NOTE / TECHNICAL REPORT

Canada's answer to a Marine Spatial Data Infrastructure (MSDI)

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Abstract

How does an organization of over 10,000 public servants manage authoritative marine geospatial data? To address this question, a small team within the Canadian Hydrographic Service of Fisheries and Oceans Canada was tasked to create a workable enterprise solution: A Marine Spatial Data Infrastructure. Implementing the solution involved collaboration with many parties, and adhering to many guiding policies, including Canada's Directive on Open Government. Released in 2014, this directive consolidates the foundation of accountability and transparency of the Government of Canada to towards its Canadian citizens. The Marine Spatial Data Infrastructure within DFO is an infrastructure that promotes interoperability and authoritativeness of data at all levels.

1 Canada's MSDI – purpose and goals

A Marine Spatial Data Infrastructure (MSDI) is a harmonized infrastructure facilitating integration and access to data supported by clear governance, directives, policies, and standards. The International Hydrographic Organization (IHO) has defined a Spatial Data Infrastructure (SDI) to be "the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to spatial data" (Cooper et al., 2010). A MSDI hosts data related to spatial information including the structure of the data and all the interfaces to the systems that disseminate or present the information. The Department of Fisheries and Oceans Canada's (DFO) MSDI provides a department-wide Geographic Information System (GIS) solution for customized, value added and decision-making applications.

Canada is a vast coastal nation with significant marine resources and diverse ecosystems. The Canadian MSDI plays a crucial role in supporting sustainable marine management, conservation efforts, and integration of Indigenous knowledge and science-based data. The main goal of the MSDI is to provide targeted, value-added applications using marine data to support evidence-based analysis, decision making and data dissemination within and outside of the department. The MSDI is a national enterprise GIS approach that facilitates communication channels relevant to deploy applications, as well as bridging scientists with the information technology world.

The Canadian MSDI has four main objectives:
- Enabling data discovery of marine geospatial datasets by being able to visualize and query their location and content
- Ensuring accurate and complete description of the metadata in a standardized format compliant to all applicable standards within the Government of Canada
- Providing data visualization and querying mechanisms
- Populating web application with metadata and data

Land Spatial Data Infrastructures (SDIs) are well established internationally, recognized for linking together users with required land focused data. Marine specific SDIs are a newer concept highlighting specifically marine inputs with datasets focusing on connecting end users to marine geospatial data. The real complexity of the marine environment is multidimension in space, time and parameters measured. For an effective MSDI, the aim was to support and facilitate the access to and representation of 2D, 3D, and 4D information both statically and dynamically.

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Canada's implementation of an MSDI started with establishing a functional skeleton focusing on data interoperability, while delivering value added products supporting decision making. This is done through the four pillars of Canada's MSDI.

2 The four pillars of Canada's MSDI
2.1 Data and metadata
Both data and metadata accessed in MSDI are described using unambiguous language in Canada's two official languages (English and French); where data must be accessible rather than available, authoritative, and accurate; where metadata must be harmonized and maintained by the owner.

2.2 Information systems / technology
The system infrastructure is set up to be flexible enough to support both data and its supporting technology; where the system must be robust, scalable, and sustainable to implement a functional solution.

2.3 Standards
Standards specify the rules for data access, content, and exchange. Standards are used to ensure interoperability and integrability of different datasets.

The Government of Canada is continuously developing and adopting new standards to integrate data/metadata in modern system designs. These efforts are done in alignment with International Standard Organization (ISO), Open Geospatial Consortium (OGC), Canada's Geospatial Data Infrastructure (CGDI) standard groups and follows both International Hydrographic Organization (IHO) and International Maritime Organization (IMO) international maritime directions.

2.4 Policy and Governance
Initiatives such Open Government (OG), Open Data (OD), and Open Science (OS) within the Government of Canada are making government-held information and data more open and accessible. Governance structures have been set up across the federal government to ensure coordination and adherence to relevant policies.

Enabling policies to have been key to accelerating publishing of data in an open and accessible manner.

The Directive on OG dictates information management practices that enable the proactive and ongoing release of government information. The objective of the directive is 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 (GC, 2014b; GC, 2019). The expected results of this directive are that Canadians can find and use Government of Canada information and data to support accountability, to facilitate value-added analysis, to drive socio-economic benefits through reuse, and to support meaningful engagement with their government.

3 MSDI roles and responsibilities
MSDI is important for Canada; Canada is a vast coastal nation with abundant marine resources and diverse ecosystems. Canada's MSDI is working towards a thematic approach which is meant to strategically represent, structure, and preselect relevant data, tools and documents associated with themes of interest to the public and highlight priority areas. Applications are designed to simplify the user experience, improve efficiency, visibility, and discovery in support of decision making for all.

MSDI would not be possible without strong collaboration within DFO, other Government of Canada departments, as well as industry. The Chief Digital Officer Sector (CDOS) is the Information Management and Technology team within DFO and played a crucial role in developing Canada's MSDI. To deliver MSDI in a timely manner, the use of an external contractor was leveraged to complete some of the work. MSDI continues to use an external contractor to help deliver specific aspects of the overall MSDI Program.

CHS MSDI project team's role
- Gather, document, and functionally demonstrate client requirements
- Leverage a close relationship with CDOS for application development and maintenance of the DFO Enterprise GIS infrastructure, as well as internal communications
- Act as a link to Open Government and Open Data
- Provide expertise, training and awareness in data standards and metadata to ISO 19115:2003 HNAP (Harmonized North American Profile) standards
- Participate in International Bodies such as the Arctic Marine Spatial Data Infrastructure Working Group under the Arctic Regional Hydrographic Commission, as well as the IHO MSDI Working Group, to share and learn best practices and to align work internationally

Chief Digital Officer Sector (CDOS) role
- Deliver and maintain DFO's Enterprise GIS infrastructure with associated information technology (IT) services
- Develop and maintain applications for clients using the client's business requirements (documentation and mockup package).
- Publish client data via Open Government, or MSDI, as required, to be used by the application
- Coordinate with CHS MSDI team for client needs

Communications role
- Ensure Government of Canada communication, and web content policies are adhered to on the web pages, applications, and StoryMaps by verifying and enforcing
- Web Content Accessibility Guidelines (WGAC) compliance
- Plain language is being used

- All information is available in both Canadian official languages (French and English)
- Promotion of new applications, web content and data availability

Data owners' role
- Provide application requirements, using a standardized form to document core requirements and functionality, and data desired for contribution to MSDI, and OD
- Create and maintain metadata, complying with the Government of Canada's metadata standard
- Allocation of funds required for the use of consultants during the requirements gathering and application mock-up phase, as well as data storage costs incurred
- Responsible for maintaining data and metadata to current and authoritative state

Consultants' role
- Gather requirements from project sponsors for new application
- Create a functional mock-up of the application
- Validate requirements with the application sponsor (often an iterative practice)

4 Success Stories
MSDI has successfully enabled the creation of over 50 applications available both internally to DFO and available to the public through OG. MSDI enables these applications to be mocked up, tested, developed, and deployed in a timely manner while following publishing and approval processes throughout.

4.1 Internal success story: The CHS Priority Planning Tool
The CHS Priority Planning Tool (CPPT) is a national operational tool to assist in chart and survey planning by modelling analytical processes on spatial data. The CPPT was originally developed before MSDI and the DFO Enterprise GIS Infrastructure in 2014. Once MSDI was fully functional within the department, the CPPT was transferred and redeveloped into what is used now by CHS. The MSDI team helped in porting the old application into a more modern, user-friendly, and compliant application while ensuring standards were met in both web compliancy as well as being bilingual in the data and metadata within the application. "The CPPT was developed on a national scale to be served and to be used by all staff no matter their geomatic skill level, to help highlight gaps in data holdings, as well as plan future survey and charting needs" (Chenier et al., 2023).

4.2 External Public Facing success stories:
The Canadian MSP Atlases were one of the first projects developed through the MSDI program. Marine Spatial Planning (MSP) within DFO is the process of managing Canada's ocean spaces to achieve eco-logical, economic, cultural, and social objectives (DFO, 2023b). The atlases were created as a key component of MSP in Canada, as a comprehensive tool that provides visual and spatial information about the distribution of various marine activities, habitats, and conservation measures in Canada's coastal and marine regions. The way Canada's marine spaces are managed differ from coast to coast to coast; project sponsors requested two atlases to be developed, the Atlantic atlas, and the Pacific atlas (DFO, 2023a). The Atlases group data by themes and give users the ability to add publicly available data that is deemed useful, using the add data widget available directly in the application. The atlas is under ongoing development as DFO continues to gather insights from partners and stakeholders on evolving functionality to meet the needs of all interested parties.

Another external MSDI application is the Bridging Indigenous and Science-Based Knowledge (BIAS-K) Platform. The original intent of the application was for DFO research scientists to use as a database of relevant studies, showing the location of where studies have taken place across Canada (Alexander et al., 2019). The scope changed throughout the project development, to be available to the public as there was a need for all DFO science advisors, researchers, policy analysts, other Government Departments as well as Indigenous organizations. The application makes accessible key information regarding published case studies that seek to integrate and/or include Indigenous and science-based knowledge in coastal-marine research, monitoring, and management in Canada, provided through geographic boundaries to illustrate where Indigenous knowledge and science highlighting the type of work and location that has been done to date (Bridging Indigenous and Science-based Knowledge Web Portal, 2023). Through project sponsor stakeholder engagements, that are still ongoing, this MSDI application has many valuable use cases, including enabling and enhancing collaboration and partnership with Canada's Indigenous communities.

5 Status and next steps
While the Canadian MSDI is thriving with over 50 applications housed on the infrastructure, there are always improvements that can be made. One constraint is access to persistent and ongoing funding with dedicated resources to maintain the infrastructure. While the data owner and project sponsor are responsible for paying for project development with a contractor, the infrastructure and CDOS resources are funded through the MSDI Program. Costs for running the MSDI Program are significant, and stable funding is required for infrastructure maintenance and to keep core capacity flowing.

The road ahead involves continuous development of applications, migration to cloud technologies, publishing datasets and metadata to support the Gov-

ernment of Canada's Directive on OD (GC, 2014a) where OD is described as structured, machine-readable, and freely shared with citizens. The MSDI Project Team remains committed to collaborating with international communities to ensure that Canada's MSDI stays aligned with global standards and practices. There will be a focus on streamlining data publishing, targeting application development to support key Government of Canada priorities in the marine space, and develop internal metrics to help the team objectively measure progress and define success. The MSDI will continue to be used to enable effective management of Canada's ocean spaces by continuing to support to MSP through ongoing development of the Canadian Marine Planning Atlases.

6 Conclusion

As the Canadian MSDI implementation progresses and evolves, its MSDI Project Team of data management and GIS experts, and policy advisors continue to act as liaison between scientists and program managers within DFO and CDOS to ensure all business requirement needs are met along the development and publishing process. MSDI is being used to bridge marine data to scientists internationally in a user-friendly way, while fulfilling its mandated role for supporting sustainable marine management, conservation efforts, and integration of Indigenous knowledge while respecting the Indigenous ownership, control, access, and possessions (OCAP) principles, and science-based data. As MDSI continues maturing, there will be ongoing efforts to collaborate not only within Canada but on an international level.

MSDI is an infrastructure tailored for the collection, management, organization, and dissemination of authoritative, accurate and accessible geospatial data and metadata pertaining to marine and coastal regions. It serves as a critical resource utilized by government agencies, researchers, environmental organizations, indigenous partners, and industries to inform their decisions and policies regarding marine and coastal environments. The Canadian MSDI is crucial in addressing the complex and interconnected challenges facing marine and coastal regions by offering an interoperable infrastructure available internally to DFO as well as to the public.

Acknowledgments

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