Arctic Regional Marine Spatial Data Infrastructure (MSDI) Working Group

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Biography

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Abstract

Hydrographic Offices (HOs) have traditionally operated under a product-centric model: creating and maintaining individual, navigational chart products. Of course, these products will remain to support Safety of Navigation (SoN) around the world, but the modern HO is transitioning to a data-centric production environment where a centralized data store can serve any desired output. Consequently, these offices are transforming their original role as a chart provider to a hydrographic data provider. With about 5% of the data housed by the HO ultimately represented on a finished navigational product intended for use by mariners only, these raw hydrographic datasets have an additional potential to contribute to the development of other societal realms (e.g., natural resource exploration, scientific research, fisheries management, emergency management) (Chair of MSDIWG, Denmark). In order to promote this data to the broader user base, the establishment of a Marine Spatial Data Infrastructure (MSDI) is generally accepted as the solution to assist the HO in assisting these new users of HO data.

A MSDI is a framework established at a common level (e.g., national, regional, international) in which people and organizations develop the proper policies/governance to allow marine geospatial data to be released through the harmonization of technical standards and information systems. A MSDI stimulates standardization, management, and interoperability of data to allow its efficient sharing and discoverability across boundaries. Furthermore, it serves as the marine dimension to the broader Spatial Data Infrastructure (SDI) which may include data from various other geospatial authorities.

In October 2016, Member States (MS) of the International Hydrographic Organization (IHO) Arctic Regional Hydrographic Commission (ARHC) established a working group under the ARHC named the Arctic Regional MSDI Working Group (ARMSDIWG). The ARMSDIWG is comprised of HO representatives from the ARHC MS that are working towards the implementation of a MSDI for the Arctic through SDI-related activity monitoring in the region, considering policies and data contributions of Arctic maritime authorities, and by working closely with open standards organizations and related projects including the Open Geospatial Consortium Marine Domain Working Group and the Arctic Spatial Data Infrastructure (Arctic SDI). The Arctic SDI is an organization of the “8 National Mapping Agencies of the Arctic countries” all operating under a Memorandum of Understanding. In its first year of existence, the ARMSDIWG has been coordinating with the Arctic SDI to explore future areas of collaboration to strengthen the overall SDI for the region.

Introduction

Changes in ocean accessibility, due to significant decreases in sea ice extent, has increased scientific and economic interest in the Arctic region, especially for maritime- and marine- related activities (United States Coast Guard 7). Presently, Arctic Sea Routes are very limited in access, but U.S. Navy research predicts that in the not-too-distant future, beyond 2030, major regional waterways will be consistently open and "the Northern Sea Route and Transpolar Route should be navigable 130 days per year, with open water passage up to 75 days per year" while the Northwest Passage becomes more accessible "during the late summer and early fall" (United States Navy 11-12). The combination of emerging strategic interests and increased accessibility heightens the need for data to support new operations and research in the region. The Hydrographic Offices (HOs) of the Arctic nations with territorial waters in the Arctic Ocean are uniquely positioned to support interested users with valuable marine spatial data to enhance Arctic activities and, in turn, gain support, relevance, and reliability from a large user-base to support their Safety of Navigation (SoN) missions.

Each year, HOs and their partner organizations spend a massive amount of time and resources to conduct hydrographic survey and charting operations in support of SoN for their national and international obligations. At a very high level, this translates to millions of dollars in HO operations, to collect large datasets that are ultimately processed to represent only the safest data on a finished product (e.g., an area containing thousands of depths collected in a multibeam bathymetric survey are finished on a navigational chart as a single, shoal sounding for a mariner's use). The full potential of the source dataset is never reached when this data is filtered for the SoN product(s) then archived by the HO and never released to the public. These source datasets, or a derivative thereof, could be leveraged by other sectors of society (e.g., natural resource exploration, scientific research, fisheries management, emergency management).

Modern computing environments are allowing forward-leaning HOs to make an efficient shift from product-centric to data-centric production. A data-centric production environment allows all spatial data to be maintained in a centralized way and be parametrically "pushed" to update existing products and services that are refined for SoN. Because products are no longer being maintained individually, this unified collection of spatial data can provide new and valuable datasets to the aforementioned societal sectors.

While new technologies are already available to improve the HO's constant of providing a safe representation of the sea for the mariner, a daunting transition for the HO is required. In some cases, the HO may have been focused on providing hardcopy (i.e. printed paper) products the same way for literally a century or more. Given the long legacies of some HOs, the transition has generally flowed from creating traditional hardcopy Standard Nautical Charts (SNCs), to only recently (ca. 2000s) producing Electronic Navigational Charts (ENCs) for use in e-Navigation (enhanced navigation by electronic means), to only recently (within the last few years) starting to store all ENC data and its bathymetric source data in common database holdings of the HO for production efficiency. In many cases, cartographic hardcopy products were used as the initial source for ENC which, now amassed in one database, generates inherent scaling, positional, geometric, and existence inconsistences in representations of the same features. For example, a collection of underwater hazards (i.e., rocks, wrecks, and

obstructions) may be represented by area features at a large scale, but by a single point feature at a smaller scale which may have been shifted slightly in order to cartographically accommodate another high priority feature or text that appears in close proximity at that scale. Harmonization of these multiple representations of spatial data in the database requires a massive amount of time spent by analysts, even when reviewing the results of automated conflation processes.

When marine spatial data is finally harmonized in a centralized database, the HO has a very valuable dataset for both SoN and non-SoN users. The problem that still remains is in addressing how the HO can distribute and contribute their marine spatial data in a relevant and shareable way to all users. Establishing a Marine Spatial Data Infrastructure (MSDI) is generally regarded as the solution to this problem.

At the higher level, a Spatial Data Infrastructure (SDI) is defined as "the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data" (GSDI 4). A MSDI is an element of the larger SDI focused on the marine input (i.e. the Marine Spatial Data component) (IHO MSDIWG, "C-17"). In addition to the marine spatial data component, a MSDI consists of policies & governance, information systems, and technical standards working together to promote the availability, accessibility, and interoperability of the data (IHO MSDIWG, "C-17").

The International Hydrographic Organization (IHO) has, within its structure, the MSDI Working Group (MSDIWG). The MSDIWG has many functions, but in particular, it is responsible for monitoring "national, regional, and international SDI activities and trends" and supplying information up to the organizational structure of the IHO to the Inter-Regional Coordination Committee (IRCC) (IHO MSDIWG, "Marine Spatial" 1). As the IRCC is a steering committee for coordination and support of hydrographic activities for IHO Member States (MS) at a regional level (e.g., Baltic Sea, Arctic, East Asia, South West Atlantic, etc.), there have been several multi-national efforts among Regional Hydrographic Commissions (RHCs) to address MSDI for their hydrographic region (IHO "Inter-Regional"; IHO "Regional"). The Arctic Regional Hydrographic Commission (ARHC) established the Arctic Regional Marine Spatial Data Infrastructures Working Group (ARMSDIWG) in October 2016 based on the benefits observed in other RHCs and their MSDI projects or working groups. Today, the Arctic has an active and organized working group of representatives from six nations, currently chaired by the United States. Together, the HOs from Canada, Denmark, Finland, Iceland, Norway, and the United States are coordinating and monitoring SDI and MSDI activities in the region and cooperating with other relevant projects and groups, primarily the "8 National Mapping Agencies of the Arctic countries" all operating under a Memorandum of Understanding within the Arctic Spatial Data Infrastructure (IHO ARHC ARMSDIWG; Arctic SDI 2).

Related Work

Other multi-national groups have been successful in MSDI/SDI-related work and projects. Within the IHO, the Baltic Sea-North Sea MSDIWG (BS-NSMSDIWG) has been one of the longer-standing groups that has combined both MSDI efforts of the Baltic Sea Hydrographic Commission (BSHC) and North Sea Hydrographic Commission (NSHC). Stemming from its BSHC legacy working group in 2012, the BS-NSMSDIWG became such when it incorporated NSHC representatives in 2015 when the NSHC recognized "a need for a coordinated approach for the North Sea area. As several MS are represented

in either IHO MSDIWG or BSHC MSDIWG or both, the Commission concluded that to set up a separate MSDI WG under the NSHC was not expedient. To build on and benefit from the progress of the work done within BSHC would be favorable" (IHO BSHC-NSHC BS-NSMSDIWG, "WG"). The BS-NSMSDIWG monitors SDI/MSDI activities in the Baltic Sea and North Sea regions, considers MSDI policies from several international projects that exist in those regions (e.g. INSPIRE - Infrastructure for spatial information in Europe), and works with the regional maritime authorities, other governing bodies and cooperatives (e.g., HELCOM - Helsinki Commission, VASAB - Vision and Strategies Around the Baltic Sea) (IHO BSHC-NSHC BS-NSMSDIWG, "Workshop No 5").

Another long-standing, regionally organized, MSDI-focused working group within the IHO is the Meso-American and Caribbean Sea Hydrographic Commission (MACHC) Marine Economic Infrastructure Programme (MEIP) (IHO MACHC MEIP, "Terms of Reference"). The idea of the MEIP began in 2011 and was formally established in 2012 by the MACHC (Thorne). The MEIP has leveraged an application within the United States' National Oceanic and Atmospheric Administration (NOAA) Office of Coast Survey (OCS) to openly display ENC (Electronic Navigation Chart) data within one platform for MS from the MACHC participating/contributing in the MEIP (IHO MACHC MEIP, "MACHC ENCOnline"). The main objective of the MEIP is "to support the Spatial Data Infrastructure (SDI) activities of the MACHC" (IHO MACHC MEIP, "Marine Economic").

Scope

The ARMSDIWG was established to be the functional body under the ARHC to promote MSDI in the region. Two other organized groups that the ARMSDIWG would work with to accomplish its key activities is the aforementioned Arctic SDI and the Open Geospatial Consortium (OGC) Marine Domain Working Group (DWG). The major activities that the ARMSDIWG was established to execute:

- Identify and assess the statuses of individual MS MSDI implementation.
- Consider MSDI policies in related international projects and cooperate specifically with the Arctic SDI.
- Analyze how maritime authorities can contribute their spatial information and the necessary updates, so information can easily be collated with other information to a current overall picture for the region.
- Focus on how ARHC in the future can benefit from a regional approach.
- Monitor the development of SDI (specifically the Arctic SDI) that could be relevant for the region.
- Monitor the development of relevant and applicable OGC standards and activities through association with the OGC Marine DWG.
- To present a yearly report to the ARHC at their meeting. This report should include a description on the current status, recommendations on how to proceed with the MSDI implementation, and if deemed necessary, an action plan with specified time schedule for future ARMSDI actions (IHO ARHC ARMSDIWG).

In reference to the activities above, working with the Arctic SDI, the ARMSDIWG would seek "areas for collaboration, sharing, and interoperability in order to connect both

topographic and hydrographic data in a larger" and more complete regional infrastructure (IHO ARHC, "Proposal" 3). These two groups would be addressing the policies and governance of data, for at least their respective organized offices/agencies, in order to make Arctic spatial data available to any interested users. The OGC Marine DWG would likely assist in enabling groups like the ARMSDIWG to efficiently address technical initiatives tasked by the ARHC. The OGC Marine DWG has several planned activities, but two of them are to "research the requirements and processes needed to use high resolution bathymetry data for purposes other than safe navigation" and "explore the potential for an interoperability testbed to carry out these research activities and find sponsors and partners" (Hoggarth 5). These two activities have the potential to aid the ARMSDIWG in two of their initiatives: Arctic Voyage Planning Guide, and a Pan-Arctic Bathymetry Database.

The Arctic Voyage Planning Guide was a past project of the ARHC that "established a comprehensive thematic framework for which data and publications are to be included" when planning a voyage in the Arctic (IHO ARHC, "Proposal" 2). The ARMSDIWG could incorporate the themes of the AVPG in to a web-based, geospatial portal to not only link users to the relevant information, but represent it spatially to ultimately assist users using the portal directly for planning, or furthermore, allow them to connect to the web services offered for the AVPG to bring in to their own Geographical Information System (GIS) (IHO ARHC, "Proposal" 2). The following are conceptual examples of how AVPG themes could be portrayed:

- Port point locations with attributed/linked entry procedures
- ENC Cell boundaries with attributed links to acquire
- Hardcopy Chart footprints with attributed links to acquire
- Geographic boundaries linked to publications such as Sailing Directions
- Polygonal sea ice extents
- Locations of HYDROARC Warnings
- Routing geometries (IHO ARHC, "Proposal" 2)

The Pan-Arctic Bathymetry Database was recommended for investigation at the October 2016 ARHC meeting for the ARMSDIWG to execute (IHO ARHC, "Final List of Actions" 3). Perhaps a HO's most valuable data asset is its bathymetric survey data. From full point clouds to lower-resolution bathymetric grids, the collective contributions of bathymetry from the prime hydrographic authorities in the Arctic would likely be a welcomed dataset to support key, non-navigational activities in the region. The term "database" is probably a misnomer in that a better approach with today's technology and broad adoption of open geospatial standards would be a federated view of data where bathymetry is kept by the originator (i.e. the HO) and serviced through the web. This approach makes a lot of sense from a data governance standpoint where each nation volunteering data still maintains control of their data, but simply shares a service in an open and interoperable format. In several instances, this bathymetry is already available to the public, and in other instances, multi-national bathymetry and its derivatives have been interpolated to create a model of the Arctic seabed, like International Bathymetric Chart of the Arctic Ocean (IBCAO). However, the discoverability and accessibility of higher-resolution, individual bathymetric datasets at a regional Arctic level with similarly standardized and delivered formats, in an efficient and formal infrastructure, is not yet achieved.

Conclusion

A MSDI for the Arctic could be of great benefit to the various sectors of society conducting key activities that operate in the marine/maritime environment. The ARMSDIWG is tasked with initiatives by the IHO ARHC to facilitate and monitor MSDI for the region, and in doing so, may regionally address what is arguably the most nebulous and difficult component to control in a MSDI: data policies and governance. With some of the ARMSDIWG projects/initiatives mentioned above, the conglomeration of different national- and even agency-level policies may become clear enough to bring some collective hydrographic data to fruition in a regional infrastructure. Additionally, the work of the ARMSDWIG, in promoting open data, may reveal broad user needs that, in the Arctic, often cross boundaries or exist in international areas. These once traditional, product-centric HOs evolving into data providers are positioned to develop alongside a somewhat broadly-defined and emerging user base in the Arctic that is simultaneously gaining more physical access to the region as the environment changes. Details on user requirements and specific user types will likely be defined in feedback when prompted by data that is discoverable and accessible through the MSDI. Projects like the OGC Arctic Spatial Data Pilot are already helping in defining the stakeholders and their spatial data requirements (OGC). In general, a MSDI developing in the Arctic could be an excellent test case and serve as a best practice for other regions around the world to understand marine data governance, and the technologies and standards that best deliver mass-acceptable marine spatial data.

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