Marine Spatial Data Infrastructure: GIS for a Blue Planet

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SUMMARY

Geographic information systems (GIS) have a dramatic impact on how spatial information is used in different domains. Cloud computing is becoming more popular and the proliferation of simple applications are flooding computers, tablets and smart phones.

For organizations the problem comes when trying to share their geographic information. GIS is not a field exclusive to the GIS professional anymore, common people require and use spatial data through the cloud.

Spatial data can grow exponentially and the problem of having a “messy warehouse” is very possible. Spatial Data Infrastructures and the efficient use of databases can be the framework to orderly organize and enable access to authoritative spatial data; a clear example is the multinational Infrastructure for Spatial Information in Europe (INSPIRE) project.

But meanwhile land based SDIs are already developing, a Marine SDI has so far a quite smaller role, not because is less important but because the Marine community is slowly turning into it. The International Hydrographic Organization (IHO) started three years ago a campaign promoting the development of a Marine SDI among its member states; encouraging them to be part of the National SDI. The recently approved new Universal Hydrographic Data Model S-100 opens up a whole new horizon of opportunities for data production and sharing beyond traditional users (the mariner).

This paper discusses considerations in building a Marine SDI, its benefits, some examples and how data can be shared and products created taking advantage of server and cloud technologies as well as the trend to the future.

Key words: GIS, Marine SDI, IHO, Hydrography, S-100, Data Model, INSPIRE.

1. GIS AND ITS RELEVANCE

GIS is evolving to a new whole dimension; 30 years ago the debate was how to model and store data, then around 20 years ago, it was how to do geo-processing with that data and nowadays is how to share it and put it available to everyone.

There are three main levels for data management and analysis: at a local level, in a desktop environment, where GIS specialists utilize and develop many applications, data models and geo-processes to create products and services; at the enterprise level, the data can be shared across the organization (intranet level), and finally the “cloud” concept, where data and services can be put available through the web to the whole world, where everybody can contribute with their own data and create their own maps and put them available on line. In turn, light weight users will consume this data and products through a “simple” web browser, in a mobile device or even become a heavy weight user in a desktop environment. In other words, GIS is becoming a “democratic” asset.

2. GEO DESIGN

Now, for the GIS professionals, analyzing how the world is and planning how it could be (geo-designing our world), are some of their most important tasks. Sketching is the domain and language of this GeoDesign environment. Designers use graphics as a method to visualize the future. GeoDesign considers a number of geographic questions, to describe the world as it is and as it could be. The first one is *"How can we describe geography?"* Most of designers do this in various ways, with layers of data. The second question is *"How does this geography actually operate?"* And here we use models, process models that describe things like seabed erosion or shoreline change or vessel traffic models to predict or describe how it works. Third is, *"How can we alter geography considering all the factors, for example, a suitability map or a capability map?"* And then going on not simply describing the world as it is—this is, these first three questions are largely what you do—but moving on, the world as it could be. *What are the* *scenarios, alternative scenarios, for designing an answer to the program or my desire, sketching out alternatives?* And then, quickly or as part of the process, evaluating the consequences of those changes using GIS information. And then the sixth question, *"How geography should be changed fundamentally?"* This is where people like the governor or coastal authority and their expressing integrated values and policies really come together. Decision-makers do this kind of effort. This sixth step mode originally described by Carl Steinitz at Harvard University and integrated into GIS provides us a rapid adaptive process for creating a more sustainable future.

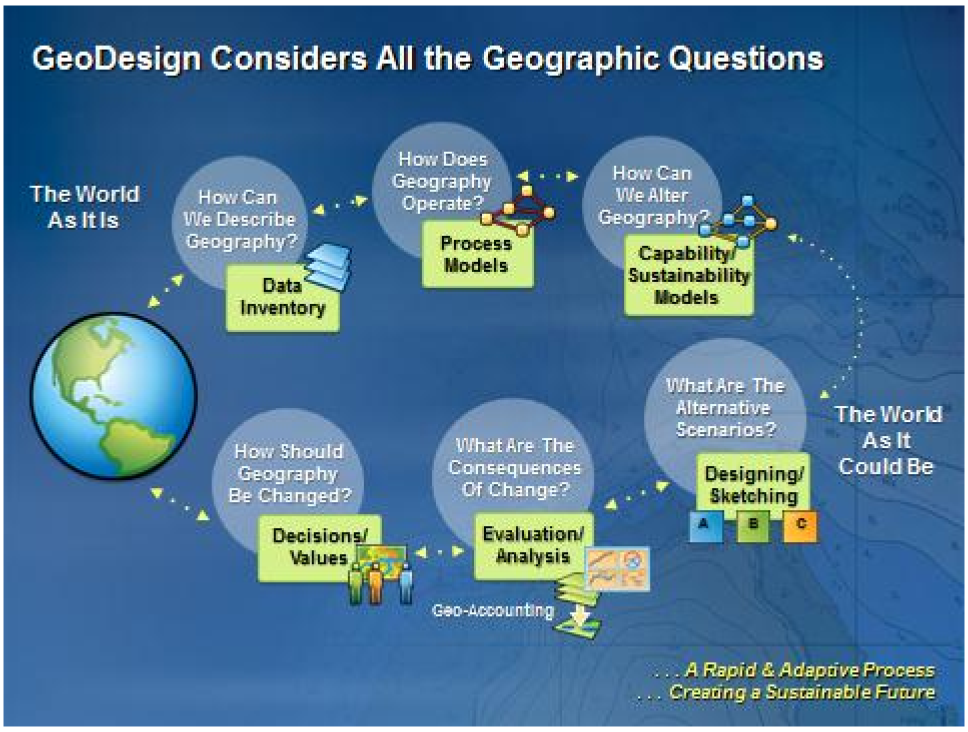

Fig. 1. GeoDesign concept, going beyond describing the world.

3. GEOSPATIAL DATA

But before we go further, let's define what is spatial data (or at least our understanding of it). Spatial data is everything that occupies a place in space, anything that can be physically represented and described and their relationships. Spatial data is stored as coordinates and topology and all their required attributes to describe the real world feature. Spatial data is ideally displayed and manipulated in GIS.

The scientific community generates, uses and requires to share spatial data and sometimes don't take advantage of the latest technologies currently available.

Do not focus too much in justifying the need, but assume this as a fact and move then from needs to solutions to your geo-spatial problems. Gathering data is very costly, time consuming and one of the hardest part of the scientific work. Once collected, you not only require to analyze it, but most likely to share it among your colleagues and even the common people to extract the most of that data. How good is data while seating in a drawer or archived in a digital file in a desktop somewhere? People need data and the possibility to share it today is immense; SDI provides the necessary framework to exploit data in the most efficient way.

GIS supports (almost) any government initiative, is key for planning and decision making, you can target places by priority, develop and coordinate different projects and interconnect them. Marine sanctuaries, coastal zone management, ports, bays, etc. are areas greatly benefited from GIS. There are many examples of successful implementations, and we will see some below.

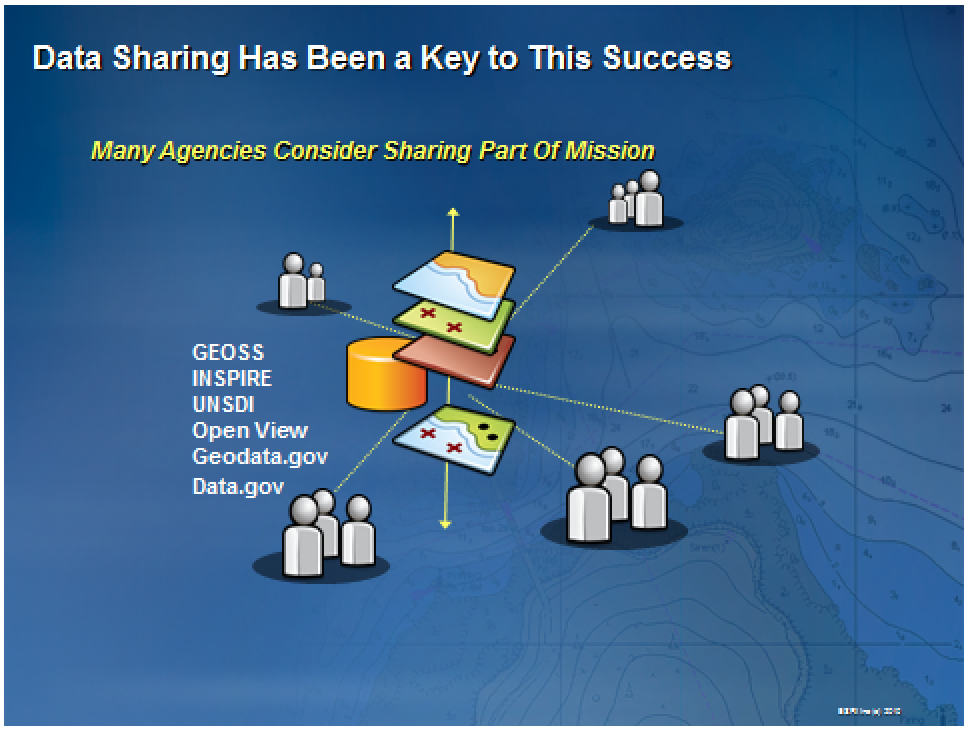

Fig. 2. Geospatial Data sharing.

All these successful projects wouldn't be possible without the willing to share data. Many government agencies and NGOs consider data sharing one of their primary missions. Examples of successful SDIs are GEOSS, INSPIRE, INSDI, Open View; Geodata.gov and Data.gov in the US.

4. SPATIAL DATA INFRASTRUCTURE (SDI)

Now that we have mentioned some examples above, what exactly a Spatial Data Infrastructure is? Based on the Global Spatial Data Infrastructure Cookbook (Global Spatial Data Association, 2008), it is defined as *"the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of and access to saptial data."*

Then we can consider technologies, policies and institutions as key SDI constituents. Technology, together with standards and metadata are the *enablers* of a SDI; an authoritative body would create the *policy* to provide order to data sharing and storage, directly linking the nation's strategy for sharing and exchanging geographic information; people and institutions will establish cooperation among stakeholders through a defined governance structure and transparency in decision making. These enablers facilitate cross-discipline exchange, supporting a large community of users. Published data and products are always backed up by an authoritative agency; there would be different levels of users: from the general public to developers and researchers, each peer could access different datasets and do different actions, perhaps some applications would require a fee, and others wouldn't; that's part of the regulations imposed to the SDI; although the final goal, is always to provide means and data to a large community of users, that's why it greatly relies on web services and the Internet as a platform without which a SDI would be practically non-existent.

4.1 SDI key components

So far, we have discussed what an SDI is and what are its enablers, but once we start thinking on actually building one, we will need some key components to assemble it:

- Spatial data and services: authoritative content that will offer the geographic information and the means to disseminate it through the web.
- Metadata: to describe resources for discovery and use.
- A geoportal: a central access point where producers of data can share their resources and users can search, evaluates and use.

- Web applications: means to manage, publish and store metadata, based on policies, institutions and technologies.
- Social network: to enable collaborations and exchange of experiences among contributors.
- Governance: policies for sharing information and data, interoperability agreements among participating agencies.
- Implementation architecture: how to set up the infrastructure.

Keeping as our design principles the concept of a system with the *flexibility* to meet new business needs and *interoperable* between the SDI contributors.

5. MARINE SPATIAL DATA INFRASTRUCTURE (MSDI)

SDIs cover many different themes and scales, from worldwide coverage to national and regional coverage. In this paper, we discuss an SDI in the marine context, regardless of scale. So let’s start with its definition:

“MSDI is the component of an SDI that encompasses marine geographic and business information in its widest sense. This would typically include seabed topography (bathymetry), geology, marine infrastructure (e.g. wrecks, offshore installations, pipelines and cables), administrative and legal boundaries, and areas of conservation, marine habitats and oceanography.” (IHO Pub. C-17, Spatial Data Infrastructures “The Marine Dimension”. Guidance for Hydrographic Offices. Ed. 1.1 February 2011).

Beside the enablers and key constituents common to any SDI, a marine one would require marine data stored and organized so that the marine community (“in its widest sense”) can share and consume.

Marine SDI or MSDI is a relatively new concept for a large piece of the hydrographic and oceanographic communities. These two communities are key in providing authoritative ocean’s data and the sooner they jump into the MSDI wagon the better.

5.1 IHO and MSDI

The International Hydrographic Organization (IHO) started not long ago, a campaign towards encouraging its member states to participate in their national SDIs as a fundamental player in the marine side. In 2008, and as a result of the 17th International Hydrographic Conference held in May 2007, a new working group was formed under the title Marine Spatial Data Infrastructure Working Group (MSDIWG); their objective is to connect the Hydrographic community to National Spatial Data Infrastructures in a clear recognition that hydrography should be one of the main authoritative contributors. In order to provide its member states with comprehensive guidelines and to establish the role of national hydrographic authorities in MSDIs, the MSDIWG developed the IHO C-17 publication titled *Spatial Data Infrastructures: “The Marine Dimension” – Guidance for Hydrographic Offices*, which 2nd edition was endorsed by the Hydrographic Services and Standards Committee (HSSC) in October 2010.

While among the oceanographic community, data sharing hasn’t been that difficult, hydrographic data can be “trickier” to share; in one hand the IHO S-57 standard is limited in terms of accessibility by GIS professionals not only because is not common beyond ECDIS applications but because of rigid data encryption policies that ban any effort to incorporate S-57 data into a GIS environment and in the other hand the hydrographic offices (HOs) concerns regarding safety of navigation and misuse of data with the potential of altering navigational products; although there are different ways to ensure “official” data integrity and to allow sharing it with “non-traditional” users, very little has been done regarding the possibility to deliver non-encrypted S-57 data. But this paper will not discuss any hydrographic data sharing policy regarding SDIs and will assume data (beyond S-57) is ready available and focus on its technical and beneficial aspects in a MSDI.

5.2 Building a MSDI

So far, it has been briefly mentioned the main components of a SDI; now let’s focus on the technical matters, such as data, technology, standards and delivery mechanisms of marine data.

Data in a MSDI should address multiple uses. This data should also be arranged referring the real world, in other words, it should include concrete themes, such as infrastructure (piers and port facilities, breakwaters, oil platforms, etc.), terrain elevation (near shore), bathymetry, oceanography (physical, chemical and biological) and meteorology; it should also include other non-physical features, like administrative boundaries cadastral parcels, political boundaries (Territorial Sea, EEZ), among others. All this data should constitute the geographic information that is necessary for optimal use in most GIS; this is defined as “Core data” by the GSDI Cookbook, which also emphasises the risk of non-interoperability of geographic information when produced with different technologies and from different sources. Some interoperability problems could be solved ensuring the GIS technology follows international standards, but other complications may exist when edge matching adjacent datasets, mainly when they have been created for different applications, or when working with vector and raster data types or when exists some overlapping between datasets and same features coming from different sources have different uncertainties (or accuracies).

The concept of the “Core data” aims at sharing the core data sets between users in order to facilitate the development of GIS. Data items are provided by different data providers. Such data providers produce data through their daily businesses in their respective domains. Although there may be many data providers, the data sets they provide must be integrated to develop core data sets. When these core data sets are shared between data users, they don’t have to develop the core data by themselves, and can avoid duplicated efforts of core data development. Consequently, by sharing the cost of developing the core data, data development cost can be minimized and shared between users. But beyond the data creation, a very significant benefit of “core data” comes when updating data; data updates are more frequent than data creation (normally only once).

All data constituting a MSDI should be arranged in databases. These databases contain a collection of geographic datasets of various types (feature classes, raster datasets and tables) that will be used for analysis and production (creating and updating features). Data contained in these databases are organized in a logical way, including both the schema and the rule base for each geographic dataset, plus a tabular storage of the spatial and attribute data. The primary datasets in the database are stored using tables. The spatial representations in geographic datasets are stored as either vector features or rasters. These geometries are stored and managed in attribute columns along with traditional tabular attribute fields. All these tables should be accessible using a Structured Query Language (SQL) for managing data in a relational database management system (RDBMS).

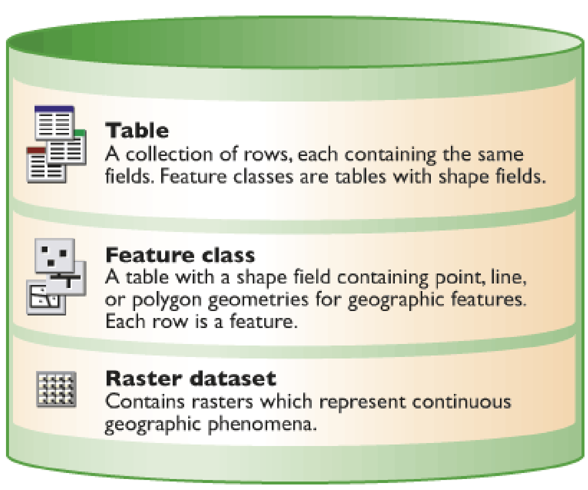

Fig. 3.Esri’s basic Database elements.

5.2.1 Data Models

The logical organization of data varies depending the purpose and nature of data to be managed. It is imperative to rigorously model the data before attempting to implement a GIS database. Data models lie at the heart of GIS, determining the ways in which real world phenomena may best be represented in digital form. A Marine GIS could use several different data models; here you will see a few that would cover some basic marine and coastal purposes.

5.2.2 ArcMarine Data Model

Esri has an object oriented data model framework called “geodatabase”; it is basically a collection of geographic datasets of various types held in a common file system folder, either a Microsoft Access database or a multi-user RDBMS (Oracle, Microsoft SQL Server, PostgresSQL, Informix or IBM DB2).

The ArcMarine data model has been developed to be used in deep ocean and coastal areas, as a starting point to build and leverage marine and coastal community experience and expertise in a broad sense, enabling users with a model that could be used in many different ways.

In the development of ArcMarine, a general framework called “Common Marine Data Types” has been established to include the core feature classes required to represent coastal and marine data, including temporal and spatial dynamic process in a three-dimensional volume (depth). This framework has been designed to be generic and inclusive, leaving its extension and modification to the user.

The Common Marine Data Types are divided into Marine Points (instantaneous and time series points), Marine Lines (profile line, time duration line, feature line and shoreline as a specialized line feature), Marine Areas (feature area and time duration area) and Marine Rasters, Grids and Meshes (regularly interpolated surfaces, irregularly interpolated surfaces and mesh volumes), and finally a derived data type or Placeholder for animations or videos.

ArcMarine contains 10 thematic layers, such as Shorelines, Tracks and Cruises, Time Duration Features, Time Series Locations, Instantaneous Measured Points, Location Series Observations, Survey Transects, Scientific Mesh, Mesh Volumes, Bathymetry and Backscatter.

One application of coastal GIS usage of ArcMarine is for Nearshore and Coastal analysis, particularly for shoreline analysis. The shoreline is a very important linear feature that defines the interface between land and sea, it moves due to the action of meteorological and astronomical influence on sea surface in the form of tides and currents, creating an ocean dynamic and provoking erosion or accretion in the coast; it also marks the different limits for government, judicial responsibilities or research management. The shoreline acts as the baseline to define political boundaries such as the territorial sea and exclusive economic zone and extended continental shelf limits.

ArcMarine can be used in combination with different GIS applications or complementary to other systems.

6. GEOGRAPHIC INFORMATION SYSTEMS FOR SPECIFIC COASTAL APPLICATIONS

Data models and special software tools must be used in connection with systems containing the geoprocessing and analysis capabilities that will transform data into useful information and derived products. The Esri’s Bathymetric Information System and Nautical Information System are two examples of special purpose enterprise GIS implementations for marine and coastal purposes that can be part of a MSDI.

6.1 A Bathymetric Information System

Bathymetric information is at the foundation of any Marine SDI, this data not only tells us the depth but also the seabed morphology, to be used in any Marine GIS requirement. The Esri Bathymetric Information System (BIS) is a commercial off the shelf GIS system for the management and deployment of bathymetric data, products and related information. It includes a specialized data model, published workflows, integration with complementary applications, metadata engine specific to hydrographic content, user interfaces for adding data and creating navigational and non-navigational surfaces. It is all built within a service-oriented architecture and includes a commercially available web application for query and dissemination.

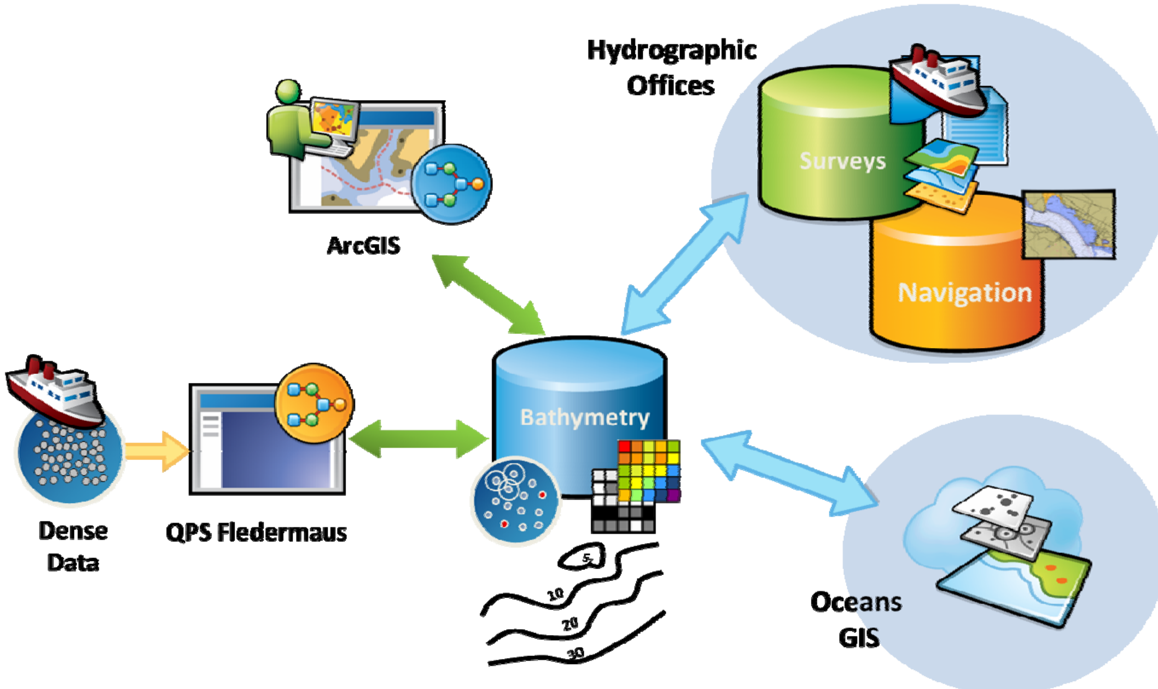

Fig 4. The Esri's Bathymetric Information System concept.

The primary objectives of such a system are to manage large amounts of gridded data such as Bathymetric Attributed Grids (BAG) and post-processed soundings and depths, keeping its important metadata such as the Total Propagated Uncertainty (TPU) and other parameters about the survey, as well as ancillary information (survey area, tidal adjustment reports, sound velocity cast reports, navigation lines, etc.), and the storage and dissemination of bathymetric gridded data. The system is able to communicate in a service-oriented architecture via published feature and map services, integration with other geospatially enabled databases and consuming other data feeds through mash-ups and crowd sourcing.

The architectural sections of the end-to-end data flow are connected together by database server, desktop workstation and web based tiers of technology. Database server components include the physical storage of gridded and vector based data at the relational database and file system level. They can also host the communication channels between existing file-based systems and geodatabases such as Fledermaus and the BIS respectively. Spatial analysis and modeling can also be performed on the database server, effectively allowing non-GIS users to access information and perform geospatial information processing from thin or thick clients. Web services, discussed later, allow for the dissemination and deployment of content for consumption by the application and web technology tiers.

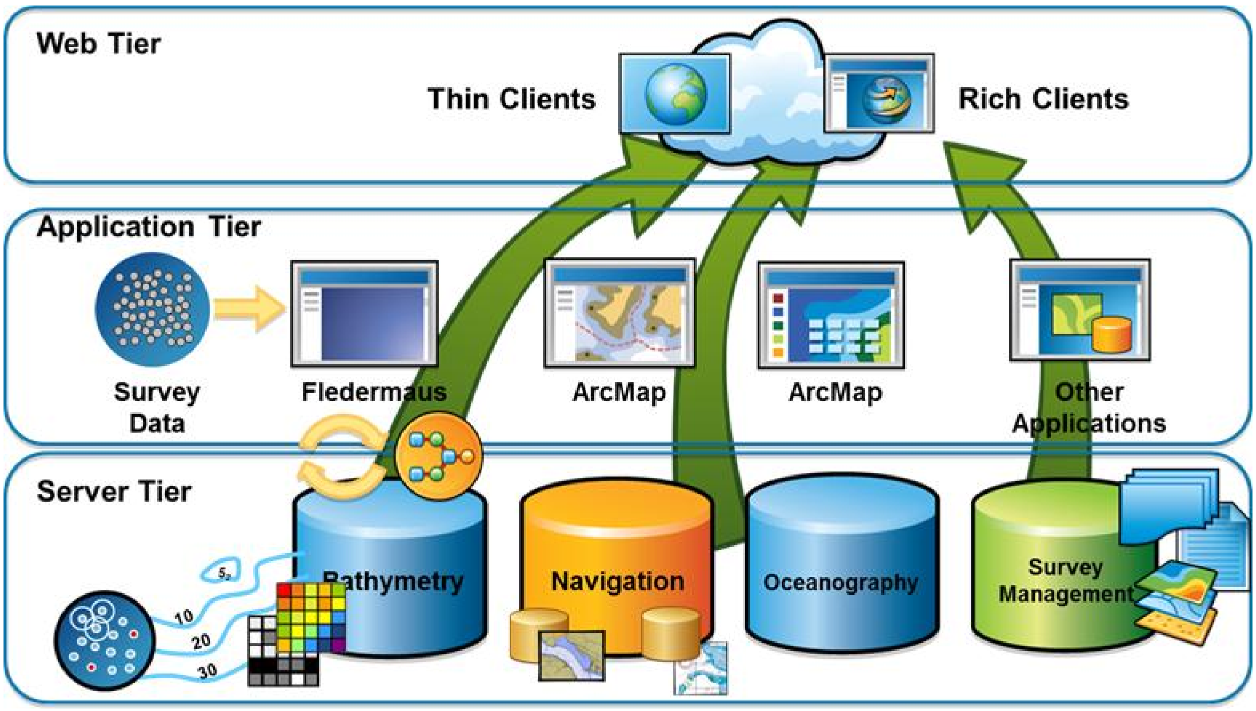

Figure 5. Three tiers of a Marine GIS in a MSDI context.

The client application tier is responsible for interacting with the data, metadata, server side and cloud computing. A variety of GIS applications can sit on this layer, with some adaptations made for the specific needs of the bathymetry community supporting hydrography, coastal zone management, oceanography and other specific domains. In the Esri BIS, further integration between QPS Fledermaus and the Esri's ArcGIS product suite is being made to incorporate a rich experience for the user in both Fledermaus and Esri applications requiring bathymetric processing, analysis and modeling. It is at this tier that metadata management is a principal focus. Data being ingested into the system is appropriately catalogued and the metadata at both the feature and dataset level are captured and persisted within the BIS through to final output products.

A modern enterprise GIS is fully geared to take advantage of service-oriented architectures and cloud computing. Usually accessed via a web browser, data stored on servers (either remote or local) can be interrogated, have geoprocessing executed and extracted and downloaded to the client for additional processing and/or publication. Utilizing other online content, such as ArcGIS.com basemap and complementary data can be added to the session to create mash-ups, new map products and even new hosted content for others to consume.

These architectural components and technology tiers are pivotal to the BIS and the data that is part of the system. However, a key indicator to the success of this system is demonstrated through the ability to connect to other systems, both spatial and non-spatial, for the support of an infrastructure dedicated to marine and coast spatial planning or MSDI.

6.1.1 Serving Bathymetric Gridded Data

The advent of service-oriented architectures has changed the way content from modern GIS platforms is shared with others. The ability to publish maps, charts, metadata and data from hosted services to the internet, intranet and even local workstations enables consumers of geographic content have more access to GIS than they've ever had before. A user with very little GIS background can create new maps and charts, mash-ups, query data and perform geospatial analysis from a web browser or light weight web application.

A GIS server hosts GIS services. A GIS service represents a GIS resource--such as a map, globe, locator, or geodatabase connection--that is located on the server and is made available to client applications. Services make it easy to share the use of resources across clients. You can be sure that each client has the same view of the resource, and you save resources because the server is storing the resources and the clients don't need to have the GIS software installed. Instead, the server stores the resource, hosts the service, and does the GIS work, sending back a common format of result--such as images or text--to the client. (Childs, 2010)

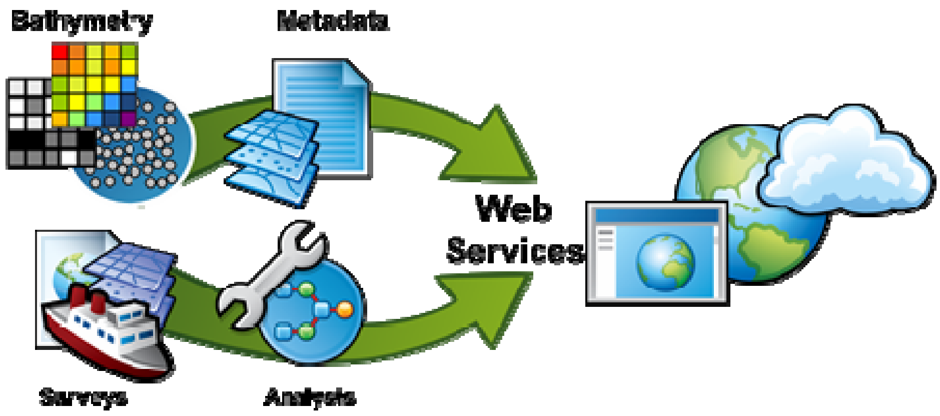

Figure 6. Using the web for image, geoprocessing and feature services.

Map services can publish map and chart content to the web in compliance with many OGC (Open Geospatial Consortium Inc.) standards, allowing for consumption and analysis of the data. Geocoding services provide the ability for a user to get address locator information by typing in a location or clicking on the map to discover the geographic location. Geoprocessing services allow users to access geoprocessing capabilities hosted on a remote server or within a web application. Globe services enable the publishing of three dimensional scenes and surfaces, while image services allow gridded and raster based content to be published and shared with others.

Image services are hosted by Server technology for the optimized distribution of imagery, including raster data, Bathymetric Attributed Grids (BAG) data and mosaic datasets. Any supported raster dataset or raster type can be served as an image service so that it is accessible to a wide range of client and web applications. Client applications define properties such as the extent of the request, projection, and sampling method. When the server receives a request for raster data, it accesses and processes the raster data directly from the source. Client requests can include information on the compression to be used for transmission. Setting a lower compression quality enables users to quickly access raster data over low bandwidth networks (i.e. for navigation purposes) and then set high quality to get raster data for analysis purposes. Image services can return raster data as a picture that can be used as a background for applications or as data values that can be used in analysis. Image services provide a one-to-many relationship between source raster datasets and image services. A single raster dataset can be served in multiple forms. The functionality, if further extended in client applications, can also define additional processing that is performed on the server. (Childs, 2010).

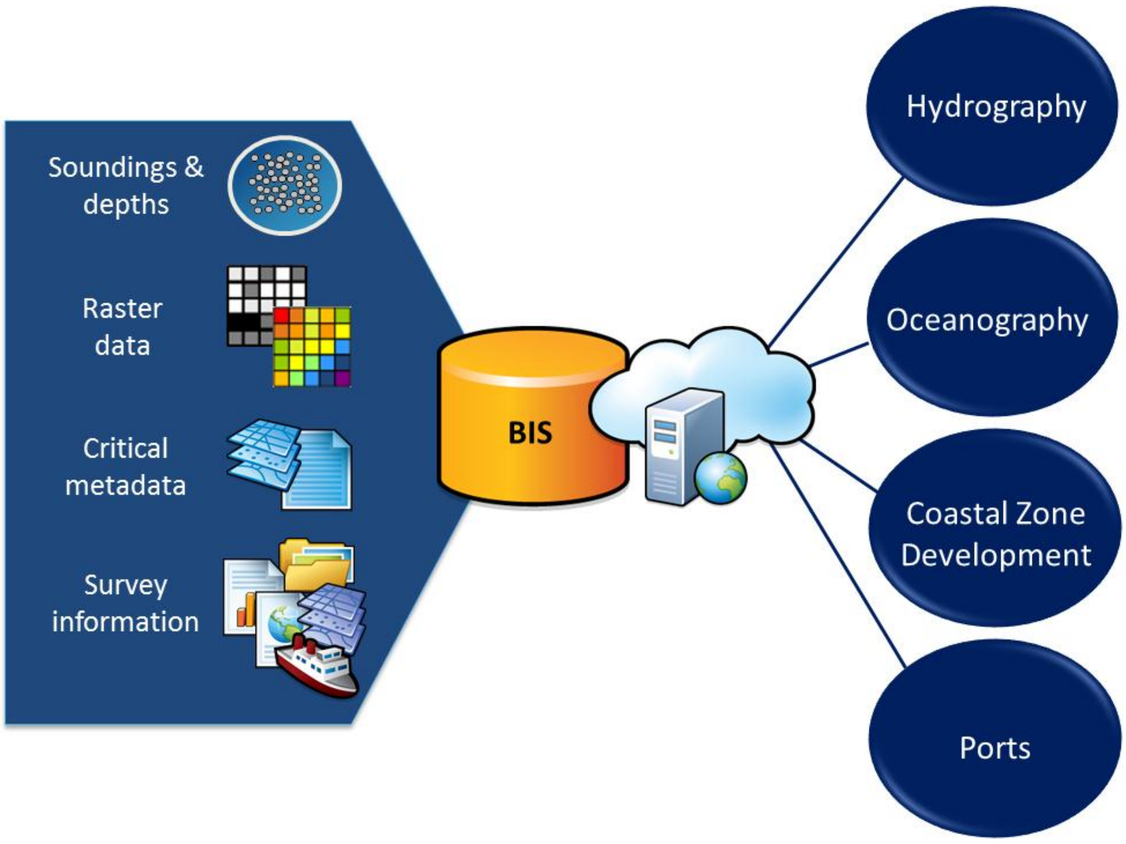

Figure 7. Marine and Coastal usages for the Esri BIS.

6.2 A Nautical Information System

An MSDI wouldn't be complete without nautical information. Although most users of nautical products (navigational charts) are the mariners, this type of information is very important for coastal management. Vessel traffic control systems, and port operations and maintenance, require nautical data for their specific GIS applications. The Esri Nautical Information System (NIS) is an integral component of the enterprise version of the Esri Nautical Solution, a complete system for managing nautical related data, products, workflows and quality.

Similarly to the BIS, the Nautical Information System contains a specialized data model; in this case arranging nautical data based on the IHO S-57 and INT1 standards so the same data can produce paper charts, raster charts and Electronic Navigational Charts (ENC) simultaneously. Because the database is product neutral, the NIS can easily interact and feed other databases as part of a MSDI. So, in an enterprise marine GIS, the BIS would connect to the NIS and feed the appropriate amount of bathymetric data at a specific uncertainty value for the scale required so it can be used for navigational purposes, either chart production or coastal planning, operations and development.

Figure 9. The Esri's Nautical Information System concept.

7. AN OCEAN BASEMAP FOR MARINE AND COASTAL APPLICATIONS

To help connect the marine GIS community, and using the BIS for organizing its bathymetric source data Esri is authoring an ocean map designed to be used as a basemap to support a variety of GIS applications. The Ocean Basemap enriches and improves ocean content that is currently available on Esri's online basemaps. The Ocean Basemap is designed with uniform cartography for consistency, and a muted color palate for the purposes of overlaying additional user-specific content.

The map is being built using a variety of authoritative data. Sources include the General Bathymetric Chart of Oceans (GEBCO) for bathymetry and undersea features names; National Geographic for marine water body names and undersea features names; and DeLorme, and other suppliers for land content.

The Ocean Basemap was released to the public as a cached map service in ArcGIS.com on June 21st. last year. The basemap currently provides global coverage up to 1:577 000 and in US waters up to 1:72 000. The Ocean Basemap is freely available and ready to support a variety of GIS applications for hydrographic, marine science, coastal zone planning, conservation, and oil & gas users among other activities. It can be used in mash-ups with other ocean layers or content, or as a backdrop in web applications; it also helps in showing how marine content could be shared and re-used in the framework of a MSDI.

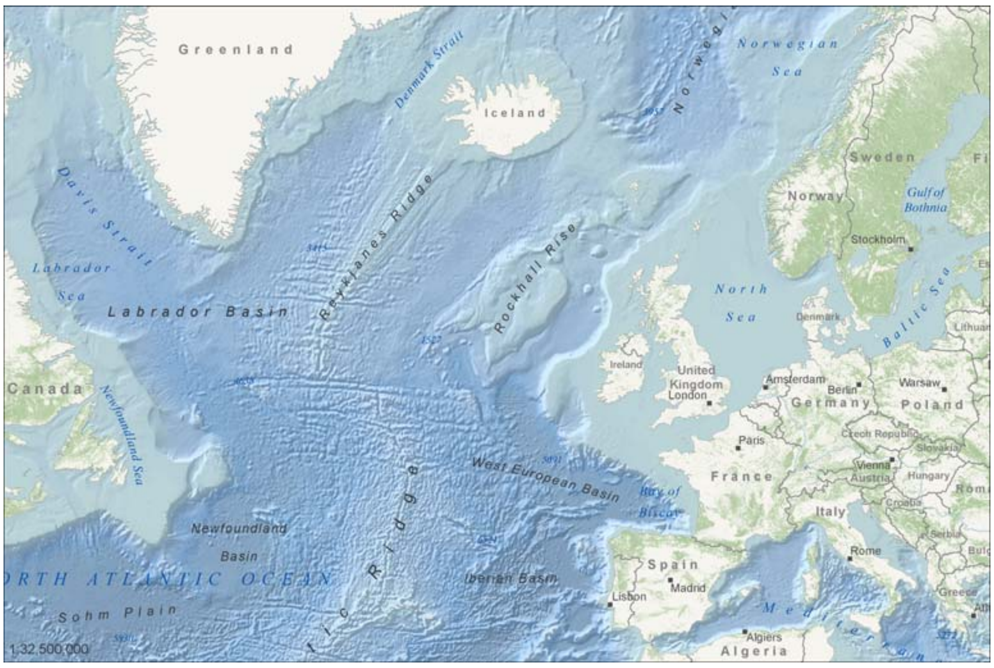

Figure 8. Esri's Ocean Basemap in ArcGIS.com.

8. A GEOPORTAL

Once data has been logically arranged, the RDBMS established and datasets and products produced, a web service to make all this information accessible is required. Something that not only enables discovery and use of geospatial resources but also helps organizations to manage and publish metadata for their geospatial resources to let users discover and connect to those resources, in other words, a geoportal. Esri provides a free, open source geoportal server for this task. Through a geoportal an organization's MSDI provides a central access point where data producers can share their resources, and users discover them. A geoportal not only should be able to serve as a search interface, but a way to connect to and search for geospatial data. There are several groups already having specific directives and customizing their geoportals to meet their needs, such as North American Profile users, INSPIRE and GEOSS.

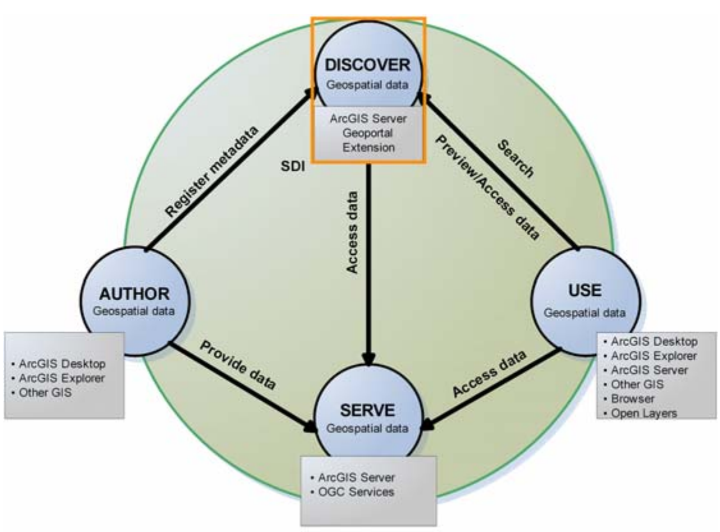

Figure 10. Free Esri's Geoportal for searching and accessing geospatial data.

9. INSPIRE

One of the best and most complete examples of SDIs is INSPIRE (Infrastructure for Spatial Information in the European Community), a European Spatial Data Infrastructure for assisting "in policy-making across boundaries". The INSPIRE directive came into force on May 15 2007, and it is expected that its full implementation will be completed by 2019. This is so far, the largest and most ambitious spatial data infrastructure initiative. Their goal is to enable environmental spatial information between government organizations and facilitate its access to the general public across Europe (http://inspire.jrc.ec.europa.eu/index.cfm/pageid/48). In the directive, the EU establishes its vision for INSPIRE and the requirements framework for development of an INSPIRE-compliant GIS. The directive addresses 34 key spatial data themes organized in three annexes, from which several are marine and coast related, such as Hydrography, Oceanographic geographical features, Sea regions and Elevation (Bathymetry) among others. The rules and requirements pertaining to technology include Metadata, Interoperability of spatial datasets and services, and Network services; and those pertaining to institutional responsibilities are Data sharing, Monitoring and Reporting.

In that context, Esri has developed ArcGIS for INSPIRE, with the required geodatabase templates and applications to provide INSPIRE-compliant GIS solutions at EU Member State level, regional governmental and constituent organization levels, enabling synchronization of independent ArcGIS software-based geospatial information activities with mandated INSPIRE operations. Some of the Esri supported SDIs in Europe include at national level The Republic of Croatia, Lithuania's LGII, Portugal National System for Geographic Information (SNIG), Austrian Umbrella Organization for Geographic Information AGEOportal; at subnational level: Regione Lombardia Italy, Geoportal Saarland Germany, GeoSN Sachsen Germany, Navarra Spain; and some thematic portals: British Geological Survey GeoScience Portal, Geological Survey of Sweden Balance Data Portal, Polish Geological Survey, and Italian Geological Survey Geoportal.

INSPIRE rules and requirements are becoming the "de facto" standard around the world for the development of SDIs and several nations outside the EU are demanding "INSPIRE-compliant" GIS solutions for their national SDIs. This is probably the best indication that the EU is going in the right direction and that if GIS software doesn't comply with these rules and requirements; it probably can't be used in SDIs.

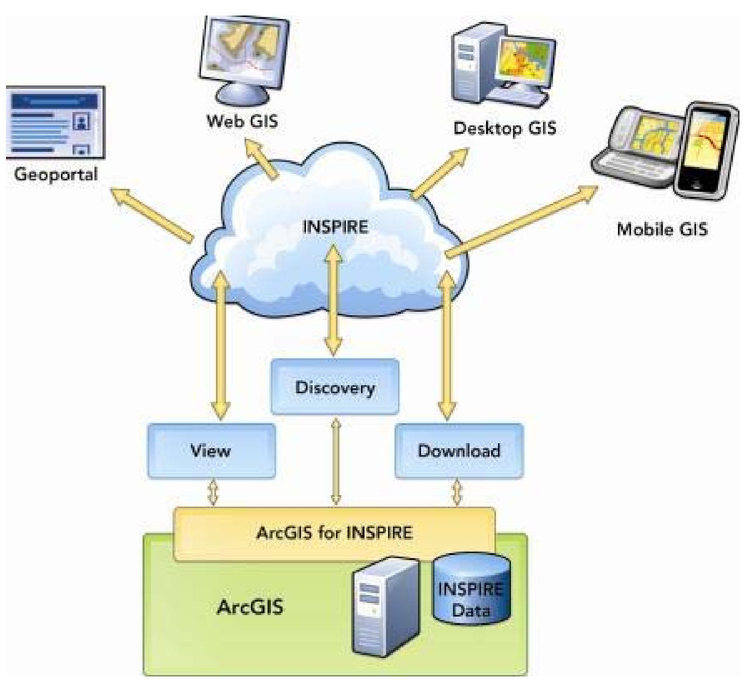

Figure 11. ArcGIS for INSPIRE implements INSPIRE Rules and Technical Guidance for View Services, Download Services, Discovery Services and Metadata.

(http://resources.arcgis.com/content/inspire/1.0/compliance)

10. A MARINE GIS AT THE CORE OF MSDIs

While MSDI establishes how marine data should be created, arranged and shared, its core resides in the GIS. We have seen what a MSDI is in both, a general SDI and in specific applications contexts, how the world can be modelled for planning an decision making, how data can be arranged in a database and the use of different database models, and some application examples for oceanographic, bathymetric and nautical data, and the creation and use of a base map, and how all these data and products can be made accessible to the world. Now it's time to connect the dots. All these databases and information systems can live and work in isolation and independently from each other, pretty much any GIS could do that (in a better or worse way), but the real benefit comes when these systems are able to interact between them even if they are made by different manufacturers (as long as they comply with OGC and other international standards) in order to enable a broad user community with datasets and applications to help them solve their specific problems and achieve their goals.

A MSDI requires a robust GIS, built upon a flexible database or databases, capable of ingesting the most common source data formats re-arranging them in extendable standard-based data models, that provides the tools for geospatial analysis, geodesign and production, enabling this data and information across the organization, outside the organization and to the general public (assuming different levels of usability and data provided). Ideally, multiple special purpose databases should be able to receive data from production systems, store and organize this data, share selected datasets among them, and allow a broad user base to access only what they need, when they need it and as many times as needed, using a geoportal for data search and retrieval, a light weight web application or a rich content web service, or other type of server technology or heavy desktop software to exploit that data.

Interoperability among data producers, flexibility to adapt to practically any specific needs and scalability to grow according to demands of their customer base, are the pillars of any GIS that wants to play its important role in the SDI world.

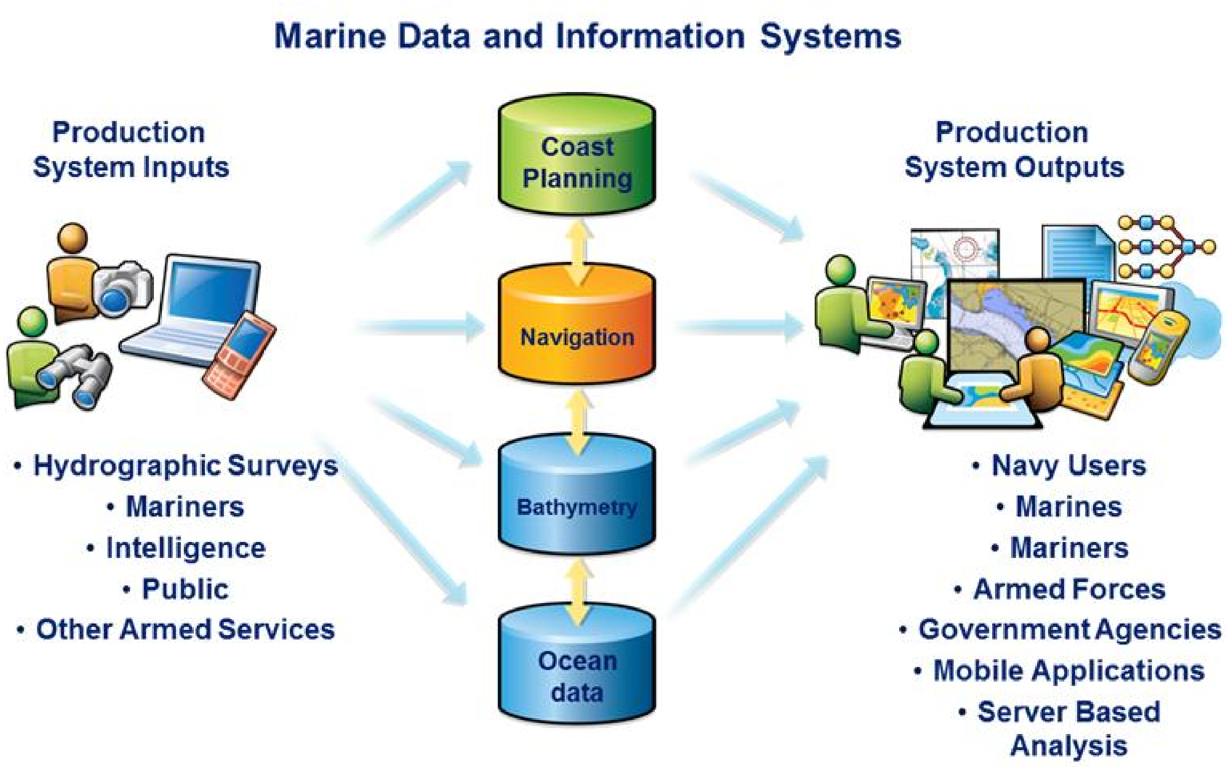

Figure 12. A complete Marine GIS to serve multiple types of users as the core of a MSDI.

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