada and around the world. If marine resources are to be used sustainably, ways have to be found to reconcile differing economic, social, and environmental demands with the marine environment's capacity to accommodate these demands, particularly in light of increasing and competing use, and growing commitments to protect the environment. Atlases built on data that are up-to-date, objective, reliable, relevant and easily compared can help to visualise competing demands and assess the implications of new uses or new management measures on both the environment and on existing users, and guide proactive decision making.[3]

This Discussion Paper draws on lessons learned from some of these atlases and highlights key aspects to be considered in the development of an Atlantic Canada marine atlas. Discussion questions are put forward throughout this paper that will be explored further in a Data Sharing workshop on March 12-13, 2020 in Halifax.

Data Sharing Workshop

While 'lessons learned' from other atlases can inform the development of an Atlantic Canada marine atlas, it is critical to the success of this initiative that the process be led and shaped by the needs and expertise of regional users. Recognizing this, marine planners and data experts from across sectors and around Atlantic Canada, have been invited to a workshop on March 12-13, 2020 in Halifax, Nova Scotia to discuss how an Atlantic Canada marine atlas can address their specific needs, assess data availability, and identify data sharing requirements.

Marine Atlases – From Static Maps to Interactive Data Portals

- ✓ Marine atlases come in many forms with **different kinds of functionality**, ranging from printed and digital collections of static maps to data portals that provide access to raw data and interactive maps with data layers and querying tools.
- ✓ The format of an atlas is dependent on different factors, including **available technology, the target audience and what they need the atlas for, the purpose of the atlas and the resources available** to the atlas developer(s).
- ✓ Differences in atlases exist with respect to **land-sea integration**; some atlases incorporate land and sea territory, while others exclusively focus on sea areas.

At its simplest, an atlas can be a printed or digital "collection of maps often including illustrations, informative tables or textual matter."[4] These kinds of atlases are characterized by static maps (without the ability to interact, query, or customize), and present information from a discrete period of time. An example of this type of marine atlas is The Scotian Shelf: An Atlas of Human Activities. The goal of this atlas was to collect the most current information available from authoritative sources (for the period 1999-2003) and present a snapshot of human use on the Scotian Shelf.

Interactive Atlases

Web-based marine atlases with more specialized functionalities present a diversity of data layers and give the user control over what layers are viewed on the map. For example, the NL Seabed Atlas presents various seabed parameters to support understanding of the benthic habitat in Newfoundland and Labrador waters. This atlas allows users to turn on and off data layers, which include 'Trawl Intensity', 'Bottom Temperatures' and 'Vessel Traffic'.

Data Portals

Still more specialized online atlases – commonly referred to as 'data portals' - provide users with access to raw data and regularly updated data sources, among other features. Wright[5] provides the following definition for a data portal:

> [A]n Internet environment (large web site or content management system) that features some kind of metadata catalogue with descriptions of available data sets and imagery. The portal may be rich in content itself, but more often than not serves as a focal point linking many networked servers distributed over a large geographic area (these being invisible to the user if need be). In addition to spatial data, content available to the user also includes documents, web site addresses, and even software applications. In addition, registered map services allow users to build online maps using data within the portal. Another critical ingredient is Internet map service technology that allow users to visually browse and query individual or multiple data sets in order to determine whether a download is necessary. Once downloaded, the data may then be viewed in other software or analyzed using a GIS or image processing package.

An example of a well-established marine data portal is the European Marine Observation and Data Network (EMODnet). EMODnet consists of a network of organisations that work together to observe the sea, process the data according to international standards and make that information freely available as

interoperable data layers and data products. EMODnet provides access to European marine data across seven discipline-based themes: Bathymetry, Geology, Seabed habitats, Chemistry, Biology, Physics and Human Activity. Each theme has an accompanying data portal that allows users to access and interact with data layers on a map. Detailed metadata and the raw data are provided for each layer.

Land-Sea Interface

Differences in atlas approaches also exist with respect to land-sea integration; some atlases incorporate land and sea territory, while others exclusively focus on sea areas. The European Commission takes the position that effective marine spatial planning cannot take place unless consideration is given to the interface between terrestrial and marine environments. A report produced by the Commission explores the land-sea interactions of the most typical marine development sectors including aquaculture, ports and shipping, offshore energy and tourism and coastal recreation.[6]

DISCUSSION QUESTIONS - MARINE ATLASES

1. What, in your opinion, should be the purpose of an Atlantic Canada marine web atlas?
2. How would you use an Atlantic Canada marine web atlas?
3. What level of land-sea integration should be captured by an Atlantic Canada marine web atlas?

Marine Spatial Data Infrastructure

- ✓ **Lack of coordination between agencies** tasked with collecting marine data has resulted in information in diverse formats, scattered across different online sources.
- ✓ **Aggregating and integrating data** is laborious; success is contingent on a well-developed data infrastructure, commonly known as **spatial data infrastructure**.
- ✓ An Information Technology team within the **Canadian Hydrographic Service is leading the development of Marine Spatial Data Infrastructure**; this team will develop the Atlantic Canada marine atlas based on user needs.

The responsibility for mapping coastal and ocean zones typically lies with many federal, provincial, and local agencies, each with their own unique mission or geographic area.[7] These organizations have often worked in isolation which has resulted in information in a variety of formats scattered across different online catalogues, portals and web mapping applications. Other factors that add to the challenge of managing marine data include sampling distribution, resolution, frequency and the number of dimensions that some data, like temperature, occupy (spatial and temporal).

Key to the success of developing a marine atlas is a well-designed spatial data infrastructure (SDI). An SDI is the overarching framework of technologies, policies and institutional arrangements that help people with acquiring, processing, using and preserving spatial data.[8] Spatial data infrastructures are typically comprised of data sets which are:[9]

- Created with consistent technical and quality standards
- Under adequate licencing terms
- Accessible for use in GIS and WebGIS with accompanying metadata
- Follow appropriate standards

- Comply with best practices

A Marine Spatial Data Infrastructure (MSDI) is specific to marine and coastal information and allows for the combination of a variety of data types at different resolutions, allowing efficient analyses by a wide range of disciplines, such as marine spatial planning, environmental management and emergency response.[10]

SDIs specific to marine and coastal data and information can be found around the world, including Integrated Ocean and Coastal Mapping (IOCM) in the United States and Europe's INSPIRE Directive (Infrastructure for Spatial Information in the European Community). The INSPIRE Directive's implementing rules are legally enforceable in all EU member states and which has expedited implementation of common specifications and standards.[11]

Canada

The Canadian Geospatial Data Infrastructure (CGDI) was initiated in 1999 in recognition of the need for interoperability between international, national, and regional ocean information and associated standards.[12] Since then, GeoConnections, a national program led by Natural Resources Canada, has coordinated efforts to build the CGDI.

The federal government released an Open Government directive in 2014 with the objective "to maximize the release of government information and data of business value to support transparency, accountability, citizen engagement, and socio-economic benefits through reuse, subject to applicable restrictions associated with privacy, confidentiality, and security." Key commitments in the *2018-2020 National Action Plan on Open Government* include increasing the availability and usability of geospatial data through the Federal Geospatial Platform and the Open Maps section of the Open Government Portal.[13]

An Information and Technology (IT) team within the Canadian Hydrographic Service (CHS) is leading the Marine Spatial Data Infrastructure process within the federal government. This initiative is inline with the Open Government directives and leverages the Federal Geospatial Platform. Much of the work to date has been on the development of applications internal to the federal government, however, the focus is moving to new opportunities, including the development and publication of interactive marine atlases that can be served on external platforms.

Atlantic Canada Provinces and Municipalities

All Atlantic Canadian provinces and a number of municipalities have Open Data portals and geospatial data catalogues. Data is typically grouped by different categories (for example, 'Business and Economy' and 'Nature and Environment') and varying degrees of mapping functionality are offered.

DISCUSSION QUESTIONS - MARINE SPATIAL DATA INFRASTRUCTURE (MSDI)

4. How does your department/organization manage marine and coastal geospatial data? What is working well and where do the challenges lie?
5. How does your department/organization share marine and coastal geospatial data with the public and external agencies?

Marine Atlases and Mitigation of Ecological and Socio-Economic Conflicts and Risks

- ✓ Marine atlases **improve access to information on the spatial and temporal presence of vulnerable assets** and the intensity of human activities, thereby **supporting understanding of ecological and socio-economic conflicts and opportunities** and enabling better risk management.
- ✓ Atlases have played a role in reducing socio-economic conflicts and risks as seen in examples from **conservation, resource development, navigation and safety, and public capacity building**.

Marine and coastal web atlases can be an "engine" for implementing marine spatial planning by serving as a tool for improved access to interactive data and information about land and seascape features of interest.[14] This includes the presence of vulnerable assets, or the intensity and distribution of socio-economic activities.[15] Examples of how data portals and web atlases support conflict and risk reduction are provided below under the following themes: conservation, resource development, navigation and safety, and public capacity building.

Conservation

- In order to develop an amendment for protecting deep-sea corals in the Gulf of Maine, the New England Fishery Management Council used the Northeast Ocean Data Portal to create public maps of draft protected management area alternatives.[16] The portal reduced the burden of creating multiple static maps in response to the diverse data relationships that stakeholders wanted assessed and provided a means to create multiple draft management zone alternatives for consultation.
- The NOAA Choptank Digital Atlas improved the ability to conduct biogeographic assessments focused on risk assessment and conflict resolution by integrating geospatial socio-economic data layers with environmental data. This allowed managers, stakeholders and the public to visualize relevant data for decisions being made on the management of ecosystems in the Choptank watershed.[17]

Resource Development

- The European EMODnet Human Activities Portal reduces conflicts between offshore wind development and non-renewables by highlighting infrastructure data for wind farm and hydrocarbon extraction, advancing development of areas of interest.[18]
- The Mid-Atlantic Regional Council on the Ocean (MARCO) plays a key role in facilitating open discussion around offshore wind development using their Mid-Atlantic Ocean Data Portal.[19] The U.S. Naval Undersea Warfare Center used the Ocean Data Portal to gain the situational awareness necessary to locate a new test site for an unmanned underwater vehicle that would not interfere with commercial vessel traffic, recreational boating and other ocean uses.[20]

Navigation and Safety

- The Northeast Ocean Data Portal helped to reduce conflict in waterways by allowing the overlay of commercial vessel traffic, recreational boaters, and navigational aids on the same map enabling the characterization of risk for waterways.[21]

- The United States Coast Guard assessed bay-level risk by comparing annual marine traffic with proposed Wind Energy Areas (WEAs) by overlaying traffic layers with bathymetric water depth.[22]
- The three-year HAZADR Atlas of Risk Scenarios increased capacity for community response to hazards from collisions, shipwrecking and toxic spillage in the Adriatic Region through thematic layers such as coastal vulnerability, risk index for vessels, oil spill diffusion forecasts, and meteorological and sea condition forecasts.[23]

Public Capacity Building

- An increasing use of online coastal and ocean atlases by non-specialists is improving ocean literacy in the public.[24] The Oregon Coastal Atlas has benefited coastal homeowners by providing clear and visual information that clarified the degrees of risk facing their property or area.[25]

DISCUSSION QUESTIONS - ECOLOGICAL AND SOCIO-ECONOMIC RISKS AND CONFLICTS

6. What ecological and/or socio-economic conflicts/ risks (past, current, and potential) from your jurisdiction could be addressed using a marine atlas?
7. Have you used a marine atlas to mitigate ecological or socio-economic conflict or risk? What data layers have you drawn on? What data layers were missing?

Marine Atlases and Regulatory-Based Decision-Making

- ✓ Combining ecological and socio-economic **data layers into a single mapping platform expedites the ability to visualize and evaluate spatial/temporal overlap** of features for informed decision-making.
- ✓ Marine atlases can be valuable tools for establishing **interregional collaborative approaches** to data sharing, geared toward serving sector-based regulatory priorities.

Marine web atlases can serve as governance structure points for informing regional decisions and policy making that transcend departmental priorities and support the development of a unified vision and integrated approach to coastal and ocean management that accounts for cumulative impacts of human actions on the marine environment,[26] including climate change and resource extraction. Marine atlases also save time through improved efficiency.[27] For a marine web-based atlas to play this key role in supporting regulatory decision making, data products available in the atlas must be useable by those agents affecting policy and decision processes who may not be GIS experts.[28]

Marine atlases provide accessibility for general users to identify, visualize, and query datasets and information applicable to interests.[29] In the Adriatic basin, the Adriatic Atlas is a tool for storing, visualizing, and managing harmonized data across borders in support of the implementation of MSP and integrated coastal zone management policies, [30] including territorial data and the legislative and planning frameworks for the Adriatic marine and coastal area[31]. Web atlases could serve biological regulations too.

Fisheries regulations have long required certain common-property resource industries such as fisheries to rigorously collect and share detailed information about activities (effort and catch value) with managers.[32]

The recent DFO Atlantic Canadian Protocol on Mapping Fishing Activity provides common and consistent methods and guidelines for mapping fishing activity.[33] Critical to operationalizing this protocol is the ability to compare interregional spatial data products such as maps and data layers for use inter- and intra-departmentally, or to be shared publicly through a bioregional atlas.[34] However, competing policies related to development, conservation, hazard mitigation and shoreline protection coupled with the highly social environments that policies are applied in, can make decision making challenging. An integrated management approach between federal, provincial, and Indigenous governments, where appropriate, that advances coastal and ocean programs, is supported by Canada's Oceans Act (1996) and Oceans Strategy (2002). An adaptive geospatial data tool, such as a marine atlas, can help open discussions around management and regulatory strategies under these prominent ocean legislations.[35]

The range of marine-related policies and decisions that marine atlases support include sovereignty, resource management, maritime safety, risk assessment, climate change, pressures such as the over-allocation of marine resource use, and hazards such as oil spill response.[36] Examples include:

- The Mid-Atlantic Ocean Data Portal has been instrumental in stakeholder engagement and planning as it integrates human use activities such as fishing, recreation, shipping, offshore renewable energy sites and habitat areas through mapping and visualization technologies which are available to public agencies, marine industries, community leaders and the public.[37]
- The Scottish Sustainable Marine Environment Initiative (SSMEI) developed a Marine Atlas that served a collection of baseline spatial data for use in developing place-based policies designed to guide the future development of their regional marine space.[38]
- Access to data and maps through the Northeast Ocean Data Portal facilitated an easier permitting process and compliance with local laws for the Northeastern Massachusetts Aquaculture Center's blue mussel offshore aquaculture site; the first offshore shellfish farm in federal waters on the Atlantic Coast.[39]
- Local governments in Maryland, with over 7,500 miles of coastline, developed the Maryland Shorelines Online Atlas tool to help with reviewing land parcel conditions before issuing building permits.[40]

DISCUSSION QUESTIONS - REGULATORY DECISIONS

8. In your experience, how have marine web atlases supported regulatory-based decision making? What data layers or combinations of information were involved?

Marine Atlases - Relevant and Required Data

- ✓ Data and information needs for an atlas depend on the **type of planning** that is carried out, including spatial optimisation and risk minimisation or a fully integrated approach.
- ✓ Marine atlases and data portals around the world typically **group data by similar themes**
- ✓ Information on the marine environment is dominated by data on environmental conditions; **common data gaps are found within socio-economic and cultural data**.

The question of what data and information is relevant and required for an atlas is strongly dependent on the type of planning the atlas is intended to support, as well as who its intended users are. Initial efforts may be focused on data and information needs that relate to evidence which describes the current

situation (stocktaking), e.g. baseline information on the current range of activities and their potential impacts on the surroundings. Later, data and information needs may become more complicated and relate to analysis of conflicts and synergies, spatial and environmental compatibility of different activities, and future scenarios for coastal and ocean management. Under a spatial optimisation and risk minimization approach, for example, the main goal is to support a rational arrangement of key maritime sectors in response to sectorial calls for space.[41] Other planning approaches may be guided more by strategic objectives (with consideration given to sectorial policy goals), and seek to integrate economic, social and environmental objectives.

The European Atlas of the Sea, a web-based coastal and marine information system, was originally aimed at the general public and provided a series of 'ready made' maps which presented popular themes such as sea level rise, security, tourism, energy and fish consumption. However, over time the atlas has been upgraded to improve availability of both environmental and socio-economic data, and to provide instruments for the evaluation of coastal and marine issues. Not only is it a public communication and education tool, but it also provides policy makers access to highly specialized information in support of their work on coastal and marine issues.[42]

Data Sources

Data for marine atlases can be drawn from a diversity of sources, including national and regional public archives and databases, or sources that are not publicly available but where permissions and conditions of use have been obtained. Most spatial planning efforts rely heavily on government sources in addition to the scientific literature and expert scientific opinion. However, local knowledge is increasingly recognized as an important source of information.[43] Taking an inclusive approach to data for the development of a marine atlas can help avoid conflicts in the subsequent planning and decision-making processes.[44] This requires involvement of different stakeholders and acceptance of other beliefs, values and knowledge as legitimate contributions.

Data Themes

Marine atlases and data portals around the world typically group available data by themes or categories. Similar themes are found across atlases, starting with base data which commonly include infrastructure, topography/bathymetry, and satellite imagery. Additional, commonly used themes include:[45] Jurisdictional Boundaries, Federal Georegulations, Navigation and Infrastructure, Human Use (energy, mineral extraction, recreation, nature conservation, fishing, underwater heritage, and military), Marine Habitat and Biodiversity, and Geology and Seafloor. Cultural themes such as recreation, culture and heritage, tourism and industry are also often included.[46]

Where differences lie between atlases are mostly related to the weight given each sector in terms of diversity of data and specific expression of the sector.[47] For example, a common theme in marine atlases is "energy resources", but where one atlas may provide data primarily associated with wind energy another may be richer in data associated with offshore oil and gas. This, of course, is reflective of the specific geographic, economic and cultural differences between jurisdictions.

Two examples of marine atlases are given below to illustrate similarities and differences in thematic approaches and associated data.

Ireland's Marine Atlas

Theme	Associated Data
Maritime Boundaries	Exclusive Economic Zone, Local Authority Area, National Marine Planning Framework Area, 12NM Territorial Sea Limit, Designated Maritime Boundary Continental Shelf, Sea-floor depth below mean sea level
Biodiversity	Benthic Habitats, Distribution of Harbour Seals and Grey Seals, Distribution of Sea Cliffs, Saltmarsh and Subtidal Sandbanks
Climate Change	National marine sediment that store carbon
Heritage Assets	Coastal built heritage sites, the Wild Atlantic Way, Historical coastal towns, shipwrecks in Irish waters
Marine Protected Areas	Designated sites
Aquaculture	Aquaculture sites
Energy – Petroleum	Offshore gas pipelines, exploration wells, current authorizations
Energy – Offshore Renewable Energy	Windfarms, wave energy infrastructure
Fisheries	Offshore, Inshore
Marine Aggregates and Mining	Marine Aggregate Type
Ports, Harbours and Shipping	Passenger vessel density 2017, national ferry route, ferry port, cargo vessel density 2017, popular destination
Sport and Recreation Trends and Features	Sailing activity, marinas
Tourism Trends and Features	Main coastal city or town, accommodation hotspot type
Waste Water Treatment and Disposal	EPA coastal water quality, bathing water location, raw sewage discharge points, EPA transitional water quality
Fish Spawning and Nursery Grounds	Atlantic mackerel, horse mackerel, Atlantic haddock, blue whiting, Atlantic cod, Atlantic hake, monkfish, Atlantic herring, whiting, megrim

BC Marine Conservation Analysis: Marine Atlas of Pacific Canada

Theme	Data Layer	Information Shown
Ecological	Seabirds	At-Sea, Colonies, Nearshore, Shorebirds
	Fish	Basking Shark Sightings and Captures, Herring Spawn, Salmon-bearing Stream Mouths, Salmon-bearing Watersheds
	Invertebrates	Coral Occurrences, Important Invertebrate Habitat, Selected Corals, Selected Crustaceans, Selected Echinoderms, Selected Molluscs, Selected Segmented Worms, Selected Sponges, Sponge Occurrence, Sponge Reef
	Marine Mammals	California sea lion, Dall's Porpoise, Elephant Seal, Fin Whale, Harbour Porpoise, Harbour Seal, Humpback Whale, Minke Whale, Northern and Southern Resident Killer Whale Critical Habitat and Distribution, Northern Fur Seals – Pup Habitat, Pacific White-sided Dolphin, Sea Otter distribution and Range, Stellar Sea Lion Haul-outs Distribution and Rookeries
	Physical	Benthic Classes, Coastal Classes, Ecosections, Exclusive Economic Zone, Hydrothermal vents, Shore zone Exposure, Tidal Current, Upper Ocean Sub-regions
	Plants	Algae, Kelp, Vascular, Chlorophyll
	Fish/Invertebrate Surveys	Groundfish Fishery Observer Data, Groundfish Trawl Survey Observed Catch Density, Groundfish Trawl Survey Species Richness, IPHC Standardized Stock Assessment Survey, Shrimp Trawl Areas, Shrimp Trawl Survey Observed Catch Density, Shrimp Travel Survey Species Richness
Human Use	Commercial Fishing	Different fisheries (e.g. Red Sea Urchin, Halibut, Dungeness Crab, Chinook Salmon)
	Ocean Energy	Renewable Energy Tenures, Offshore Exploratory Oil Wells, Offshore Petroleum Tenures (Federal and Provincial), Oil and Gas Prospectivity, Tidal Current Power potential, Tidal Energy Areas of Interest, Wave Energy Areas of Interest, Wave Power Potential, Wave Energy Potential
	Shipping and Transportation	Disposal at sea sites, ferry routes, fishing vessel traffic hours, ferry terminals, government vessel traffic hours, historical shipwrecks, merchant vessel traffic

		hours, passenger and cruise vessel traffic hours, pilotage areas, pilot boarding stations, pleasure craft and yacht vessel traffic hours, research vessel traffic hours, tanker vessel traffic hours, tanker exclusion zone, tug and service vessel traffic hours, tow boat reserves
	Sport Fishing	Anadromous fish, crab, groundfish, prawn and shrimp
	Tenures	Finfish aquaculture, Shellfish aquaculture, commercial and industrial tenures, log handling and storage, residential marine, utilities
	Tourism and Recreation	Anchorages, coastal campsite and kayak use sites, commercial and recreation tenures, environmental tenures, federal protected areas, marinas and coastal facilities, provincial protected areas, recreational boating routes, sea kayak routes, scuba dive site
	Maritime Zones	Contiguous Zone Limit, Territorial Sea limit, Coastal Baselines

Data Gaps

Existing information on the marine environment is dominated by data on geophysical, chemical and biological conditions. Common data gaps are found under the categories of socio-economic data and cultural information. Some examples of socio-economic data relevant to a marine and coastal atlas include: Gross Domestic Product (GDP), population density, population changes, active population and other age groups, urban-rural typology, employment and unemployment by sector. Cultural information can include location of shipwrecks, or history and place names.

DISCUSSION QUESTIONS - RELEVANT AND REQUIRED DATA FOR AN ATLAS

9. What themes are a priority for you in an Atlantic Canada marine atlas and why? Does your organization/department have data to populate these themes?

10. Are you aware of data gaps that might impact the utility of an Atlantic Canada marine atlas?

Data Access and Availability in Atlantic Canada

- ✓ Many government departments and organizations collect coastal and marine data in Atlantic Canada; gathering this data will require **significant stakeholder and rightsholder engagement in order to identify available data, determine accessibility**, conduct any formatting or standardization necessary to ensure interoperability and address data ownership considerations.
- ✓ Open data portals and repositories provide access to some relevant data; however, these **open access portals do not reflect the full extent of data holdings** and more targeted engagement is necessary.

There are a multitude of federal, provincial and municipal government departments, Indigenous organizations, non-governmental organizations, research institutions, and private-sector companies that collect coastal and marine data in Atlantic Canada. The types of data being collected and the methods of collecting the data are equally diverse.

The Scotian Shelf: An Atlas of Human Activities (2005) used the following sources of data and information to produce the atlas:

International
- United States National Oceanographic and Atmospheric Administration

Federal
- Natural Resources Canada
- Fisheries and Oceans Canada
- Canadian Hydrographic Service
- Environment Canada
- Canadian Coast Guard
- Canadian Department of Natural Defence
- Department of Justice Canada

Provincial
- Nova Scotia Department of Natural Resources
- New Brunswick Department of Natural Resources and Department of Tourism and Parks

Private Sector
- WorldSat International, Inc.
- Admiralty Ocean Passages for the World
- Eastern Canada Vessel Traffic Services Zone System (ECAREG)
- Canadian Nova Scotia Offshore Petroleum Board
- Atlantic Canada Cruise Association
- Encana Corporation

Other
- Sir Alister Hardy Foundation for Ocean Science
- Joint Rescue Coordination Centre
- Coastal Communities Network

A marine atlas to support a Marine Spatial Planning process for Atlantic Canada will require a mix of spatial and non-spatial data on biological, physical, chemical, social, economic and cultural topics. Gathering this data will require significant stakeholder and rightsholder engagement in order to identify available data, determine accessibility, conduct any formatting or standardization necessary to ensure interoperability and address data ownership considerations.

Data collection and sharing is an important and difficult task because it needs to bring as much of the existing data as possible into the atlas development process, but also fill data gaps across different geographic and thematic areas.

Federal, provincial and municipal open data portals can be used to discover and access relevant data for a marine atlas. For example, Newfoundland and Labrador's Offshore Petroleum Activity Mapping contains geospatial data for Petroleum Wells and Conservation Areas that appear to span several relevant bioregions. Nova Scotia's Open Data Portal contains geospatial information for Ferry Terminals and Aquaculture Employment Data. Open-access repositories have been established for research data such as Scholar's Portal Dataverse and the Federated Research Data Repository (FRDR), but widespread use by academic researchers is still not common. The Canadian Integrated Ocean Observing System (CIOOS) is an online platform that was recently established with the goal of increasing discovery, access and sharing

of ocean data. Additionally, while Indigenous organizations and NGOs across Atlantic Canada are engaged in ocean observing and monitoring activities, this data and information may not be publicly available online and targeted outreach will be necessary to determine the existence of relevant data and the interest and capacity to contribute the data to the atlas.

Thus, in order to collect as much data as possible, multiple data collection approaches should be used from targeted workshops with federal, provincial, and municipal governments, to data collection workshops with industry associations, NGOs and local knowledge holders. Other data collection approaches include participatory mapping sessions and creation of teams of various stakeholders who can help pull together various data sources into a coherent whole.

Recommendations for streamlining the process of data collection include:

- Start in the data-rich areas
- Recognize that not all data has to be collected at once
- Avoid the risk of getting stuck in too much data and information gathering without leaving enough space for addressing actual issues and problems
- Keep the focus on information which is relevant and necessary for the inter-regional MSP questions and issues to be tackled

DISCUSSION QUESTIONS – DATA IN ATLANTIC CANADA

11. Do you hold data, or are you aware of data, that would be useful in the development of a marine atlas for Atlantic Canada? Is the data publicly accessible? Why or why not? What quality considerations are there, if any?
12. What other existing data collecting and sharing initiatives are you aware of and how could these contribute to the development of an Atlantic Canada marine atlas?

Atlas Functionalities

- ✓ Identifying key atlas functionalities requires an **understanding of the decisions being served by the atlas**
- ✓ Atlas functionalities are divided between those for **interacting with the map and those with the data**

The ability of marine and coastal web atlases to support marine planning is achieved through a set of relatively basic to more specialized functions built into the atlas platform. Achieving optimal functionality is a balance between effectiveness and efficiency. This means ensuring the appropriate functions required for decision making are included, while avoiding unnecessary or overly complex functions that only hinder the processing efficiency of the atlas and the user experience. Determining the functionality of an atlas requires understanding the ultimate utility that the atlas will serve.

Core functions of a marine atlas applicable when interacting with the map platform, as well as when interacting with the data, are provided below:[48]

Functionalities when interacting with **the map**

Pan/ zoom function allows navigation between areas of the map, at different scales	**Add or draw points, lines, polygons, and erase** to generate your own spatial plan	**Add data layer** from external shapefile, KML, WMS, REST API, other
Undo/ redo	**Turn on and off layers/ layer transparency**	**Add text** additional textual information
Modify symbology (colour, thickness, point styles, symbol size)	**Identify features tool** - opens an attribute table by clicking on a point, line, or polygon.	**Save/ share map** with users provided with map URL, ensuring the legend and symbology are maintained
Change base map	**Multimedia** such as illustrations, video, photos.	**Edit/ Save layer**
Print maps	**Previous map extent**	**Measuring tool**
Adjust layer order for which layers are in front of others.	**Identify tool** for viewing attribute table for a point, line, or polygon feature	**Zoom to location -** quickly access bookmarked locations on the map

Functionalities when interacting with **the data**

Add buffers of a certain width around data points or polygons	**Download data** from a list of file types: KML, netCDF, shapefiles, png, CSV	**Relevant links** and resources (including guidelines and tutorials)
Scale-factor limit- 'grey out' certain data when user zooms to an area beyond the minimum or maximum scale of that data layer.	**Admin options** for various levels of access for different user types (admin, publisher, read-only)	**Search query** based on attributes, including data type, collection date, or location will help users find the data they need most. – Search for a specific attribute in tables.
Attribute table - users can see the data fields that are contained within the dataset	**Reporting tool** - draw an area of interest to query a series of datasets and databases that returns a report of basic information about that location, including relevant regulations.	**Decision support tools*** that enable users to specify a particular issue; system uses a herring-bone decision tree to return suggested data layers related to issue[49]
Copyright Statement or watermark required by data owners.	**Add/ view metadata** through **Abstract Metadata:** brief overview/ quick snapshot of data. **Discovery metadata**: Moderate detail. **Full Metadata**: Highly detailed information.	**Customizable map legend** when adding data
Mechanism for declaring **accuracy and spatial confidence** of data layer	Mechanism for declaring **data licensing agreements** associated with data layer (CCBY attribution)	Ability to **compare, analyze, and evaluate trade offs** such as using INtegrated Valuation of Ecosystem Services and Tradeoffs (INVEST) is an open-source model used to map and value ecosystems services
* See Figure 1 for additional Decision Support Tool purposes		

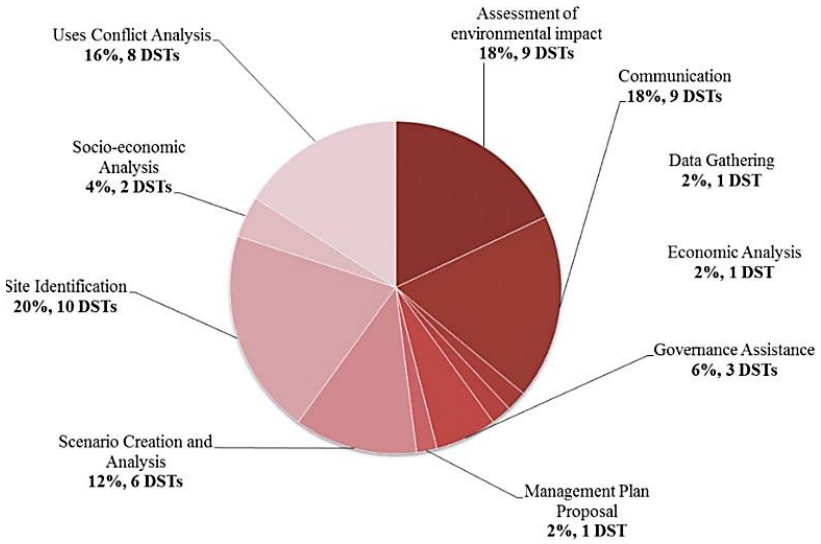

Figure 1. Purpose of use for Decision Support Tools (DST) (percentage and number of the total number of cases) within the Marine Spatial Planning process.[50]

DISCUSSION QUESTIONS - FUNCTIONALITY

13. Are there atlas functionalities not listed above that you would like to see in an Atlantic Canada bioregional atlas? If so, can you provide an example?

14. What functionalities do you consider essential in a marine atlas for advancing the decisions you are required to make? (maps, data layers, visualizations, data products, decision support tools)

Considerations of Scale

- ✓ Marine **atlases need to support planning and decision-making at different scales**: site, bay, subregional, regional and interregional.
- ✓ **Varying scale, completeness, and accuracy across datasets** highlights the need to implement a common practice that enables cross-scale comparisons of the effects of impacts across sectors.[51]

Spatial scale is an important aspect when considering the marine environment, as the oceans exhibit high spatial variability in physical, chemical and biological parameters at a variety of scales including vertical gradients in light levels, horizontal and vertical gradients in temperature and salinity, nutrient concentrations, phytoplankton concentrations and primary productivity, and predator-prey species distributions, and temporal dynamics.[52]

Map scale refers to the reduction between the real world and its graphic representation, usually expressed as a ratio. The larger the second number in the ratio (1:250,000), the less detailed the representation, referred to as small scale. While the opposite, large scale (1:1000), contains much finer detail.[53] The scale at which data are produced can vary, depending on the purpose for which the data were created or what resources were available. Environmental data, for example, are often collected at

local scales, in spatially discontinuous patterns, or gathered via surveys aimed at a limited set of objectives covering only a portion of the region or population of interest.[54]

Depending on the geographic extent of the planning area, a marine atlas may need to support decisions made at different scales from the site-level through to interregional. The variable nature of scale, completeness and accuracy across datasets between and even within departments highlights the need to implement a common practice through which data on the effects of impacts are comparable across scales.[55] Some features are better mapped at a larger scale (close up) and if mapped at a smaller scale – like at the Atlantic Canada-wide scale - there will need to be consideration around how to represent those features. For example, Marine Protected Areas (MPAs) are quite small when viewed at the Atlantic Canada-wide scale but they are important, so consideration needs to be given to the best way to represent this feature. This can be achieved using bright colours and/or labelling to indicate where the features are located, and as users zoom in, the actual polygon that depicts the MPA can be seen.

To achieve transboundary ecological planning, data layers must contain features suitably scaled to the planning region.[56] Stitching jurisdictional maps (1:25,000; 1:100,000) is one solution for amalgamating large-scale datasets to suit small-scale planning areas. In busy marine spaces, marine spatial planning is used to create small-scale networks of multiple use zones or protection.[57] These larger areas are more reflective of species' ranges and can operate as protected corridors or networks in a manner unlike that of smaller protected areas. The mix of large- and small-scale datasets in MSP will provide complementary management in certain areas.[58] Additional scale considerations relate to the significance of pressures: inputs of nutrients and organic matter from fish farms are a minor pollution source at the interregional scale, while on a local scale it can have dominating impacts on ecosystem functioning.[59]

DISCUSSION QUESTIONS – SCALE

15. What has your experience been with managing/considering scale considerations when aggregating geospatial data?
16. Can you provide an example of a scale consideration that would arise in the context of decision making using spatial data? How would you suggest this scale factor be managed?

Data Sharing Impediments and Requirements

- ✓ Despite commitments to open data and data sharing initiatives such as marine spatial data infrastructures, **issues with data sharing are common and include:** limited human resources to identify and acquire relevant data, data quality and accuracy and variations in metadata standards.
- ✓ Data **sensitivities can be specific to sectors and require special considerations** and data manipulations.
- ✓ Recommendations for data sharing requirements include**: adopt a common metadata standard**, establish data flows and processes for accessing relevant data, and allocate sufficient time for data collection.

Atlases and data portals often draw on data that is publicly available or 'open-access'. Open data is based on the concept that certain data should be freely available to everyone to use and republish as they wish, without restrictions from copyright, patents or other mechanisms of control.[60] However, despite open

data commitments and data sharing initiatives such as marine spatial data infrastructures, issues with data sharing are common.

Impediments

Some common impediments to data sharing are listed below:[61]

- Data access. The global open data movement is increasing the number of data sets available free of charge, however, some base data such as coastline, bathymetry, digital terrain modeling, and hydrographic chart data can be expensive to acquire. Additionally, access may be difficult due to strategic and commercial factors.
- The broad spectrum of ocean and coastal data holders can make it challenging to learn who owns what. Data acquisition involves personal knowledge, word of mouth and time investment to contact potential data sources.
- Data quality and accuracy. Factors that affect data quality include variations in scale and methods used for collecting data (which can lead to misinterpretation when data are displayed together), who collected the data and whether data validation occurred through an accredited process.
- Searches of different portals may reveal different versions of a data type in varying degrees of completeness or update, with poor documentation.
- Limited data interoperability due to variations in metadata standards and quality. Metadata typically covers the who, what, where, when, why, and how of the data being served. Metadata may not exist for a given dataset and if it does exist, it can be sparse or not in a standard form.
- Data processing. Once obtained, time is required to prepare the data for the atlas. Due to the variety of GIS packages that exist, data comes in various GIS formats and may need to be converted into formats compatible with the format being used by the atlas. Some information may not be readily available in GIS format, which means that a certain amount of data capture and data processing is necessary to transform data from paper or alternative digital formats for inclusion in a GIS framework.
- Human and financial resources. Frequently, data sharing issues arise not through a lack of appreciation for effective data management, but from limited additional capacity, either financial or human, to implement data management practices into the workplace culture. Limited capacity for retroactively applying these practices to data previously collected is also a factor.

Data sharing impediments can be specific to particular sectors. For example, the academic reward system is associated with publication and its impact, and there is a lack of recognition incentive for sharing data. Data-sharing policies with incentives for data-owners such as the provision of Digital Object Identifiers (DOIs), recognition of data owner, and traceability can help overcome this impediment to sharing.[62] Within maritime industry, data is often considered a strictly commercial commodity, exchanged primarily via a fee-based structure. In the absence of a clear and immediate return, the private sector may be reluctant to share data that they have collected at a cost and which may reduce costs for competitors. Additionally, companies may fear potential liability issues from third party use of their data and may be hesitant to share data which could be used against them (e.g. to show environmental impacts of their activities).

Requirements

General recommendations for data sharing include:[63]

- Adopt standards to enable data sharing, including metadata and technology.
- Allocate sufficient time for data collection as data sharing between institutions, provinces and countries requires trust and building trust is a time-consuming process requiring continuity of institutions and also continuity within institutions.
- Focus on not only what to share, but how to share it. Establish data flows and mechanisms for tapping suitable data, as well as for developing a common framework for the type of data to be collected.
- Broadly supported transboundary working groups are essential. Specific to a data theme, a dedicated group of marine planners and data experts can be useful in working towards a mechanism for data sharing and access.
- Build on existing transboundary organisations.
- Strengthen and support regional data infrastructure for MSP.
- Develop an update strategy in order to keep the atlas current, particularly with datasets that change often. If the datasets cannot be updated regularly, the publication date of the displayed dataset and the update frequency should be prominently displayed in the metadata.

Disclaimers

Data quality issues and ownership are often addressed through Disclaimers associated with web atlases. These disclaimers require the user to tick a box or click 'accept' to indicate that they have read and agree to abide by the terms and conditions outlined in the Disclaimer. These Disclaimers typically absolve the atlas provider from responsibility associated with data quality issues (errors, omissions, misleading information), encourage users to consult the metadata for specific information about data layers (limitations and data manipulations), include Data Use Agreements, and information about proper Data Citation and Copyright. Disclaimers are also used to indicate that atlases or portals are in the process of being updated. For example, the European MSP platform currently notes, **"**The Commission is in the process of updating some of the content on this website in light of the withdrawal of the United Kingdom from the European Union. If the site contains content that does not yet reflect the withdrawal of the United Kingdom, it is unintentional and will be addressed."

Data Sensitivity Issues

Data sensitivity considerations can also be an impediment to data sharing and include the following:[64]

- Data ownership. There may be a need to gain explicit written agreement as to whether data can be made available to third parties and what format this should take (raw data, processed GIS, PDF/paper copies only); for what purpose(s) the data can be used; whether permission to use data should be time-limited. This requires consideration of data ownership, intellectual property rights and copyright. For example, to honor the intellectual property rights of data contributors, the Digital Atlas of the North Sea represents geospatial data not in the form of "raw data" but as distribution maps. Data can be displayed in full or in part, with options to remove sensitive or commercial data within the data table.
- Collection granulation. The level of detail the data are collected at has the potential to affect a stakeholder's willingness to share information. For example, fishers may be willing to reveal the general location of important fishing areas but may be hesitant to share exact locations due to commercial sensitivity. For sensitive point data, locations can be generalised by drawing buffer zones around study areas. Modifications can also be made to reduce spatial data quality. For example, the resolution of vector or raster data can be altered using a GIS system so that the level of detail is

reduced. Another way to protect sensitive data is to indicate that there is something of importance within a buffer zone, but not indicate the exact contents. If the scientific or similar community needs access to more accurate information, then that can be provided based on suitable guarantees.

- Collection purpose. Data sets may be collected under a number of assumptions or caveats that were considered acceptable for the purpose for which the data were collected, however, this may render the data unsuitable for re-use (ethically and accuracy).

Data sensitivity issues can be specific to sectors; sensitivities associated with fisheries catch and effort and Traditional Ecological Knowledge (TEK) are explored below.

Private Sector - Fisheries Data

Fisheries catch and effort and Vessel Monitoring System (VMS) data are considered personal information for self-enterprise fishers and are considered sensitive, proprietary information for commercial fishers. DFO is not permitted to disclose information or data products that might reveal personal or third-party information without the consent of the individual or enterprise to whom it relates, except in limited and specific circumstances. To protect against this, fisheries activity maps and other spatial data products intended for public distribution follow the "Rule of Five." That is, spatial data products made available to external interests cannot reveal any information where there are less than five different licence holders, licences, or vessels in any one geographic area during any of the timeframes displayed. For cases where there is a risk of not meeting the Rule of Five, data aggregation and quantitative data classification approaches can be used to address the problem.[65]

Indigenous Organizations and First Nation Governments – Traditional Ecological Knowledge

There is no one definition of Traditional Ecological Knowledge (TEK) but Mailhot[66] provides the following: "TEK is the sum of the data and ideas acquired by a human group on its environment as a result of the groups' use and occupation of a region over many generations." TEK is a complex field, and there are a number of considerations when mapping this diverse body of knowledge. An example of such a mapping process is Imappivut, a plan to manage and protect Labrador Inuit interests in the coastal and marine areas of Labrador. An aspect of this process is the gathering of knowledge about areas, uses, and activities that have ecological, social, cultural, and economic importance to Labrador Inuit. This knowledge will inform the development of a marine plan that represents Labrador Inuit interests and priorities.[67] Additionally, the National Indigenous Fisheries Institute has published a report that provides guidance on how to assess Indigenous technical capacity to participate in marine spatial planning.[68]

Key considerations when working with TEK include:[69]

- Knowledge is power, and TEK-holders may be reluctant to share information if doing so means they will lose control over how it is used and interpreted. Concerns over intellectual property rights as well as ethical issues regarding how knowledge-holders are involved (e.g. seeking their permission, offering compensation, level of involvement) provide additional complexities. Obtaining permission from individuals and/or collectives and the negotiation and creation of formal research agreements is vital as is establishing intellectual property rights, research protocols and the ethics of traditional knowledge.
- TEK is about much more than just biological or environmental data – it also includes values and rules for life and livelihood. This meaning can be lost if it is separated from those who hold it and the context

within which it was developed. This means that it is neither appropriate nor ethical for scientists and managers to just extract pieces of TEK to plug data gaps.

- Governments tend to conduct single-species fisheries management, whereas the scale of TEK tends to be at the population or stock level. There may also be professional barriers to inclusion of TEK by scientists or managers whose performance and credibility are measured by adherence to Western scientific methods and management approaches.
- Knowledge which cannot be expressed quantitatively can be ignored. Qualitative data such as observations of the presence or relative numbers of particular fish species, changes in environmental conditions and locations of fishing areas do not readily fit into current stock assessment models.

DISCUSSION QUESTIONS – DATA SHARING IMPEDIMENTS AND REQUIREMENTS

17. What data ownership considerations does your organization/department commonly encounter and how are they managed?

18. How should sensitive data be considered in marine spatial planning?

Conclusions and Recommendations

While this Discussion Paper has focussed on factors that need to be considered in the development of a marine atlas for Atlantic Canada, this process must be informed by the larger objectives of marine spatial planning (MSP); the 'purpose' of the marine atlas and the data that populates it should be driven by user needs and sound policy and institutional frameworks. Properly engaging stakeholders in MSP is key to its acceptance and adoption, and effective MSP requires adequate understanding of the complexity of both biophysical and human dimensions, along with spatial information on such dimensions. Accurately reflecting the complexity of socio-spatial relationships in a planning area, together with understanding stakeholder practices, expectations and current and future interests is fundamental to balance economic, social, and environmental objectives in MSP, and to reduce conflicts among coastal and ocean users.[70]

Technological advances in GIS have helped resolve some of the unique challenges with mapping marine regions and presenting the corresponding data and information, which include the highly mobile characteristics of the aquatic environment and the need to portray interrelationships between coastal, nearshore and offshore zones. Adopting best data practices (including standard terminologies) and a common metadata standard are also important requirements for the development of an online marine atlas. Where some of the most significant challenges lie in the process of developing a marine atlas for Atlantic Canada is obtaining buy-in from stakeholder agencies/organizations and the willingness and capacity of these stakeholders to share and contribute data freely.

Climate change presents an additional overarching and evolving challenge to atlases in their support of MSP. Climate-related drivers of change, such as ocean warming, acidification and sea level rise, are altering present ocean conditions and leading to a redistribution of marine ecosystem goods and services. In turn, ocean uses that rely on those services, such as fisheries and aquaculture, will undergo change, with potential for new use conflicts and increased cumulative environmental impacts[71]. Planning for a

changing ocean will require flexible and adaptive approaches which will allow better preparedness, improved response capacity and a reduced vulnerability of marine socio-ecological systems.

In the course of researching this Discussion Paper, a number of 'lessons learned' for the development of online marine atlases have been extracted. These are listed below for consideration.

- Atlases need to be developed with the end users in mind. What does the end user need the atlas for? Decision making? Access to raw data? It is imperative to invest sufficient time at the beginning of an atlas project to designate clear goals and to identify how best to achieve those goals. During the atlas development process, acquire regular user feedback (e.g., hands-on workshops, surveying across user groups).[72]
- As much as possible, the underlying raw data used to produce a product (e.g. a map) should be made available for download so that users may develop their own product which may be more suited for their needs.
- Start simple; focus on priority datasets. Atlases often go through many iterations over time to improve functionality and incorporate new and improved data sets.
- Establish an effective, low-cost mechanism for the sharing, use and management of coastal and marine data between the host institution of the project and all data providers/stakeholders.
- Consider long-term maintenance needs and resources; consider housing the atlas outside of government structures to buffer against changes in political direction and support.
- Provide adequate attention to social data so that people's values and preferences can be well understood, together with the spatial and temporal distribution of human interactions with the environment.
- Consider interoperability with other existing platforms and build on existing efforts where data communities have already organized themselves. Proliferation of platforms can fragment data sharing efforts and lead to confusion for users about where to go for the best information.

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