INTEGRATED OCEAN OBSERVING SYSTEM

Data Management and Communications Concept of Operations

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NOAA IOOS Data Management and Communications Concept of Operations
Signature Page

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Chapter 1
Introduction

The National Oceanic and Atmospheric Administration (NOAA) was designated as the lead federal agency for developing an Integrated Ocean Observing System (IOOS).[1] The NOAA IOOS mission is to:

> lead the integration of ocean, coastal, and Great Lakes observing capabilities, in collaboration with Federal and non-federal partners, to maximize access to data and generation of information products to inform decision making and promote economic, environmental and social benefits to our nation and the world.[2]

NOAA's goal for the IOOS is to "provide continuous data on our open oceans, coastal waters, and Great Lakes in the formats, rates, and scales required by scientists, managers, businesses, governments, and the public to support research and inform decision-making."[3] To realize the goal, the national IOOS has three components:

- Observing subsystem. This subsystem comprises the collection of non-sensor and sensor (remotely sensed and in situ) measurements and their transmission from regional and national backbone platforms.
- Data management and communications (DMAC) subsystem. This subsystem comprises the information technology infrastructure such as national backbone data systems, regional data centers, and data assembly centers (DACs) connected by the Internet and using shared standards and protocols.
- Modeling and analysis subsystem. This subsystem consists of evaluation and forecasting of the state of the marine environment based on assimilated measurements; it also includes decision support.[4]

Each of the subsystems consists of a set of functions, hardware, software, and infrastructures, as well as a variety of entities and programs.

Figure 1-1 shows how the three IOOS subsystems interact to enhance the nation's ability to collect (via the observing subsystem), deliver (via the DMAC subsystem), and use (via the modeling and analysis subsystem) information about the oceans, coastal areas, and Great Lakes.

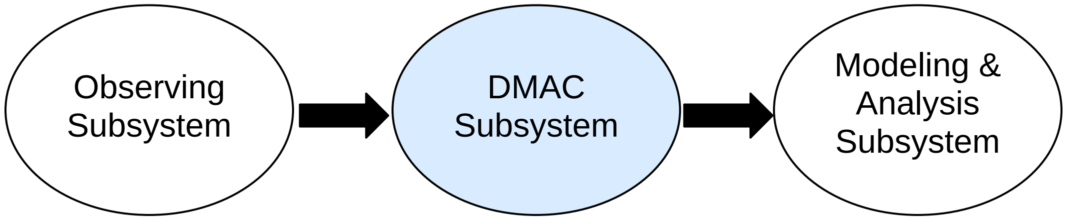
[1] Charter, Interagency Working Group on Ocean Observations (IWGOO), December 2006.

[2] NOAA, National Ocean Service, *NOAA Integrated Ocean Observing System (IOOS) Program: Strategic Plan 2008–2012*, October 2007, page 4.

[3] See http://ioos.noaa.gov/about/.

[4] National Office for Integrated and Sustained Ocean Observations, *The First U.S. Integrated Ocean Observing System (IOOS) Development Plan*, Ocean.US Publication 9, January 2006.

Figure 1-1. IOOS Components



The NOAA IOOS Program and the Interagency Working Group on Ocean Observations (IWGOO) are charged with leading the inter-agency coordination to establish IOOS, is focusing on obtaining a DMAC subsystem (depending on the selected acquisition strategy this may be via integration of existing systems or purchase of varying levels of new technology and development). An efficient and effective DMAC subsystem is crucial because it will provide the services and infrastructure required to link observational data to the modeling, analysis, and decision-support services that will use the data to provide products to support national needs. Other NOAA offices and various federal and nonfederal partners are responsible for continuing and extending their current roles in management of observation and modeling and analysis products and services, including revising or building tools to capitalize on the expanding set of data that IOOS will provide.

PURPOSE

This document describes the initial high-level concept of operations (ConOps) for the DMAC subsystem; it is not intended to be an implementation or transition plan. The focus of the document is to define the functions and services that IOOS stakeholders desire the DMAC to perform. It does not address the technology or architecture of how it will perform those functions and services. NOAA is currently running a pilot project, the Data Integration Framework (DIF), to address some of the DMAC functionality and some of the technology issues.

This ConOps also details the management (methods and procedures) and oversight required to ensure that governance and standards address not only end-user needs, industry regulations, and common practices, but also adherence to national IOOS standards. It documents DMAC's purpose, business need, user expectations (including technical and functional requirements), and roles and responsibilities, and it identifies business impacts such as change management issues.

The intent of this ConOps document is twofold: define the approach of the NOAA IOOS Program to the DMAC subsystem, and socialize the concept with stakeholders in order to collect input for refining the ConOps. In addition, this document contains information that other stakeholders can use to better define and coordinate their own efforts to revise or build observation and modeling and analysis subsystem components of the national IOOS.[5]

[5] This ConOps does not address whether the DMAC will be a single system at a single site or some form of distributed system located at several sites. The specific architecture of the DMAC (e.g. a distributed system) is yet to be determined, but will be addressed as part of the technical analysis. Hence, other stakeholders may also be responsible for contributing components of the national DMAC.

BACKGROUND

The U.S. Commission on Ocean Policy called for the implementation of an integrated ocean observing system to increase our knowledge of the ocean. In response to the commission's report, the Bush Administration's U.S. Ocean Action Plan calls for the integration of U.S. ocean observations into the Global Earth Observing System of Systems (GEOSS). The first IOOS development plan, approved by the Interagency Committee on Ocean Science and Resource Management Integration (ICOSRMI), addresses many of the recommendations of the U.S. Commission on Ocean Policy, including those for establishing an IOOS with an emphasis on regional development, developing the capacity for ecosystem-based management, and linking IOOS data and information to applications.[6]

The U.S. IOOS is a coordinated network of people and technology that work together to generate and disseminate continuous data, information, models, products, and services related to our coastal waters, ecosystems, Great Lakes, and oceans. The oceans are global, dictating that IOOS must address both local coastal and global scales through two interdependent components, a national coastal component and a global ocean component.

The national coastal component of IOOS includes U.S. observations, products, and services provided by federal agencies to monitor and manage the Great Lakes and the entire U.S. coastal ocean environment. The coastal component also includes a network of 11 regional associations that use regional coastal ocean observing systems to obtain data of particular interest to local communities.

The global component leverages a long history of U.S. participation in multinational ocean programs organized through such bodies as the World Meteorological Organization (WMO) and the Intergovernmental Oceanographic Commission (IOC). In this global perspective, IOOS is a coordinator for our nation's ocean contribution to international efforts to comprehensively monitor the Earth and transmit observations globally through GEOSS and the Global Ocean Observing System (GOOS).

Ocean observation, modeling, and research are essential services at the global, national, regional, and local levels to help achieve the following seven societal goals:[7]

- Improve predictions of climate change and weather and their effects on coastal communities and the nation
- Improve the safety and efficiency of maritime operations
- More effectively mitigate the effects of natural hazards
- Improve national and homeland security
- Reduce public health risks

[6] See Note 4.
[7] See Note 4.

- More effectively protect and restore healthy coastal ecosystems
- Enable the sustained use of ocean and coastal resources.

IOOS stakeholders include federal agencies and interagency groups; state, local, and tribal governments; coastal zone managers; regional associations; academic institutions; public-sector data providers, users, and resellers; and other nations and international agencies.[8] For the IOOS to be successful, each of the stakeholders collecting or using ocean data (directly or indirectly) must participate in the development of an efficient and effective end-to-end system. For example, it is critical that the entire community participate with the NOAA IOOS Program to establish common standards to ensure that data obtained by one element of the system are available and usable by a broad range of users. Further, the community must commit resources to ensure that their observation and modeling and analysis efforts align with the ConOps for the national IOOS DMAC subsystem.

Because IOOS is a system of multidisciplinary systems, it is vital that all IOOS stakeholders understand the following key tenets:

- IOOS will integrate existing (legacy) and new observing systems, data, organizations, and products. IOOS will (1) efficiently link environmental observations, data management and communications, data analyses, and models; (2) provide rapid access to multidisciplinary data from many sources; (3) supply data and information required to achieve multiple goals that historically have been the domain of separate agencies, offices, or programs; and (4) involve crosscutting partnerships among federal and state agencies, private-sector entities, and academic institutions.[9]
- IOOS will provide data to modeling systems and modelers. IOOS data will allow modelers to increase the data sets used in models, incorporating new and additional data into algorithms, enabling the development of new models and algorithms, and to increase quality control, comparing data expected data to determine whether data fall within expectations or require additional review.
- IOOS will provide mechanisms for aggregating (and buffering) data streams over useful spans of time and space.[10] Data aggregation is any process in which a data set is generated by joining in some manner data held in more than one data set, possibly in more than one file, possibly at more than one site. In this manner data are replicated, not restructured.[11]

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[8] IOOS also contributes to other programs, including GEOSS.

[9] See Note 4.

[10] The National Office for Integrated and Sustained Ocean Observations, *Data Management and Communications Plan for Research and Operational Integrated Ocean Observing Systems*, (The National Office for Integrated and Sustained Ocean Observations, Ocean.US Publication No. 6), March 2005., Part III, Appendix 2, page 169.

[11] See Note10.

Fully implementing IOOS means not only increasing the number, type, and geographical coverage of observations but also doing the following:

- Collecting data based on meeting a requirement from modeling and analysis systems that deliver products to support societal needs or related research.
- Standardizing data and the associated metadata. Standardization requires consideration of the data format and transmission format, among other things, so that the data can be readily used by all who need it.
- Implementing mechanisms to promote discovery and access to the data and to manage data over time.

DOCUMENT ORGANIZATION

The remainder of this document is organized as follows:

- Chapter 2 summarizes the current approach to IOOS data management and communications, focusing on the current data flow and key concerns and constraints.
- Chapter 3 describes the proposed national-level DMAC subsystem, including its operational environment and its functions and capabilities. It also identifies the major components and their interactions, and it addresses roles and responsibilities in the target DMAC state.
- Chapter 4 explains the impact that DMAC will have on business operations. It also addresses challenges and implications, suggests next steps, and identifies key events, major deliverables, and milestones.

The appendices contain supporting detail.

Chapter 2
Current State

This chapter summarizes the present flow of ocean observation data from its collection through its distribution. It also addresses resources and technology used to support the data flow. The chapter then summarizes key concerns and constraints and then summarizes the IOOS solution. The last section of the chapter identifies other initiatives that may affect IOOS efforts.

OVERVIEW

Currently, thousands of observing systems (including sensor and non-sensor systems that collect physical, biological, chemical, geological, fisheries, social-economic data, etc.) are operating in U.S. waters (with many more planned) including in the oceans, Great Lakes, and in coastal waters. These systems are owned and operated by a variety of federal, regional, state, and tribal agencies; private-sector entities; nongovernmental organizations; and academic organizations. These observing systems and the associated data collection and analyses are typically funded and fielded to support very specific research, tools, and services. Generally, each system functions as an independently owned and operated entity, with the owning organization responsible for the funding stream required to field and maintain the system.

The end users or consumers of the data collected by the legacy observing systems also are a variety of entities, including modeling and analysis organizations, product and service providers, and decision makers. In some cases, the data collecting organization is also the primary data user. In some cases, the data collection is done for a mix of users. Each legacy system is optimized for the needs of a specific subgroup of the broader user community.

Appendix A lists the observing organizations and the systems they use, along with the programs they support and data they collect. Appendix B lists the modeling and analysis organizations and the products and services they provide.[1] For simplicity and clarity in this document, we refer to roles (data collector,[2] modeling and analysis organization, data user) rather than referring to specific organizations.

DATA FLOW

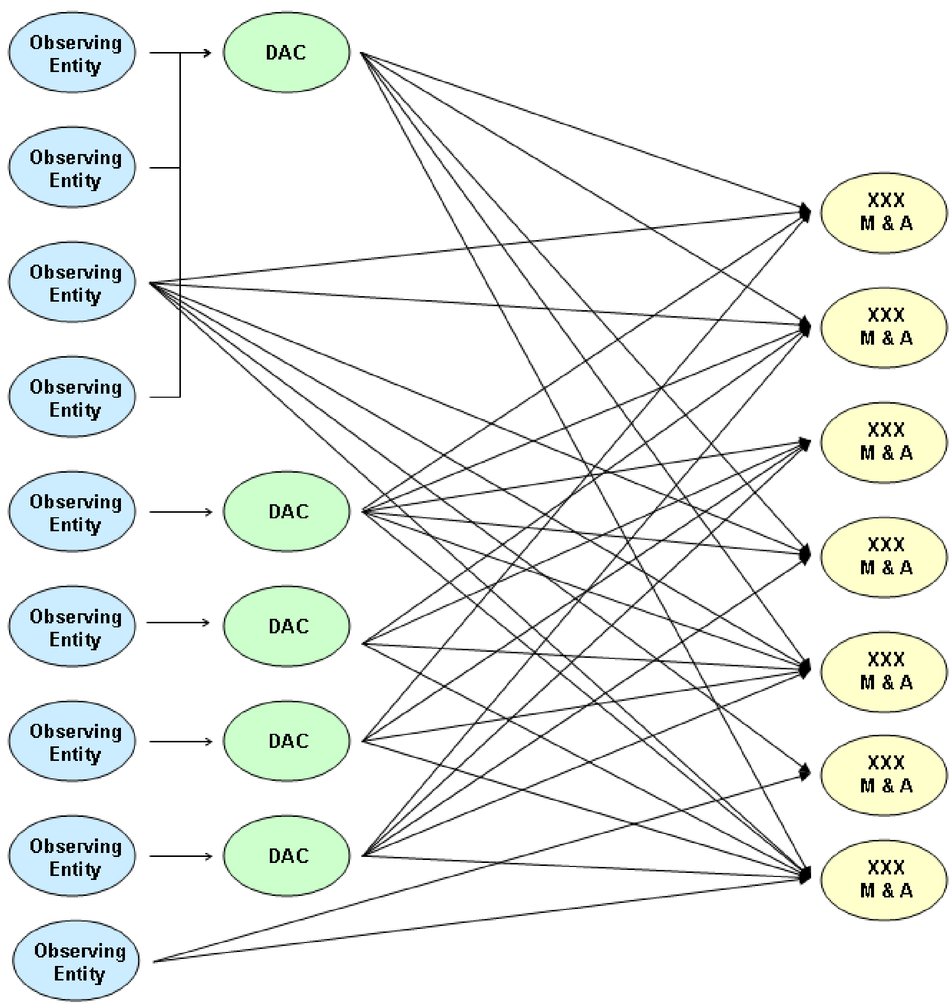
Data collected at the observing systems are, either immediately or over time, typically transmitted to data assembly centers (DACs) and/or are reprocessed, analyzed and reanalyzed throughout their life cycles. Data ranges from real-time observations with only minimal quality control to reprocessed, or long-term, high quality ("climate-quality") data. At the DACs, data from multi-

[1] These appendixes were developed using existing documentation available to the IOOS program office. The lists are not complete. They are also dynamic and require further refinement. Additions, deletions, and comments are welcome and should be included in the feedback to this document.

[2] Data collectors may use sensor or non-sensor data collection methods.

ple sensors are aggregated, undergo quality control (QC), are stored in some repository, and are made accessible to a user group. (It is also common for the data to be made accessible to the public via the Internet, but usually only in the form provided to the primary intended user.) For example, the National Data Buoy Center (NDBC) "serves as a DAC, receiving, quality controlling, and disseminating measurement data" for real-time and near-real-time physical ocean and weather data flows.[3] The NDBC then pushes the data to end users—such as the National Weather Service (NWS)—across various telecommunication networks, primarily the Global Telecommunications System (GTS). In addition, metadata is appended to the raw data and it is posted to the Internet where it is accessible to the public. Figure 2-1 depicts the current data flow.

Figure 2-1. Data Flow from Observing Entities to Modeling and Analysis Entities



Note: M&A = modeling and analysis.

Observing systems that do not collect real-time or near-real-time data may use an alternate consolidated DAC such as the Gulf of Maine Ocean Observing System, instead of the NBDC facility, or they may perform these functions themselves, as in the case of fisheries data that

[3] National Data Buoy Center website, http://www.ndbc.noaa.gov/tour/virtr5.shtml, January 22, 2008.

undergoes continual quality control and editing. In some cases, when the primary data user is also the data collector, DAC functions are unnecessary.

Because existing data flows are tailored to specific rather than general community needs, current ocean and waterway data flows often utilize point-to-point arrangements along with diverse methods and procedures to access data. Therefore, the ability to share data across environments is first dependent on the organization seeking additional data “discovering” the owning organization’s data. Once discovery occurs, the two organizations must come to an agreement as to what, when, and how data will be shared. Often this entails one or both organizations altering the content and format of the data. One or both organizations must also establish or extend tools and services for managing the data exchange, which becomes increasingly complex and expensive.

RESOURCES AND TECHNOLOGY

A variety of technologies are used to collect, transmit, access, store, and process data. The technologies used depend on such factors as maturity of technology, available funding, geography, and requirements. The diversity and age of technologies reduces and, in some cases, prohibits interoperability across the community.

More important than variations in the technology are variations in data content. Those variations are due to variations in when and how data are collected, what measurements are used (e.g., scales), and why (purpose and culture) the data are collected. These variations can dramatically diminish the utility or feasibility of data sharing among different stakeholder communities.[4]

CONCERNS AND CONSTRAINTS

Because of the multiplicity of organizational jurisdictions and user groups associated with the existing systems, the NOAA IOOS Program must negotiate a path that “does no harm” to current mission requirements while moving toward the envisioned end state. This section addresses several data, technical, and organizational and jurisdictional concerns and constraints that contribute to gaps between the current state and realizing the IOOS vision.

Data Issues

With data collected from thousands of observing sensors and non-sensors (automated and manual), representing hundreds of systems, owned and operated to support specific goals and initiatives, little standardization exists across programs, precluding data integration:

- Data are sufficiently interoperable within a given data provider or source, but compatibility is not interoperable across programs or systems due to, for example, the use of different data vocabularies and structures.

[4] Appendix C contains a list of the provisional 20 core variables, as stated in the IOOS Development Plan, page 20.

- The lack of data compatibility can be seen in something as simple as the expression of time or place. For example, data collectors do not always use common time lapses or vocabulary to express time, hampering integration.
- Variables have a variety of protocols, for example currents may be measured as a
  - Pinpoint in time,
  - Trend for an area,
  - Average at a point, or
  - Average at an area.
- Data providers do not provide public with ample documentation (as on a website) on the standards and protocols—transport, vocabularies/taxonomic conventions, data dictionaries—being used.[5]
- Integration of data is further hampered by an absence of metadata. If metadata are available, they are often not located in association with the data themselves and are difficult to find.[6]

Standardization is essential if data are to be easily shared and used across a variety of programs and user communities. The level of communication required to standardize the amount of data IOOS collects requires continual oversight to ensure that standards not only are adhered to but also reflect both the user and collection communities' needs and capabilities. Standardization is required for the following:

- Data discovery. Users do not have a single means to identify, or discover, the data being collected and used by different programs across the nation or the world.
- Data and metadata management. Naming conventions, formatting, definitions, and descriptions are not consistent across observing entities. This lack of consistent standards makes it difficult for modeling and analysis entities to be aware of, locate, extract, translate, and ultimately use data that could enhance or facilitate the development of products and services that would further support societal goals.
- Data transport. Without an integrated data transport system, it becomes increasingly expensive to transform and transmit data. In addition, managing the exchange network itself becomes increasingly complex and expensive.
- Quality control. When two organizations agree to exchange data, it is the responsibility of the sender to ensure the data quality. Therefore, the sender should do thorough QC checks on any data prior to transmission. Equally, in a large data exchange environment, the receiver must also perform QC on incoming data to ensure that the data were not cor-

[5] Data Integration Framework (DIF) Concept of Operations, April 2008, page 7.

[6] NOAA IOOS Office, *Data Integration Framework Concept of Operations*, Draft Version 2.0, December 3, 2007, page 5.

rupted in transit and will not distort analysis. Having common data and data exchange standards will simplify QC and increase interoperability.

- Data archiving. Archiving is essential yet too often, critical (irreplaceable) data have not been submitted to an archive facility. In addition, archived holdings have proven difficult to search and difficult to retrieve because of the historical inconsistencies in format and content and lack of standardization. Application of IOOS community standards in metadata, transport, and discovery to the archive facilities will greatly simplify the submission and retrieval of data needed for long-term assessments and climate change studies.
- Data access. Even when data users can locate and identify useful data, the data owner may lack the tools and procedures to enable the users to retrieve the data in the format or structure they require.

Technical Issues

Successful data integration requires not only data management and standards, but also an interoperable technical approach. The approach must ensure that data are readily available, accessible, and usable across user groups. This means that the data must be valid and in a format that is easily translated into meaningful information for each distinct user group. Further, responsibility for determining, implementing, enforcing, and maintaining a unified technical approach must be both assigned and recognized by all parties involved, regardless of their roles. The following are key technical issues pertinent to developing a fully functional IOOS:

- Data assembly (and QC). Some data collectors perform data assembly functions, others outsource those functions (such as to the NDBC), and still others leave data in the native format in which they are collected. To be useful across user groups, all data must be assembled in some way. This will require defined responsibility as to who will perform, monitor, and enforce that these functions, including QC, are completed; and the physical location where the process will take place.
- Data volume. With an increasing number of sensors being deployed each year, IOOS must manage very large quantities of data. Data management—including how (format), where (physical location), and when (time frame) data will be stored—becomes daunting when the data volumes are large. In addition, large data volumes can pose telecommunication bandwidth challenges that can manifest into data extraction, transport, and translation issues, including long wait times.

- Storage and access architecture. Diverse data users will demand that a consistent set of tools, and means to store, define, and organize data are used to ensure effective access. With the large amount of data traffic to and from observing systems to IOOS users, products, and services, some entity will need to determine, maintain, and monitor consistent storage and access (e.g., reusable models or a web portal). The fact that the data will be shared across national and international users increases the complexity of organizing and using data by location. Currently, there is no oversight into determining whether or how to segregate the data, for example, by
  - project status (research, pre-operational, operational),
  - use (critical operational, noncritical operational, research, other), or
  - age (current, archival).
- Data transport architecture. To ensure that the data are usable across all interested parties, a consistent method of data transport must be used. This will ensure that any component not only can access data of interest but also can access, extract, and translate the data. Today's technological environment offers a variety of tools—web services, service oriented architecture (SoA), and Extensible Markup Language (XML) [7], Open Source Project for a Network Data Access Protocol (OPeNDAP) software network Common Data Form (netCDF) method, etc.—to resolve these issues. However, no authority exists to determine the type of architecture to be used and then to enforce its use across the user communities.
- Security and quality. Although the majority of ocean observation data is publicly available, both the data and the systems that process the data must be protected to ensure accuracy and data integrity as well as to control access to proprietary and business-sensitive data. Further, government regulations mandate that all federal systems and systems that touch those systems must comply with specific security regulations, which might increase the requirements of certain systems within the national IOOS.

Organizational and Jurisdictional Issues

Generally, observing organizations and modeling and analysis organizations, with their largely independent legacy systems and programs, function somewhat autonomously, with little interaction with ancillary users. Because those organizations are fulfilling their legacy missions and serving their own customers, they may not be motivated to consider the effect of their operations upon the broad ocean observation community or social needs.

The following are some key concerns relating to organizational and jurisdictional issues:

- Funding. Regional associations (RA) and other entities receive funding from NOAA and other sources to perform research or fulfill mission requirements. In order for IOOS to be successful, these discrete entities must be directed to guide their efforts to help meet the

[7] Because XML carries a great deal of metadata and definition characters, it considerably exacerbates the issues of bandwidth and high storage costs.

requirements of the global IOOS community. This is a distinct difference from current practices and poses challenges as the RAs move forward without clear direction.

- Without a variable business model for regions to emulate they have no knowledge of how to work towards non-Federal sustainment.

- Without a preliminary design guiding the parallel development across regions, the integration problems is becoming more pronounced (and more expensive to solve) over time.

- Identification and coordination of input and output requirements. Organizations and programs currently typically interact only with an established set of data; they have little interaction with other data (both raw and processed) that may potentially support their missions or with other entities that may be able to use their data. Repurposing of information is difficult without interaction with regional groups, other agencies, other initiatives, and potential end users (many of whom are currently unknown). However, no organizational structure currently exists to facilitate, direct, or foster this type of interaction. However, certain initiatives, like the DIF, are addressing this area. Additionally, continued and enhanced coordination of multiple sub-regional activities will deliver a consistent message and promote IOOS as a truly global community effort.

- Data standards and governance. To share integrated ocean data across a broad community of users, the meaning and structure of each data element must be clear to all. Although data standards exist and are in use for specific programs, they need to be extended, and perhaps refined, for use throughout the IOOS community. The NOAA IOOS Program has recently established community-wide working group, procedures, and IT tools to assist with establishing standards.

Addressing Current Issues

Addressing the concerns and constraints associated with the current state of IOOS operations related to data management and communications requires creating a robust DMAC subsystem that enables the following functions:

- Data transport. DMAC will provide transparent, interoperable access and delivery of measurements and data products from computer applications across the Internet[8] or other communication network.

- Data assembly and quality control. DMAC will verify that all IOOS data adheres to the IOOS standards and to the extent possible can be understood by other users.

[8] IOOS Development Plan, page 28.

- Data access. DMAC will provide tools and support both recurring production transmissions and ad hoc requests for data:
  - Data discovery. The DMAC will provide tools to allow users to identify all of the data within the DMAC repository and to the extent possible other known ocean data collections.[9]
  - Metadata management. DMAC subsystem will include a centralized body which will coordinate and provide oversight of IOOS-wide governances for data definitions and metadata. Quality metadata will support both data discovery and use
  - Data Access
    - Data extraction tools. These tools will primarily be used by operational users on a recurring basis to pull data for use in time-sensitive models and analysis for specific outputs.
    - Online browsing. DMAC will maintain an online portal where data users, primarily members of the general public and registered users, can search, locate, and access data.
    - Modeling. DMAC will store and make available data models and processed modeling data, as requested.
- Data storage. Based on data collected and access needs, DMAC will organize the data to facilitate data discovery.
- Data archiving. DMAC will provide secure, long-term storage or archival capability of raw and processed data either directly or in cooperation with NOAA's existing data archive capability (e.g., NODC, National Oceanographic Data Center).
- Information assurance (IA). DMAC will ensure that IOOS and its data are safe from a wide range of threats, address concerns about proprietary information, and comply with government regulations.
- Support service such as governance, oversight, and coordination. DMAC will support its services to the other IOOS components. Those services include maintaining data standards and governance, establishing service level agreements, and providing general training.

Table 2-1 summarizes the alignment between the current issues and challenges and the functions to be provided by the DMAC subsystem.

[9] For simplicity only and because the technical architecture has not yet been determined, this ConOps describes the national DMAC subsystem as a single system operating at a single location. However, the NOAA IOOS Program recognizes that the national DMAC may be a single system operating in multiple locations, or an interoperable family of system (i.e., a system of systems) operating in multiple locations.

Table 2-1. DMAC Solutions to Current Issues

Issue	Challenge	DMAC function	DMAC solution
Data	Requires verifying data definitions from each observing system	Governance, oversight, and coordination	Data standards will ensure that data definitions do not vary across observing systems.
	Requires assembling data from multiple sources to ensure commonality	Data assembly and quality control	DMAC will perform data assembly functions that will normalize the data before being received by the end user.
	Requires conducting quality control before using the data	Data assembly and quality control	Initial data assembly will be performed on all data before pushing it up to DMAC where it will be available to other end users.
	Requires recognition of output requirements, which are not always acknowledged	Governance, oversight, and coordination	DMAC will provide a mechanism allowing data users and potential data users to request specific data.
	Requires accessing data from each observing system individually	Data access	All data will be available directly through DMAC.
	Requires knowledge of the data of interest: ◆ Whether data are collected ◆ Where data are accessible ◆ What format is used	Data access Governance, oversight, and coordination	DMAC will provide data and metadata searches of data, providing users with a centralized method to search for data of interest.
Technical	Requires knowledge of multiple platforms and formats Requires ability to transform each format ◆ for transport and ◆ for use Requires quality control on all data to ensure translation	Data storage Data transport Data archiving IA	DMAC's data transport function will translate data into the necessary format (e.g., transfer into storage).
	Requires capability and capacity to extract data of interest	Data transport	DMAC's data transport function will enable users to extract data of interest.

Table 2-1. DMAC Solutions to Current Issues

Issue	Challenge	DMAC function	DMAC solution
Organizational/ jurisdictional	Precludes input by prospective data users in collection process or standards (e.g., definitions, formats)	Data access (metadata management)	DMAC will ensure that data standards are established and will perform quality control on data to ensure that standards are followed. DMAC will provide a mechanism allowing users to request specific data.
	Provides little leverage to affect observing system practices Is difficult to direct change without providing funding	Data access (metadata management)	An interagency body will support DMAC by fostering communication between observing entities and modeling, analysis, and decision-support entities

In sum, the DMAC subsystem will be the crucial link required to efficiently and effectively integrate ocean, coastal, and Great Lakes observation data collected by a variety of systems and entities and to share those data amongst all IOOS users. To put it another way, without the DMAC subsystem, the benefits of IOOS—including attaining key societal goals and contributing to the global ocean observing system—cannot be realized. Table 2-2 provides examples of DMAC related products or services that will benefit each of the seven IOOS societal goals.

Table 2-2. Example IOOS Products for Addressing the Seven Societal Goals

Societal goal	DMAC-enabled product or service	Benefit
Weather and climate	More accurate weather forecasts	Plan for coastal construction projects
Maritime operations	More accurate ocean forecasts	Route ships more effectively
Natural hazards	Improved tsunami predictions	Relocate populations before disaster
Homeland security	Improved vessel tracking	Patrol coastal borders
Public health	Forecasting of harmful algal blooms	Prevent human respiratory illness
Ecosystem health	Improved ability to monitor contaminants	Gain better understanding of ecosystems
Living resources	More rapid detection of fluctuations in fish habitat	Reduce risks associated with overfishing

OTHER INITIATIVES

The NOAA IOOS Program's rationale for establishing a national-level DMAC subsystem is not unique to ocean and coastal constituencies. Other environmental programs and communities in federal agencies, state and local governments, and international organizations have recognized similar issues and launched initiatives to address them. These other initiatives are underway today with varying levels of intensity and funding, but will be significant to IOOS in several respects and must be explicitly considered as DMAC planning and implementation proceeds:

- The NOAA IOOS Program and these other initiatives need to build their data systems with a view toward an overarching data framework, such as that proposed in the U.S. Integrated Earth Observing System's Strategic Plan. Collaboration is essential to avoid building divergent and significantly incompatible systems.
- The NOAA IOOS Program can leverage the work of other initiatives which could potentially provide transferable functionality, lessons learned, best practices, industry expertise, existing partnerships, and physical assets. Many needed improvements in data management are blind to the specific environmental parameter being handled. For example, techniques for integrating data on ocean surface temperatures could be very similar to techniques for integrating data on soil moisture (information critical to drought monitoring). Leveraging other work not only will reduce development effort to be borne by the IOOS program, but also will help ensure compatibility among the broader earth observing system enterprise.

A number of initiatives external to NOAA have been identified in IOOS plans, workshop reports, and DMAC Steering Team deliberations. The following list is neither complete nor prioritized, but it does represent the diversity of relevant initiatives underway:

- Ocean Observatories Initiative (OOI)—a National Science Foundation (NSF) effort to provide the U.S. ocean sciences research community with access to the basic infrastructure required to make sustained, long-term, and adaptive measurements in the oceans. http://www.oceanleadership.org/ocean_observing
- Ocean Biogeographical Information System (OBIS)—an evolving strategic alliance of people and organizations sharing a vision to make marine biogeographical data, from all over the world, freely available over the World Wide Web. http://www.iobis.org/
- National Water Quality Monitoring Network (NWQMN)—an interagency collaboration to integrate watershed, coastal waters, and ocean monitoring data, based on common criteria and standards. The network will provide information on water quality that, when interpreted with other information such as economic and land-use data, will provide relevant scientific information to support resource management and decision making. http://acwi.gov/monitoring/network/
- U.S. Integrated Earth Observation System (IEOS)—an interagency initiative whose functions include data collection, data management, data discovery, data transport, data archiving, processing, modeling, and QC. (IOOS is recognized as the ocean component of this initiative.) http://usgeo.gov/
- World Meteorological Organization (WMO) Information System—an international integrated approach to meet the requirements for routine collection and automated dissemination of observed data and products, as well as data discovery, access, and retrieval services for all weather, climate, water, and related data produced in the framework of any WMO program. http://www.wmo.ch/pages/themes/wis/index_en.html

- Intergovernmental Oceanographic Commission International Ocean Data and Information Exchange (IODE)—an international effort to enhance marine research, exploitation, and development by facilitating the exchange of oceanographic data and information between participating member states and by meeting the needs of users for data and information products. http://www.iode.org/

- Joint Commission on Oceanography and Marine Meteorology (JCOMM)—an international commission of WMO and Intergovernmental Oceanographic Commission members that coordinates, regulates, and manages a fully integrated marine observing, data management, and services system that uses state-of-the-art technologies and capabilities. http://www.jcomm.info/

- Open Geospatial Consortium (OGC)—an international industry consortium of companies, government agencies, and universities participating in a consensus process to develop publicly available interface specifications to support interoperable solutions that "geo-enable" the World Wide Web, wireless, and location-based services. http://www.opengeospatial.org/
  Projects of current interest include the following:

  - OpenIOOS—a demonstration portal visualizing the provisional information products produced by the Southeastern University Research Association (SURA) Coastal Ocean Observing and Prediction (SCOOP) program. This interoperability demonstration relies on OGC standards and represents a coastal sciences community effort that includes several federal agencies and dozens of research universities. http://www.openioos.org/

  - OOSTethys—an ocean-science community project using OGC standards to implement an earth-observing "system of systems." OOSTethys partners develop, test, and implement easy-to-use, open-source, OGC-compliant software and have created a working prototype of networked, interoperable, real-time data systems. Their goal is to develop capabilities that will advance and support initiatives such as IOOS, OOI, GEOSS, and others. http://www.oostethys.org/

- Global Change Master Directory (GCMD)—a long-term NASA-sponsored effort to enable discovery and access of Earth science data and services through distributed, integrated information technology systems. The GCMD offers metadata authoring tools, which conform to international standards, to write and directly submit and update metadata records. http://gcmd.nasa.gov/index.html

- Marine Metadata Interoperability Project (MMI)—an NSF funded project to promote collaborative research in the marine science domain by simplifying the incredibly complex world of metadata into specific, straightforward guidance. MMI provides advice and resources to encourage scientists and data managers to apply sound metadata practices from the start of a project. http://marinemetadata.org/

NOAA and the NOAA IOOS program also have several relevant initiatives underway:

- NOAA Enterprise Architecture (EA) program—using industry best practices and government-wide standards (e.g., the Federal Enterprise Architecture Framework). The NOAA EA provides a roadmap for aligning NOAA's IT investments with mission requirements and corporate performance objectives. Developed and maintained in collaboration with all Line Offices, the NOAA EA seeks to maximize collaboration on shared enterprise-wide IT solutions for common business requirements across NOAA, enable and promote reuse of existing IT assets wherever practical, and move NOAA towards a standards-based and service-oriented IT environment.

- NOAA IOOS Data Integration Framework (DIF)—a framework to test NOAA's ability to integrate data in the current environment and to validate that the integration provides a measurable benefit. DIF incorporates seven variables (temperature, salinity, sea level, surface currents, ocean color, wind and waves) and four products (Hurricane Intensity Model, Coastal Inundation Model, Harmful Algal Bloom Model, and Integrated Ecosystem Assessment). http://ioos.noaa.gov/program/products_next.html

- NOAA Global Earth Observing–Integrated Data Environment (GEO-IDE)—a framework that provides effective and efficient integration of NOAA's many quasi-independent systems. Individually, these systems address diverse mandates in areas of resource management, weather forecasting, safe navigation, disaster response, and coastal mapping, among others. NOAA offices will participate in a well-ordered, standards-based data and information infrastructure that will allow users to easily locate, acquire, integrate, and utilize NOAA data and information.

- NOAA Meteorological Assimilation Data Ingest System (MADIS)—a developmental initiative to make data available from NOAA and non-NOAA systems for the purpose of improving weather forecasting. The system will support data assimilation, numerical weather prediction, and other hydrometeorological applications. http://madis.noaa.gov/

- NOAA Physical Oceanographic Real-Time System (PORTS®)—a decision support tool or system that improves the safety and efficiency of maritime commerce and coastal resource management through the integration of real-time environmental observations, forecasts, and other geospatial information. PORTS measures and disseminates observations and predictions of water levels, currents, salinity, and meteorological parameters (e.g., winds, atmospheric pressure, air and water temperatures) that mariners need to navigate safely. http://tidesandcurrents.noaa.gov/ports.html

- NOAA's National Ocean Service (NOS) Data Explorer—a metadata catalog with interactive mapping tools that allow users to locate NOS products throughout the United States and its territories through a metadata catalog. Search results provide users with metadata records and links to websites with additional information. http://oceanservice.noaa.gov/dataexplorer/

Although the initiatives listed above and others, are making strides toward "integration" as noted, not all are yet fully funded or operational. In addition, rather than having a complete

“IOOS” vision, each has a more limited scope, focusing on one functional area, a specific sensor type, or type of data (e.g., real- or near real time data). The scope of each is a reflection of developmental focus and original requirements, and may or may not represent a hurdle to the level of scalability required for a true IOOS.

Chapter 3
Target State

Within the broader IOOS program, the mission of the proposed DMAC subsystem is to manage services, standards, and facilities that integrate ocean, coastal, and Great Lakes observation data collected by a variety of systems and entities. The data collected will enhance modeling and analysis products to better serve the seven societal goals. Accomplishing this mission will require coordination, cooperation, and operations management across a variety of organizations operating at the regional, federal, and international levels. This chapter describes the approach to these activities, that is, the concept of operations for the DMAC subsystem.

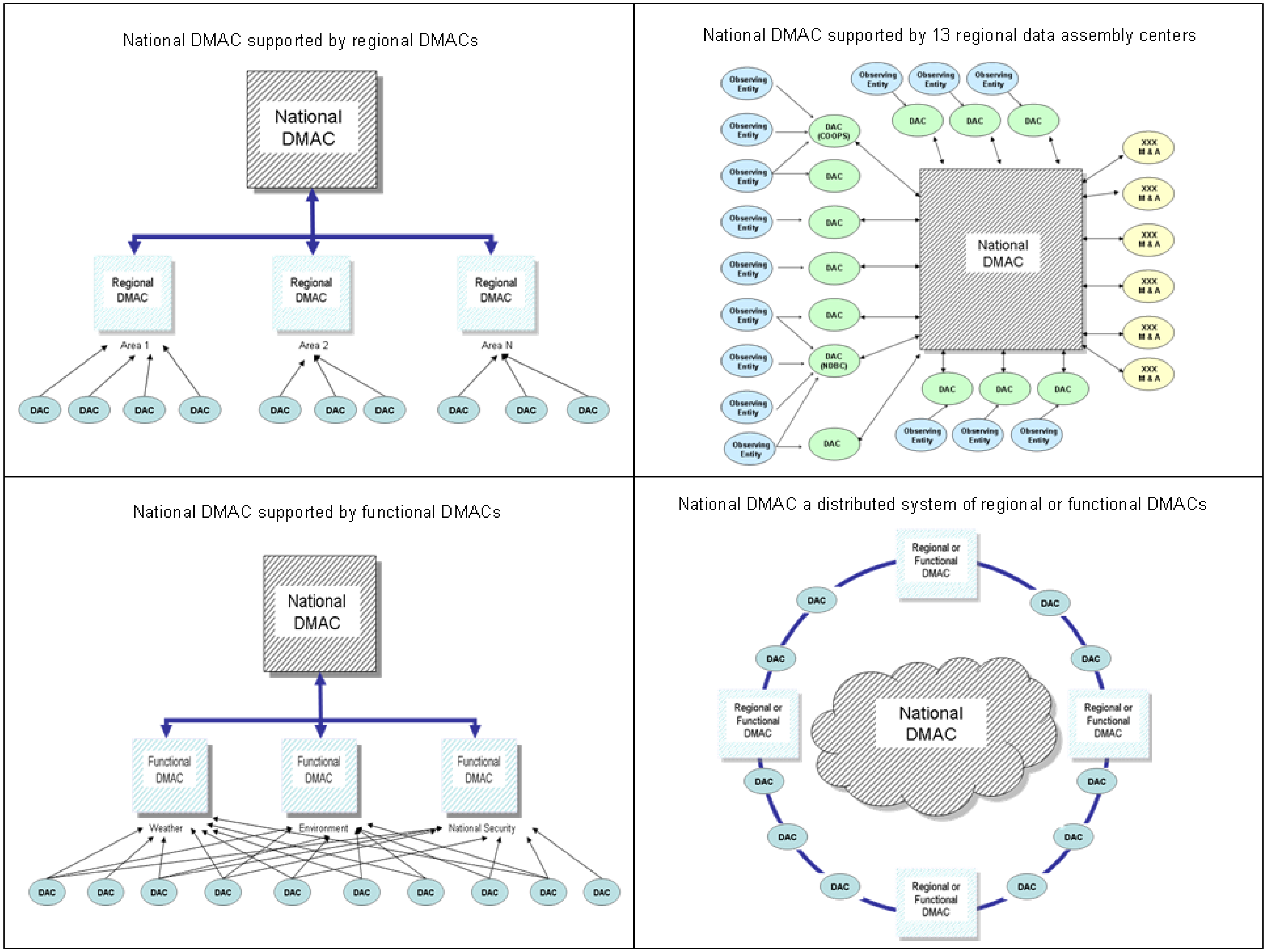
The chapter begins with an overview of the proposed DMAC subsystem. It then describes the DMAC operational environment and the functions and capabilities. Next, the chapter identifies the major DMAC components and their interactions. The final section of the chapter addresses roles and responsibilities in the target DMAC state.

This DMAC ConOps assumes the following:

- DMAC will not require disruption of existing systems at least in its initial implementation. Existing systems may retain present methods and procedures for their users. DMAC can be implemented in parallel with legacy systems.
- IOOS partners will cooperate, sharing collected data, adhering to the agreed-upon standards, and limiting redundancy of operations.
- Adequate funding will be provided to enable development and ongoing maintenance of DMAC.
- Initial data assembly will generally occur at facilities managed by IOOS participants, potentially including observing system operators and regional associations.
- Telecommunications from sensor systems to assembly centers are not included in the DMAC, but communication needs through the remainder of the enterprise will be addressed as needed to facilitate discovery and transport capabilities.
- DMAC will not independently verify or validate data quality. These functions should initially be performed by the collection or observing entities, DACs, modeling centers, and archives using the mutually agreed-upon IOOS standards and procedures.

For simplicity purposes only, this DMAC ConOps describes the national DMAC subsystem as a single system operating at a single location. However, the NOAA IOOS Program recognizes that most observing programs have some level of data assembly and quality control capabilities, and many also have data transport and modeling capabilities. This will become increasingly the case as NOAA supports the efforts of regional associations to develop regional DMACs over the next several years. In addition, initiatives such NSF's OOI and NOAA's NDBC are supplying or may supply various levels of the infrastructure. The national DMAC subsystem must leverage these capabilities. Therefore, in the long term, rather than being a single system operating at a single location, the national DMAC may be a single system operating in multiple locations, or it may be an interoperable family of systems operating in multiple locations. In some or all cases, regional DMACs may also serve either as separate but integrated partners or as integral components of the national DMAC. Figure 3-1 shows a sample of potential DMAC design alternatives. It is important to note that these more distributed models will emphasize the critical role of IOOS data and technical standards used by all parties. A detailed technical analysis and system design will be completed in a later stage of the program.

Figure 3-1. Alternative DMAC Designs



Note: DAC – Data assembly center; and M&A – Modeling & Analysis

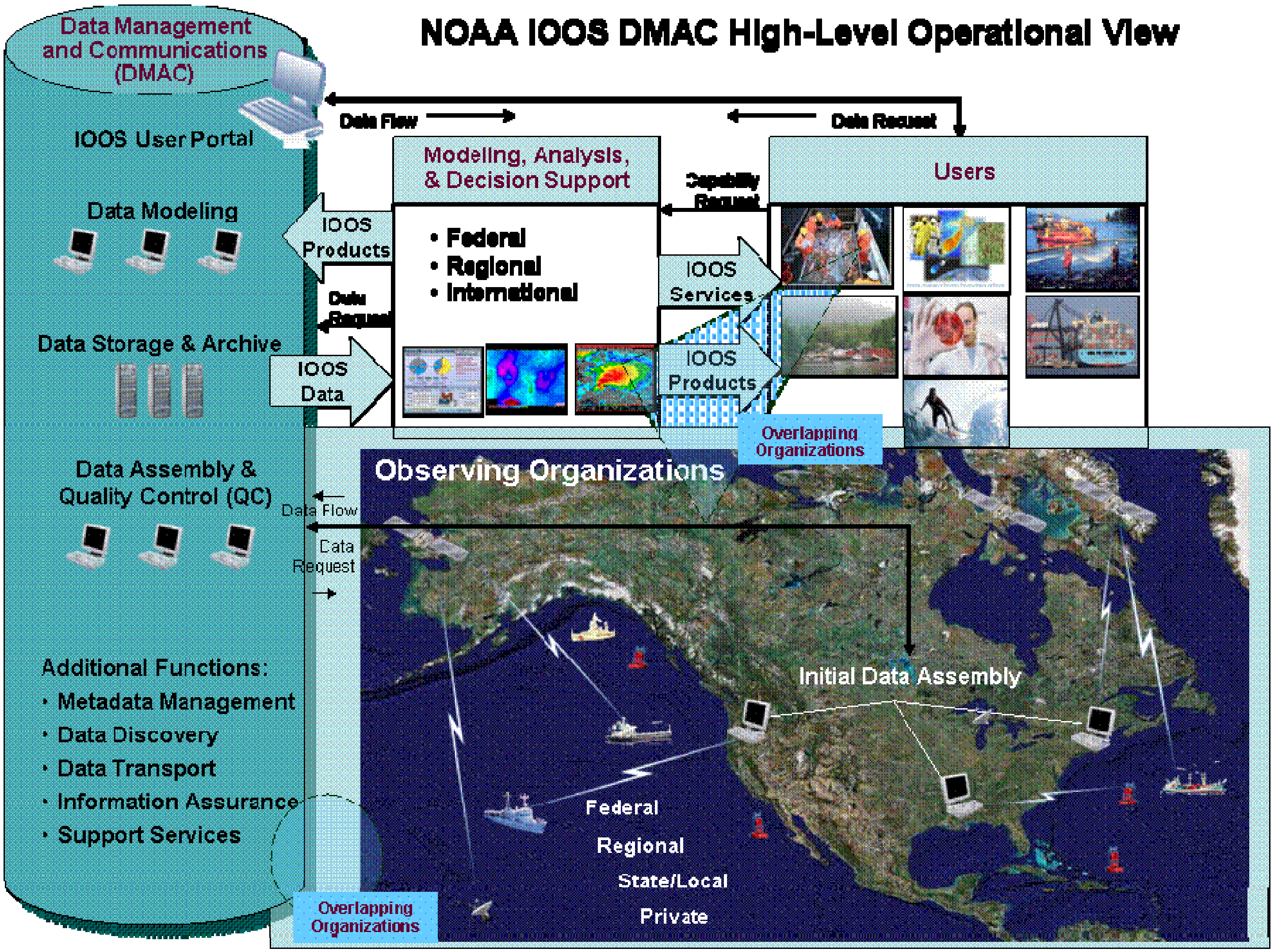
OVERVIEW

The DMAC subsystem will aggregate and integrate (public and potentially proprietary) data from thousands of independently owned and operated collection sensors as well as non-sensor or manual collection programs (e.g., surveys, human observation and interviews) and make the data available to hundreds of equally diverse users who use the data for modeling and analysis, as well as for decision support. This exchange of data requires that data collectors and users speak the same language in terms of data definition, structure, and transmission both within and across components. Therefore, the DMAC cannot consist solely of hardware, software, and communications infrastructure. To ensure that the data are interoperable across a national and global community, DMAC and all IOOS partners must also incorporate standards for data collection and management and for metadata. In addition, the DMAC will be compliant with both the Federal Enterprise Architecture, the NOAA common infrastructure, Federal information security requirements, and other applicable federal standards.

Figure 3-2 shows the DMAC role in the IOOS. As the figure shows, observing organizations across the United States will send the data they have collected to initial data assembly centers. At the DACs, the data will undergo quality control (to ensure data validity) and will then be pushed to the DMAC subsystem. The DMAC will store the data so that they can be readily retrieved by interested users. User requirements for data may be recurring—for example, regular provision of data to modeling, analysis, and decision-support organizations that produce products and services—or they may be ad hoc. After using the data, modeling, analysis, and decision support entities may opt to push their processed to DMAC. When this occurs, DMAC will perform limited quality control and will store the data.

The general public, and other registered users, will have access to the IOOS data through a portal. This web-enabled tool will provide the same data discovery, access, and transport capabilities that are provided to the modeling, analysis, and decision support entities.

Figure 3-2. High-Level Operational View of DMAC



Note: Some current observing systems also perform data modeling and some end users produce IOOS products and services. Because IOOS will be a system of systems, these existing systems will become part of IOOS. Shaded shapes depict these “overlapping organizations.”

OPERATIONAL ENVIRONMENT

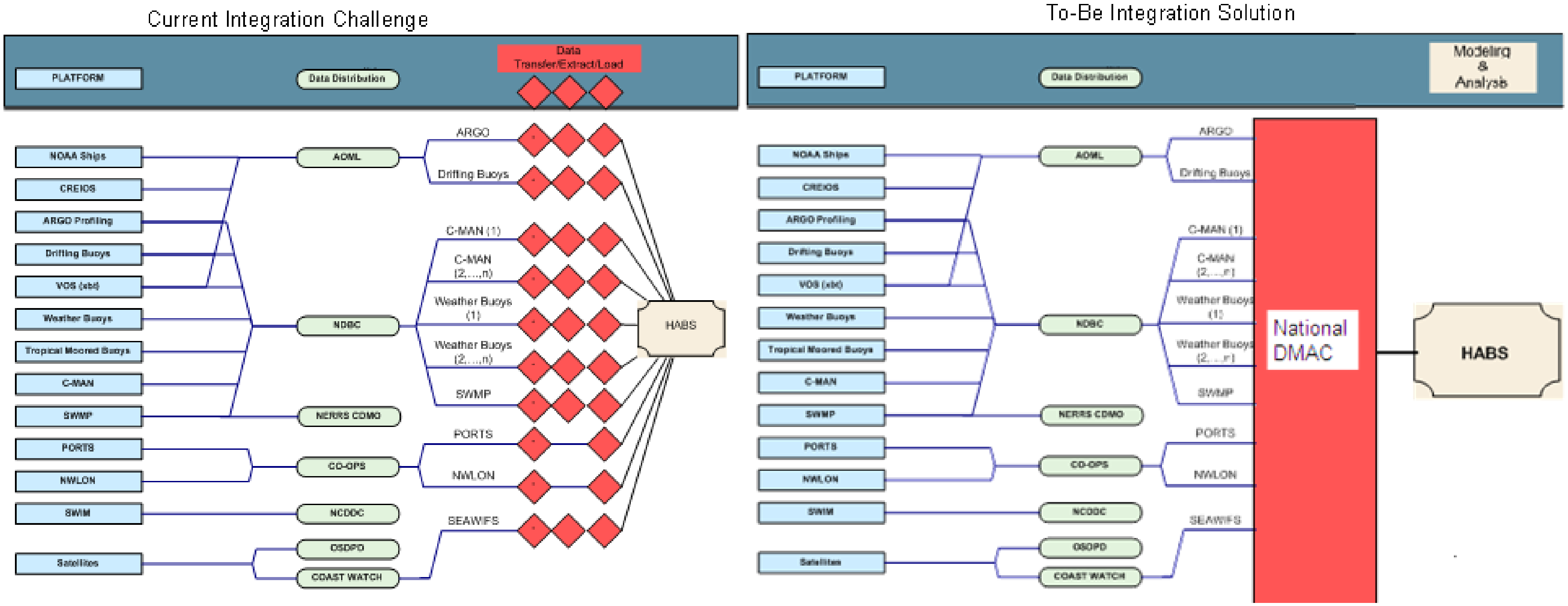
Data Flow

Within the DMAC, the data flow will be predominantly in the following order: receiving from observation providers, QC, storage, outward to data using organizations and portal users. Data will also eventually move from near-term data stores to one or more levels of archive and possibly to being discarded.

Figure 3-3 depicts both the current inefficiencies and the planned flow of IOOS data, using a harmful algal blooms forecasting model as an example. However, within this broad flow, there will be many smaller, bidirectional flows of observation data, processed modeling data, and other commonly related data. These flows will result from research and request queries and responses from user organizations and portal users. In addition, DMAC will exchange control logs, error messages, receipt confirmations, and other information with both data providers and data users. The workflow management software and processes will govern these flows.

Reusable models will likely represent the largest volume of flow in the opposite directions. In some cases, modeling entities will produce models that will be shared with and further used by other entities. For example, ocean scale models may be used to create boundary conditions for regional models. For these cases, the creating agency will take observation data from the DMAC and create reusable models. These models will be sent back to the DMAC and stored for other organizations to retrieve and use.

Figure 3-3. Data Flow in the Current and Target States



Note: AOML - Atlantic Oceanographic and Meteorological Laboratory , CO-OPS- Center for Operational Oceanographic Products and Services, C-MAN-Coastal-Marine Automated Network, CREIOS - Coral Reef Ecosystem Integrated Observing System ,HABS - Harmful Algal Blooms, NDBC - National Data Buoy Center , NCDDC - National Coastal Data Development Center, NERRS CDMO - National Estuarine Research Reserve System Centralized Data Management Office, NWLON - National Water Level Observation Network, OSDPD - Office of Satellite Data Processing and Distribution, PORTS - Physical Oceanographic Real-Time System, SEAWIFS - Sea-viewing Wide Field-of-view Sensor, SWIM - Seacoast Watershed Information Manager, and VOS - Voluntary Observing Ship.

System and Data Environment

The DMAC subsystem will operate in an intense high data volume and high data exchange environment. At least some of these exchanges may also operate on a tight schedule for delivery of time-sensitive critical products. This environment will place high demands on system performance and reliability and will require a highly trained and capable support staff.

The DMAC will also require very strong fault-tolerant and redundant systems and more than adequate backup capabilities to support operations either if volume begins to affect performance or if the primary resources fail entirely.

The DMAC must also be capable of operating in multiple levels of operational status for its data and users. In some cases, the data will support highly time sensitive and critical models; these data may pass through the DMAC rapidly. In other cases, large amounts of older data may be required to support a scientific research program; this type of effort will not be time sensitive but may place high demands on processing capabilities and the support staff. Further, DMAC will support all time classes of data, such as delayed-mode, climate-quality, and reprocessed or retrospective data and data that is collected at appropriate time scales. As another example, data from new programs and or sensors may need to be evaluated for production use; the data flow and modeling of these data may have to follow in parallel but similar tracks to operational data.

Because of the high volume of exchanges and data and the time-sensitivity of some processes, DMAC internal operations should be as automated as much as possible with minimal human intervention. To ensure that these automated processes operate correctly under diverse operating conditions, the test program must be both thorough and extensive.

The DMAC subsystem must have a multitiered environment to move system changes from development, to test, and to operations. The testing process must be very thorough. All versions of the software, hardware, and processes must be maintained under stringent version control. Requirements for version control for data and exchange standards must extend beyond the DMAC to also include the exchange partner community.

Governance Environment

Standards for metadata, data, observing processes, exchange processes, and other components will be critical; the lack of such standards will preclude the successful move of ocean research and modeling from a local to a national and then to a global capability. This is also true of non-sensor data. As described above, DMAC's ability to provide the correct data, to the correct customer in a timely manner will depend on automation and, in turn, that automation is dependent on accurate and consistent data. Beyond the DMAC, the modeling tools will be even more dependent on accurate and consistent data.

Building and managing these standards will represent a major shift from the current environment in which organizations responsible for obtaining observation data are often the primary users as well. The few partnerships that exist operate under specific agreements made to address any data challenges. In the IOOS environment, data collectors will be supplying data to a wide variety of users, many of whom may be not be familiar with this format. Data modelers may also become dependent on data sources with whom they will likely become familiar, but over whom they may have no direct organizational authority.

Although NOAA will lead the standardization effort, it must have the dedicated participation of all stakeholders, and modeling and collecting organizations must work in close collaboration. This issue is not simply a one-time "let's get it done and it's over" effort. Standards maintenance will be an ongoing issue as new collection programs begin, new geographical areas are covered, and new variables are collected. In short, the governance effort will be demanding, widespread, and long term. It will require a both a significant start-up effort and a substantial sustainment effort. Standards governance not only means reaching agreements on standards, it also means continuously managing sensor and computer applications that are consistent with these agreements.

FUNCTIONS AND CAPABILITIES

In the target environment, the DMAC subsystem will acquire data collected by participating observing organizations. The DMAC will work with the observing organization to ensure that the data are presented in a unified manner based on agreed-upon standards. Generally, the observing organization will be responsible for forwarding the data in accordance with the standards, although in some cases the DMAC may modify the data to meet the standards. The DMAC will provide data to modeling and analysis centers in accordance with the approved standards. DMAC's specific functions are as follows:[1]

- Data transport
- Data assembly, quality control, transformation (standardization), and workflow management
- Data access
  - Data Discovery and Metadata Management
  - Data Access Operations
    - Primary recurring users
    - Users from the broader community (external users)
- Data storage
- Data archiving
- Information assurance

[1] The list of identified functions draws heavily upon previous IOOS studies. The principal studies are National Office for Integrated and Sustained Ocean Observations, *Data Management and Communications Plan for Research and Operational Integrated Ocean Observing Systems*, Ocean.US Publication 6, 2005; Lockheed Martin, *Integrated Ocean Observing System (IOOS): Conceptual Design*, 2006; and Raytheon, *IOOS Conceptual Design*, Volume 1, 2006.

- Support services
  - Data standards and governance
  - Service level agreements (SLAs)
  - User support
  - System administration and monitoring.

The following subsections summarize the DMAC capabilities to be supported for each of the above functions. The focus is on what is to be done, not on how the function is to be technically performed.

Data Transport (External Exchange Services)

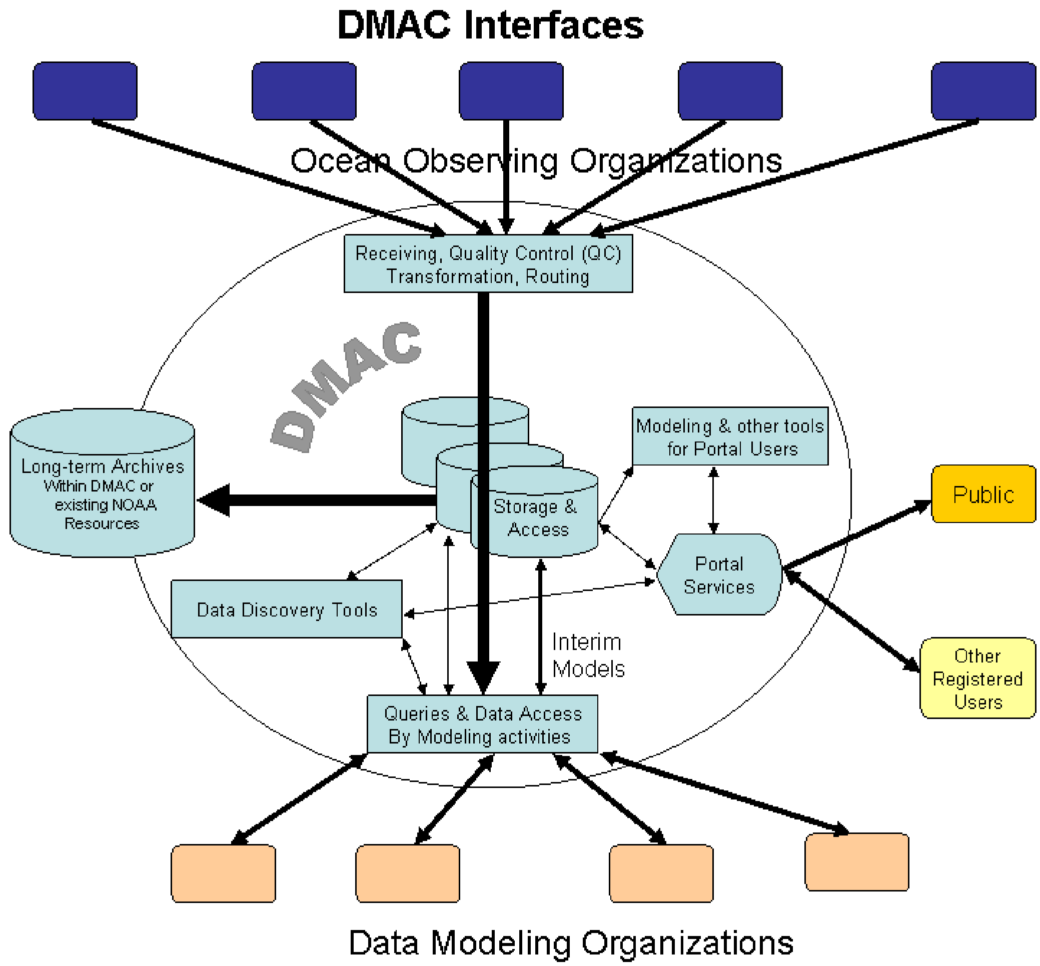
This function covers the exchange of IOOS data between the DMAC and the observing organizations and the modeling and analysis organizations. The DMAC will either receive data pushed by partners or pull data from the DACs.[2] Data exchanges can be either period based (e.g., daily) or event driven (e.g., to support a specific set of collections from a research voyage or to support a specific analysis). In any case, the DAC should ensure that the data sent

- conform to all IOOS standards
  - at the data element level and for associated metadata and
  - at the data exchange level, and
- pass data quality validation.

In addition to raw data from observing assets, the DMAC will also receive model outputs from modeling centers that can be in turn reused by other modeling organizations. These models should conform to the same quality standards as raw data. Figure 3-4 depicts the DMAC data exchange environment.

[2] Regional DMACs may serve as DACs, but there will be additional DACs that are not regional DMACs.

Figure 3-4. DMAC Data Exchange Environment



Initial technical studies commissioned by NOAA have recommended using a combination of state-of-the art industry approaches to business-to-business exchanges. At least one previous analysis also specifically discusses a network of powerful computer nodes at the DMAC and the DACs to orchestrate the data exchange services. As with other DMAC functions, specifics of how this will be accomplished technically require future detailed analysis.

Among many other factors that analysis should consider the very high volumes of ocean observations that are being collected and that the DMAC must process. The Ocean. US study identified an annual volume of 200,000 GB from NOAA and NASA sensors alone.[3] The volume of ocean data likely will increase dramatically as the program scope expands from being primarily a set of regional coastal observations to include deep ocean observations worldwide. The increasingly large number of programs that are deploying sensors, especially satellites, will also increase the data volumes.

[3] National Office for Integrated and Sustained Ocean Observations, *Data Management and Communications Plan for Research and Operational Integrated Ocean Observing Systems*, Ocean.US Publication 6, 2005, Part I, page 36.

Data Assembly, Quality Control, Transformation (Standardization), and Workflow Management

As data are received, several tasks will be performed depending on the specific design selected. These may include performing QC checks, transforming the data from transport to storage format and other possible transformations, and managing workflow. Additional administrative and security functions likely will include tasks such as archiving the data as received and updating logs of received files.

Although data should undergo QC checks at the DAC, QC checks also should occur at the DMAC to protect against possible failures at the DAC, transmission errors, or problems with performing checks against data in aggregate that cannot be performed against data in one locale.

XML requires uniform structure that includes metadata, or information about the data (both content and roles, to varying degrees). Although this allows translation across the web, the "attached" metadata may increase the volume of the data. This additional volume of data may cause challenges in terms of data transfer and archiving.[4] For this reason, other options, such as OPeNDAP and netCDF, should also be evaluated. The DMAC may also restructure the data, modify individual element formats, or add information to support national and global use.

A critical factor in the detailed design analysis to be performed will be how the data are organized for data storage and access. The data could be organized by some combination of factors such as specific variables (temperature, salinity), data type (profile, time sensitivity, gridded field) location collected, date collected, and models used by similar end users. Depending on how the data are organized, it may be necessary to have separate data flows to support critical time-sensitive applications. Data and data collections will also need to be segregated into groupings such as experimental, pre-operational, and operational. As data volumes grow, how the data are organized and stored will dramatically affect the users' ability to discover, access, transport, and manipulate the data.

Workflow management will be a set of carefully designed processes supported by automated tools. The processes and tools will be closely monitored by the staff to correctly route, manipulate, and store all data throughout the DMAC.

Data Access

The data access function is a set of procedures (including SLAs), processes, and tools employed to copy DMAC data from storage to sites where users can manipulate the data. Typically, the sites will be separate from the DMAC subsystem, but a site could be within the DMAC.

Data Discovery and Metadata Management

One of the most unique features of the DMAC will be to support IOOS users in identifying data being supplied by a broad community beyond their own organization. Data discovery will be supported by a set of tools that include both a user friendly on-line catalog of the DMAC collec-

[4] There are advocates and circumstances for retaining data in native XML format.

tion, and perhaps other relevant data repositories as well. The catalog must define the collecting programs, time periods, geography, variables, and data details. Interrelated to this is the concept of Metadata (data about data) that will provide a different way to search the collection through indexes into all of the specific data elements within the collection. Metadata (management) must be woven into the IOOS data standards as well.

DATA ACCESS OPERATIONS

Once users know what data is available and how it is structured, they can begin to use tools to actually extract and use the data. We have organized data access through two broad classes of DMAC users:

- Primary recurring users. These users are typically government or government-affiliated organizations using
  - recurring automated techniques to access data and
  - manual techniques for ad hoc access to selected data.
- Users from the broader community (external users).

We describe the data access by these user classes in the following subsections. Further analysis may result in the identification of additional user classes.

ACCESS BY PRIMARY RECURRING USERS

The major flow of data by volume should be through automated recurring data transmissions. This approach is particularly important for time-dependent data that should be received, standardized, and collected with other relevant data and pushed to the using system on an agreed-upon schedule. Alternatively, user systems can also employ web services or other techniques to generate automated queries to pull whatever time class of data are available as needed, this includes delayed-mode, climate-quality, and retrospective data.

For these recurring transfers, an SLA between the DMAC and the customer will clearly define both the data requirements and the technical approach. This applies to accessing both raw observation data and pre-processed modeling data.

However, before establishing automated processes, humans may need to perform data discovery tasks to determine what data to use. One of the major weaknesses in the current environment is that only the individual entities collecting the data know what data are available. The DMAC will deploy a highly searchable database (the DMAC Catalog and Metadata Repository) that will identify all data accessible via the DMAC.[5] The catalog will provide views into individual data elements; metadata related to those elements; sets of interrelated data; information about how, where, and when the data were collected; storage level; and information about projects and programs. The catalog should be designed for both manual and automated search.

[5] Several of the DMAC concept studies have discussed, at length, design approaches to data discovery, cataloging, and metadata management.

Once users discover data of interest to them, they can use tools to pull data for research or trial use and, if desired, create new automated recurring access procedures.

ACCESS BY USERS FROM THE BROADER COMMUNITY (EXTERNAL USERS)

The DMAC will provide at least some level of access, via a portal, to a broader community than the observing and modeling and analysis community of government agencies and affiliated organizations. These external users are of two types:

- Unidentified users who access the DMAC portal via web browsers and the World Wide Web
- Users (individuals or organizations) that in some manner identify themselves, register, and are granted a specific set of access and use privileges via an individual SLA.

For unidentified, unregistered users, the portal will provide typical static web data, including descriptions of IOOS and DMAC, contact information, and related links. The description of IOOS may also contain select viewable sample or real-time products to visually demonstrate IOOS benefits.

For users requesting to register, the IOOS program, in coordination with other key stakeholders, will need to determine registration and access policies. Potential use by other governments, research organizations, community action organizations, and industry will affect system security, responsiveness, tools required, user support and training, and other components, hence overall system cost. Access to the data must also be evaluated from the perspective of how the data will be used and what potential national or local security risks may arise from that use.

The registered user pages will enable online browsing, data discovery, and data access; in addition, users will be able to request data transport (download) of data to their computers or to use modeling tools provided by the DMAC subsystem on DMAC computers to generate output data formats, visuals, or reports. Portal users will use the same discovery, access, and transport tools and services as primary users.

Once a user has determined the structure and scope of their requirement, either online tools can be provided for the request to generate ad hoc queries to extract the data or the user can generate the request through his system, which would be forwarded through web services or other means from the using agency’s computer to the DMAC. Once either ad hoc or recurring requests are extracted from the data store and placed in the appropriate data transport format, they will be sent to the user. To put it another way, no external user will be able to manipulate the core data received from observing platforms; in all cases, users will copy the data into their own space (or space set aside for that purpose with DMAC) and will manipulate it there.

Supporting ad hoc requests will place the greatest demands on the DMAC staff and systems to provide data in a usable format and structure in a timely manner. Again, establishing SLAs will provide boundaries for providing these services.

Portal and database tools will allow the DMAC user support staff to establish categories of registered portal users to define specific roles as to what data, services, and tools a given user may access. All of the above processes must address Information Assurance (IA) policies to protect the system.

Data Storage

Data required for immediate and near-term access will be stored in a repository. The data repository will contain the most recent and heavily used data sets, supported by the fastest access storage devices and structured to support rapid retrieval. In addition, some high-priority and time-sensitive data sets may be moved directly from receiving and quality control to end users (as well as being put into the repository). Conversely, some new data may be placed immediately in lower use archival storage. As data are added to the repository, the DMAC catalog will also be updated.

Received data must be carefully organized and structured to enable easy discovery and appropriate access speeds to support the modeling and data analysis users. When data volumes increase, it is critical to correctly mesh the organization of the data with the supporting technologies and user requirements in order to provide rapid access while controlling cost and maintaining data integrity.

Data Archiving

As data age, they will become less actively accessed by some applications such as those that use the data to generate near-term predictions or current ocean status. However, those data still remain relevant for studies involving longer periods. Therefore, the less time-sensitive, less critical, and infrequently used data may be archived.

Archiving within the DMAC structure will guard against the loss of irreplaceable data as called for in the DMAC plan; facilitate reanalysis under the broader "scientific data stewardship" responsibilities highlighted by the U.S. IEOS Strategic Plan and recent studies by the National Research Council on Archiving, Stewardship, and Access;[6] and facilitate "data rescue" projects to digitize historical analog records and make them accessible for long-term analysis products.[7] Rules will be needed for archiving data. For example, the data archiving techniques may employ multiple tiers of accessibility levels, that is, as data become less and less used, they are moved to increasingly cheaper but slower access media. The need to archive data is not driven solely by cost; it also retains faster response time capacity for high-use data. NOAA has significant archiving capability that may be able to support the DMAC subsystem, for example, the NODC is the world's largest active archive of weather data, including both national and international data sets.

In an operating environment driven by the movement of large volumes of data among geographically diverse stakeholders, data age is not the only criterion for archiving. Data files will be archived as received from or sent to another partner, and sometimes as transformed from one state

[6] *Environmental Data Management at NOAA: Archiving, Stewardship, and Access,* "Executive Summary," http://www.nap.edu/catalog/12017.html.

[7] National Office for Integrated and Sustained Ocean Observations, *Data Management and Communications Plan for Research and Operational Integrated Ocean Observing Systems,* Ocean.US Publication 6, March 2005, page 69 (2.6. Data Archeology).

to another within the DMAC. These actions are usually supported by event logs. Both the files and the logs are necessary for system security.

Data retention policies will be associated with all incoming data sets and will be part of an SLA between the DMAC and stakeholders. The policies will apply to both primary use and archived data and will be based on the anticipated level of access needed, the time sensitivity, operational status, and other factors associated with the data. The data retention policy will define the types of data access and storage that will be provided for the data over time and the duration of each level of access. These policies will also govern the end state of the data—whether they should be retained permanently or discarded.

Formulation of such data retention policies and procedures is an active topic of the NOAA Science Advisory Board, Data Archive and Access Requirements Working Group.[8] Those deliberations can assist with formulating practical guidance for IOOS DMAC archiving functions.

Information Assurance (IA)

IA focuses on protecting both the system and the data and must address a range of threats:

- Human error or equipment malfunction
- Deliberate attacks upon the system from both internal and external sources
- Events of nature.

Establishing IA goes beyond firewalls and intrusion detection. IA must ensure the establishment of proper backup plans, adequate continuity of operations plans and assets, proper vetting of system personnel and external users, annual security awareness and training for all users as well as the security staff, and numerous other functions.

In the intensive data exchange environment in which the DMAC subsystem will operate, protecting the security of data being received and sent will be a prime concern especially if a decision is made to carry proprietary data. A fundamental goal for government, which has developed since September 11, 2001, is to increase the level of information sharing among the public and private sectors to the greatest extent possible, while at the same time, providing the appropriate level of protection for this information. It is essential that all federal agencies achieve a balance between the competing goals of information sharing and national security. Information sharing is an essential part of our homeland defense, and it provides a unifying link between federal, state, and local government agencies, as well as the private sector. However, national security dictates that some information must be protected and secured. This need includes protecting against cyber attacks such a denial of service and intrusion, as well as against more mundane common events of protecting data integrity, such as preventing files from inadvertently containing errors, not being sent by a partner as scheduled, being corrupted in transit, or being mishandled upon receipt at the DMAC. The same attention must be paid to outbound files and data as they are manipulated and moved within and outside of DMAC.

[8] For more information about NOAA Science Advisory Board Working Groups, see http://www.sab.noaa.gov/Working_Groups/standing/index.html.

The high-volume electronic exchange among many organizations and the possibility of a large number of users external to the community increase the risk to the DMAC (and other partners). The following are among the many policies, procedures, and technologies that must be addressed:

- Identity management
- Single sign-on
- Encryption
- Digital signatures and system certifications
- Public key infrastructure services
- Data network security controls
- Additional security controls.

The DMAC subsystem must also meet the requirements of the Federal Information Security Management Act (FISMA)[9], which address all aspects of system security. Not only must DMAC be FISMA compliant, but so must every system that exchanges data with DMAC, even if it is not a government owned or operated system.

IA planning must be incorporated at the earliest stages of system planning, and as with other design considerations, IA must be implemented with increasing levels of detail as the system moves through initial planning, design, development, testing, and deployment.

Support Services

Data Standards and Governance

In the current environment, the organization managing the collection of the data is often also the primary data user or is sharing the data with specific partners. Collectively, this results in a many-to-many data exchange environment between observing entities and modeling and analysis entities. In this environment, either the sender or the recipient of the data may have to reformat data to allow their effective use, and some data may not be usable at all because of different measurement techniques, data definitions, or other reasons. As the number of exchange partners increases, the data exchange protocols and necessary transformations become increasingly complex. The inefficiency and added costs become apparent when viewed across the entire spectrum of organizations exchanging ocean data.

In order to share integrated ocean data across a broad community of users, the meaning and structure of each data element must be clear to all. In addition, to the greatest extent possible,

[9] For more information about the Federal Information Security Management Act (FISMA), see http://csrc.nist.gov/groups/SMA/fisma/index.html.

data elements should be measured and submitted to a common standard in order to minimize transformation costs on the part of the DMAC or other users of the data.

The NOAA IOOS Program will lead, and has already begun the effort to involve the entire community to establish common data standards. In support of the DIF, the NOAA IOOS Program established a community-wide working group, procedures, and IT tools to assist with establishing standards. The standards will not be limited to the data format; they also must address the development of the measurement that the data represent. Data standards will be an integral part of metadata management and of data discovery, storage, transformation, and QC.

Virtually all DMAC processes will be driven by the standards. In turn, the DMAC must coordinate with all external partners to ensure that they are using the same standards or agreed-upon transformations. Effective management of these standards will be critical to IOOS success. The NOAA IOOS Program will leverage the work currently underway for the DIF, using existing standards to reduce the impact on data providers and users. Further the program will leverage the DIF's procedures for establishing new standards, rather than creating new processes or standards.

Service Level Agreements (SLAs)

Interrelated with standards is the concept of SLAs. The DMAC will establish a SLA with every exchange partner. The SLA will define the products and services that the DMAC will provide to the partner and will detail the data to be exchanged, format, timing, and QC, among other things. An established SLA will in turn govern the DMAC staff in configuring DMAC tools to support that partner. However, fulfilling these SLAs may require future funding considerations.

User Support

The DMAC will require a sophisticated user support staff to assist the broad range of users and provide information about the data supported and the services and products offered. The user support staff will likely conform to typical help desk practices, providing a variety of means—telephone, e-mail, website—for users to seek help and information.

The user support staff may also be responsible for other activities, including supporting educational, outreach, and research capabilities. If the DMAC adopts a distributed or family of systems, the user support group will need to be multitiered and integrated across all the systems.

Key members of the user support staff should be involved with the system development, testing, and deployment from the early stages of the project, and they must also be cognizant of both data standards and SLAs.

System Administration and Monitoring

Virtually all DMAC personnel will have some level of system administration privileges in order to serve the external user community. A few will have the security clearances and access necessary to manage and protect the system.

The technical management personnel operating the DMAC subsystem must be highly skilled in data transport, storage, quality, portal support, user services, IA, etc. They will be responsible for monitoring system performance, testing, and system security. They must also be able to plan for the future in terms of increasing data volumes, new types of observation data and users, and new technologies.

Furthermore, the DMAC will use methods to extract feedback from end users, or those using the data services, to better address their needs. For example, the system may use diagnostic tools (e.g., Google Analytics) in conjunction with web logs to access data or system use trends, and other system evaluation protocols to enhance data relay, storage, assimilations, and other functionality. This relevant and timely feedback will allow DMAC to better understand and respond to customer needs.

MAJOR COMPONENTS AND INTERFACES

One or more robust computational facilities will be required to support DMAC operations. These facilities need not be standalone and may be able to leverage existing facilities. However, they must be able to support state-of-the art computers, storage devices, and networking hardware. This hardware must support myriad software components and interfaces.

The major components, described previously, are as follows:

- Major hardware and software components by function
  - Data exchange services
  - Data storage and archiving
  - Portal services
  - Data discovery services
  - Modeling services
  - Information assurance
- Facilities
- Major personnel-based services
  - User support
  - Standards and governance
  - System management.

The following are expected to be the specific interactions by type of exchanging organization (individual) (the subsequent design may alter the approach substantially):

- Interfaces with DACs
    - Transmissions from the DACs to DMAC
        - Observation data files
        - Administrative files for scheduling data transmissions
        - Support files for standards and metadata management
        - Online manual and automated access to data discovery, DMAC data catalog, and administrative logs
    - Transmissions from DMAC to the DACs
        - Receipt confirmation of data files
        - Error reports on received data files
        - Administrative files for scheduling
        - Support files for standards and metadata management
        - Online manual and automated access to administrative logs
- Interfaces with modeling centers
    - Transmissions from the modeling centers to DMAC
        - Automated and online manual queries to obtain observation data files
        - Modeling products for reuse
        - Receipt confirmation of data files
        - Error reports on received data files
        - Online manual and automated access to data discovery, DMAC data catalog, and administrative logs
    - Transmissions from DMAC to the modeling centers
        - Observation data files
        - Reusable modeling products

    - Receipt confirmation of data files
    - Error reports on received data files
    - Online manual and automated access to administrative logs

- Portal interfaces with users (with appropriate levels of access)
  - Transmissions to the DMAC
    - Online manual and automated access to data discovery, DMAC data catalog
    - Online manual and automated access to observation data files and reusable models
    - Online access to modeling tools
  - Transmissions to the DACs
    - Observation data files
    - Reusable model files.

The DMAC subsystem design will refine and perhaps revise this list of exchanges and start to address the technologies to be used to support them.

ROLES AND RESPONSIBILITIES

The breadth of the IOOS program will bring aspects of it within the jurisdiction of many organizations. NOAA has been charged by the IWGOO to be the lead federal agency in developing IOOS. To help achieve the IOOS goals, NOAA will collaborate with international agencies and other nations; other federal agencies; state, regional, and local agencies; regional associations; universities and other research entities; and industry.

Diverse organizations have managed ocean observation and modeling products for many years. Over the last few years, these organizations and others have dramatically increased the size and scope of the number of ocean observation programs, geographic areas covered, and deployed sensors and systems. Equally, the scope of modeling efforts and studies is also expanding in correlation to the increasing number of observations.

NOAA's intent is to assist the IOOS community by improving the integration and interoperability of the data and systems. The DMAC subsystem will be the key component used to integrate and link the observing systems to the modeling systems. Well-defined data standards will be key to the success of DMAC. NOAA must closely interact with the observing and modeling communities to ensure that the correct data are available to generate information products to inform decision making and to promote economic, environmental, and social benefits.

The following subsections identify, in broad terms, the primary roles and responsibilities of the data-providing organizations and the data-using organizations. Many of the entities mentioned in this ConOps will be both data providers and data users.

Data-Providing Organizations

During the IOOS planning phase, agencies and programs that operate sensor platforms and systems will be responsible for collecting data from sensors and systems, conducting quality control, and providing data to the DMAC. It is critical that NOAA and the data-providing organizations work collaboratively. The following are key responsibilities of the data-providing organizations:

- During the planning phase
  - Identify current and planned observation program details such as data types, volumes, and locations
  - Work with NOAA and other organizations to coordinate observation program objectives with those of the modeling and analysis program and societal needs
  - Ensure that the correct assets are in the correct locations and sensing the correct variables to meet the objectives
  - Participate in the development of data standards
- During the design phase
  - Coordinate with NOAA to develop detailed DMAC SLAs
  - Participate in design reviews, testing, and other activities
- During operations
  - Ensure that their systems conform to the DMAC SLAs
  - Work with DMAC and other organizations to plan future capabilities and requirements.

Data-Using Organizations

A wide variety of agencies and programs use ocean observation data to generate products such as models and analyses to assist researchers, planners, and decision makers. Many critical models have been operating over a period of years with clearly defined data requirements. However, the IOOS program may enlarge the scope of available data by, for example, offering new data that increase geographical coverage. The program also may alter the way data move from assets to the models. Modeling organizations should begin planning as soon as possible to identify future data requirements under IOOS.

The key responsibilities of the data-using organizations are as follows:

- During the planning phase
  - Using the IOOS societal goals as a basis, identify the observation data they require for their applications and communicate those needs to the DMAC and the data-providing community
  - In light of IOOS and DMAC capabilities, reevaluate the modeling products that become the basis for other modeling efforts
  - Participate in the development of data standards
- During the design phase
  - Coordinate with NOAA to develop detailed DMAC SLAs
  - Participate in design reviews, testing, and other activities
- During operations
  - Ensure that their systems conform to the DMAC SLAs
  - Coordinate with DMAC to ensure that all data exchanges occur correctly and are timely
  - Follow agreed-upon procedures for making special requests and for changes in requirements
  - Work with the DMAC and observing organizations to plan future capabilities and requirements.

Chapter 4

The Way Forward

This chapter explains the impact that DMAC will have on business operations. It also addresses challenges and implications and identifies next steps. The final section of this chapter identifies key events, major deliverables, and milestones.

BUSINESS IMPACTS

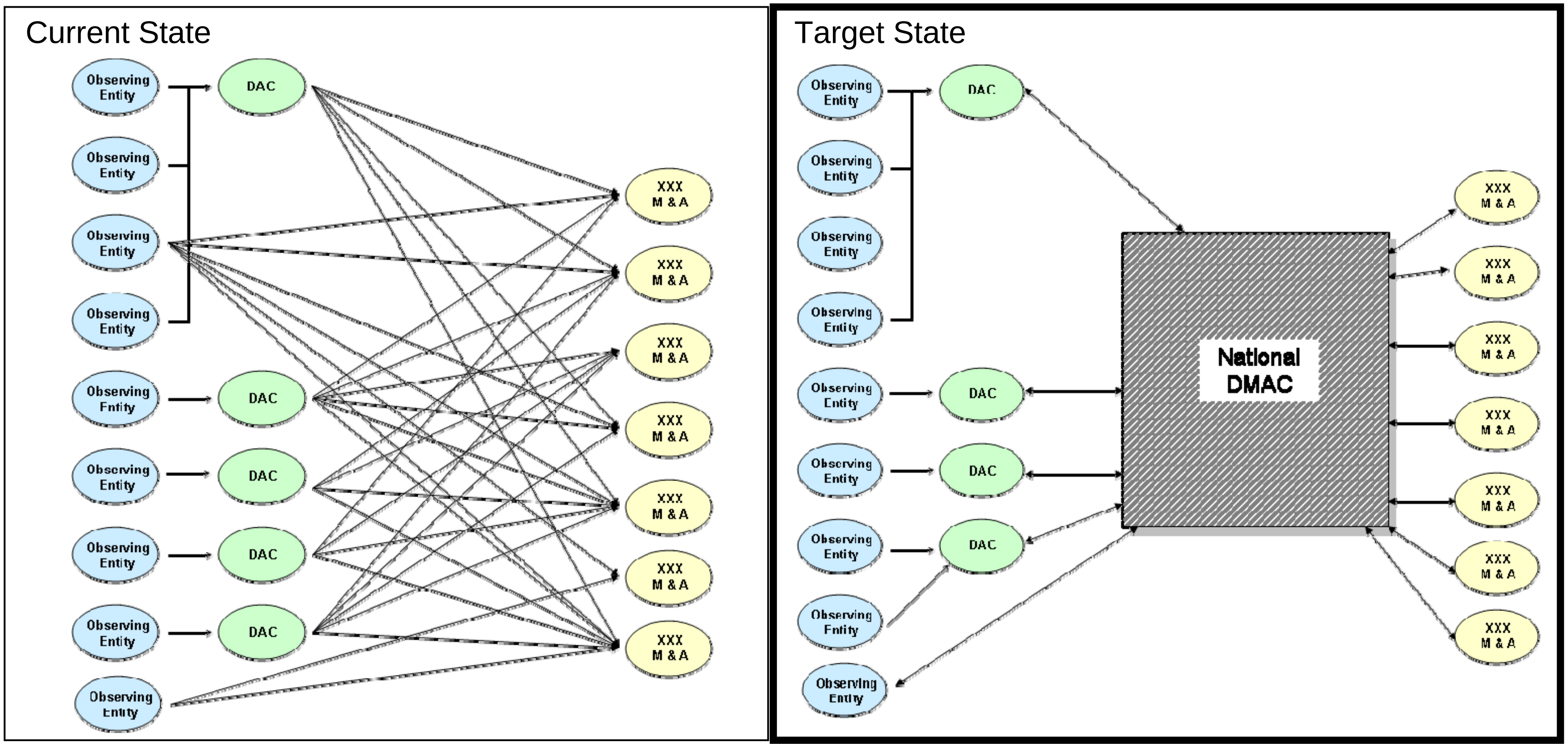
Many organizations have their own observing and modeling programs. To carry out their missions, those organizations ensure that they have the necessary sensors and systems, communications, and modeling tools. However, these resources may not be known or shared outside these organizations. This lack of sharing may be due to policy or simply a lack of communications among the diverse stakeholders. Repurposing existing infrastructure and data could provide the opportunity to model or forecast events or use current models in new ways, to improve the accuracy of the models, and to implement broader and more comprehensive research programs as well as make more efficient use of the limited funding available for ocean research.

Charged with leading the interagency coordination for the overall IOOS program, NOAA envisions a DMAC that brings together data from multiple observing systems and provides the intermediate services necessary to make standardized data available to a broad community of users. In short, DMAC will enable data-using organizations to locate all the data they need from a single access point. Further, each modeling and analysis organization will be able to feed their post-processed data back into the DMAC repository for use by other entities. Figure 4-1 compares the current data flow with the data flow and communication that will result by implementing a national-level DMAC.

The target state will have at least three major business impacts on data-providing and data-using organizations:

- The organizations will need to participate actively in building and supporting IOOS standards. This will require staff participation and, in some cases, may require revisions to hardware (including sensors), software, and processes.
- The organizations will be able to more readily share data with a broader community at a much lower cost without having to tailor their programming, buy additional hardware, or change processes to accommodate individual data users.
- The organizations will have access to a much broader set of data that they can readily assimilate into their models and tools and thereby expand their processes, services, or research.

Figure 4-1. DMAC Data Flow Enhancements



DAC – Data assembly center, and M & A – Modeling & analysis

Note: For simplicity, DMAC is depicted as a single entity; the actual architecture is yet to be determined.

At both the national and global levels, integrating and assimilating this vast set of data may radically transform the ability to understand the oceans. The level of effort required to ensure that the IOOS will be a truly integrated system of systems requires participation from many disparate organizations. Specifically efforts will be required to finalize the business case, integrate efforts across organizations and initiatives, and ensure data exchanges support data standards of the various users. It will also likely impact near term and future interagency resource funding and scheduling."

The degree of participation and cooperation this will require will change the roles and responsibilities of current participating entities and may create new organizations and roles related to the DMAC. Table 4-1 provides an overview of key roles and responsibilities as related to the DMAC.

Table 4-1. DMAC Roles and Responsibilities

Type	Title	Role	Responsibility	Design phase	Operational phase
Data provider	Observing organization (agencies and programs)	Own or operate sensor platforms	Work together to establish and maintain effective data standards	✓	✓
			Ensure proper placement of the correct assets and collection of the requested data	✓	✓
			Coordinate with DMAC to ensure conformance with SLAs	✓	✓
			Use and adhere to data standards		✓
			Collect, conduct quality control of, and provide data to the DMAC		✓
			Coordinate with DMAC to ensure correct and timely data exchanges (system administrator)		✓
			Generate special requests, evaluate potential changes, work with experimental data, and fulfill other nonroutine requirements		✓
	Modeling organization	Generate data and products used by other modeling tools or decision makers	Work together to establish and maintain effective data standards	✓	✓
			Ensure proper placement of correct assets and collection of the requested data	✓	✓
			Coordinate with DMAC to ensure conformance with SLAs	✓	✓
			Use and adhere to data standards		✓
			Collect, conduct quality control of, and provide data to the DMAC		✓
			Coordinate with DMAC to ensure correct and timely data exchanges (system administrator)		✓

Table 4-1. DMAC Roles and Responsibilities

Type	Title	Role	Responsibility	Design phase	Operational phase
			Generate special requests, evaluate potential changes, work with experimental data, and fulfill other nonroutine requirements		✓
Data user	Modeling organization	Use ocean data to generate data and products to assist with the seven societal goals	Identify and communicate current data requirements to DMAC	✓	✓
			Develop a detailed DMAC SLA	✓	✓
			Identify and communicate data requirements		✓
			Adhere to SLAs		✓
			Coordinate with DMAC to ensure correct and timely data exchanges		✓
			Make special requests and changes in requirements, as necessary		✓
	Portal user—research and public	Use DMAC portal to access IOOS data for research	Provide identification to determine authorization		✓
			Adhere to DMAC IA policies and procedures		✓
			Identify and communicate data requirements to DMAC		✓
Administrator	DMAC staff	Provide system administrator functions to serve external user community	Manage and protect the system, including ◆ data transport, ◆ storage, ◆ quality, ◆ portal support, ◆ user services (help desk support, grant access, etc.), ◆ IA, and ◆ SLA compliance		✓

Table 4-2 summarizes the current state, the improvements that the national IOOS DMAC will have on business processes, and respective challenges required to implement the enhancements associated with the collection, sharing, and use of ocean information data, products, and services.

Table 4-2. DMAC's Improvements to Business Operations

Activity	Current process	DMAC process	Challenges
Data transport	Point-to-point process Dispersed data, which requires a data "pull" from multiple locations to generate products Diverse data formats and exchanges process	Enables external exchange services Provides "one-stop" access to both raw and post-processed modeling data Encourages standard exchange process, but is enabled to support user needs	Accommodating large volumes of data Orchestrating and maintaining national and global data exchanges
Data assembly, quality control and transformation (standardization)	Various processes, at the discretion of data collectors Some tailored processes to support different data exchanges	Conducts quality control (at DACs) in a single process to support transmission to DMAC Conducts quality control (at DMAC) to protect against failure Transforms data from transport to storage format Organizes data for storage and access Archives data Updates received file logs	Establishing and maintaining data standardization governance Sustaining "partner" data assembly and quality control centers (DACs) Determining data storage and access methods, including transport and storage format Orchestrating and maintaining national and global use
Data storage	Various processes, at the discretion of system owners, data collectors, and specific users	Provides rapid access to frequently used data Moves less time-sensitive, less critical, or infrequently used data to less-expensive media, typically with slower access rates Makes archiving timelines known to all users	Understanding data-user requirements Creating, accepting, using, and enforcing data retention policies (SLA) Determining physical storage location
Access by modeling and decision support stakeholders	Point-to-point process across a variety of stovepiped systems each time data are needed	Makes broader set of data available Has data discovery tools Provides data in a variety of means convenient to the user	Creating, accepting, using, and enforcing data transmission policies (SLA) Establishing and maintaining data standardization governance Ensuring timely response to ad hoc requests in a usable format and structure Protecting the system and its data

Activity	Current process	DMAC process	Challenges
Portal services	Multiple systems, programs, and institutions maintain portals ◆ without consistency of design or content and ◆ generally with limited access to data	Establishes user categories (for public and registered users) to ◆ access static organizational information, ◆ conduct data discovery, and ◆ access data Requests data transport to a computer or to DMAC-provided modeling tools to generate output data formats, visuals, and reports	Determining, establishing, maintaining, and enforcing access policies for users Assessing system uses and requirements Determining, establishing, maintaining, and enforcing registration process
Information assurance	Various processes, at the discretion of system owners	Protects system and data from deliberate and inadvertent threats Protects security of data received and sent	Determining, establishing, maintaining, and enforcing policies, procedures, and technologies that support large numbers of users Ensuring DMAC's FISMA compliance, including compliance of its interfacing systems (government and privately owned) Incorporating IA planning early in system planning
Support services: data standards and governance	No standards[a]	Ensures that the meaning and structure of each data element are clear to all potential users	Coordinating with all external partners to ensure that ◆ standards are used or ◆ agreed-upon transformations are in place
Support services: SLAs	Not applicable	Defines the products and services that DMAC will provide	Establishing an agreement with each data exchange partner[b]
Support services: user support	Various processes, at the discretion of system owners	Performs help-desk functions Supports education, outreach, research, and marketing	Performing operational activities, funding, training, staffing, and housing and other infrastructure-related requirements

[a] The NOAA IOOS Program has established community-wide working groups, procedures, and IT tools to assist with establishing standards, and current projects like DIF are attempting to define standards.

[b] If the IOOS program determines that revenue can be generated from certain activities, SLAs will be vital to the business operations.

CHALLENGES AND IMPLICATIONS

As indicated throughout this document, the benefits associated with an IOOS are large. However, building a national-level DMAC is a substantial undertaking. Before proceeding, a team representing all stakeholders should further analyze particularly challenging areas, specifically, the following:

- Business case. Intuitively, there is little question of the value of a national IOOS. However, to ensure a sufficient funding stream, the business case must be developed. The IOOS program office is currently developing a business case. As the program matures the business case will be refined to meet OMB 300 requirements. The business case will require a clear sense of end-user data needs and activities. With the large number of independent observing systems, many with limited and specific missions, defining and aligning end-user requirements with the societal goals may prove challenging.
- Integration efforts. The national DMAC will be the keystone between the observing organizations and the modeling and analysis organizations. Coordinating efforts across the myriad partner organizations and components, with disparate data formats and disparate user needs, will be challenging. Coordination will require a firm understanding of each partner, including their current and planned observations, data, and data volumes. Then each must weigh in on the development and deployment of an IOOS DMAC implementation plan.
- Stakeholder initiatives. IOOS must integrate with existing initiatives and incorporate planned initiatives. Before this integration can occur, it will be necessary to determine a technical approach. For example, an interface could be created to allow an existing system to transfer data to and from the national DMAC. Another example approach is to allow observing organizations to transmit collected data to both their current system and the national DMAC. Once an approach is determined, interagency resources, funding, and scheduling must be allocated and defined.
- Data standards. Data exchanges, whether local or global, require a data architecture and supporting standards that meet the broad spectrum of user requirements. A system of systems, IOOS will incorporate, or integrate with, diverse stakeholder communities, some of which already have standards. These communities may be reluctant to embrace and use different standards.

NEXT STEPS

Before the DMAC subsystem can be designed and implemented, many critical questions must be answered. They can be grouped into the following categories:

- Functional requirements. Will IOOS incorporate existing data standards, develop new standards, or use a blend? This decision must include data formats. Will IOOS use a markup language like XML to provide uniform structure to the data?

- Technical requirements. Will the national DMAC be a system of DMACs (e.g., regional DMACs) linking existing systems, or a single DMAC?
- Deployment. How will IOOS be deployed? Will it be phased in based on modeling and analysis or observing organizations, societal benefit area, mission, or will an alternative method be used?
- Acquisition approach.[1] What approach will best meet IOOS requirements? For example, could DIF be expanded to become the DMAC subsystem? Can existing or developing systems be integrated to fulfill DMAC requirements or is an acquisition required?

Functional Requirements

The DMAC functional capabilities are summarized in Chapter 3 and documented in The Integrated Ocean Observing System High-Level Functional Requirements (April 2008).[2] In FY2009, the NOAA IOOS Program will develop DMAC functional use cases as part of a detailed functional requirements document (FRD). The FRD, in conjunction with other documentation, will be the basis for competitively acquiring a systems integrator (SI) that will initiate detailed functional and technical analysis and design work. That analysis will provide answers to the "hows" that are not addressed in this ConOps.

Technical Requirements

Detailed DMAC technical requirements will be developed over the 2011–2012 time frame. At the highest level, the technical requirements must address all of the following topics:

- Hardware
- Software
- Infrastructure, including networks
- Facilities.

Each of the above must address the following:

- High availability
- Scalability and ability to support modernization
- Performance

[1] The word acquisition is used to mean "obtain" and not necessarily to "buy."

[2] The High-Level Functional Requirements Document (HLFRD) is a compilation of IOOS requirements extracted from several existing IOOS documents. Further, they are IOOS-wide requirements and are broader than the DMAC.

- Information assurance, including COOP[3]
- Systems management, including configuration management
- Specific federal requirements.

The largest technical challenges for the DMAC center on the data:

- Large quantity of data to store and retrieve
- High volume of inputs and outputs
- Complex data characteristics that will evolve over time
- Data streams from different partners may need to be linked.

Other aspects of the data issue concern how the IOOS network of users interact in terms of roles and responsibilities and how they exchange data from both a functional and technical viewpoint. Is more or less responsibility put on the national DMAC, regional DMACs, and DACs? Design analysis needs to evaluate the concept of using XML, web services, and SoA as the basis for data exchange. This concept may also incorporate deployment of specialized network node computers with the sole task of managing data exchange tasks, including supporting SOA/web services queries to pull selected data. Another related challenge will be to effectively align the DIF, the regional DMACs, and other initiatives that are already underway with the national DMAC.

Deployment

Many factors must be considered when planning the DMAC development and deployment approach. Among these are the success and status of the DIF and other related initiatives, including regional DMACs.

The size and scope of IOOS and the steadily increasing number of deployed sensors and systems likely encourage an incremental implementation of the national DMAC. Any number of approaches could be taken, including either working “forward” by providing support to a select number of observing programs and their model users, or working “backward” from a modeling activity to include the necessary observing programs. Any approach selected must incorporate a “tooth to tail” solution to both ensure demonstration of the complete set of core DMAC capabilities and demonstrate the value of IOOS to government leaders and the public. Once one set of data providers and users is thoroughly tested and becomes operational, a new set can be incorporated. Ideally, the initial sets would be relatively small and simple, as long as no key component of the design is omitted. The deployment plan can also incorporate the best stages to establish support capabilities such as portal services and data discovery services, both of which can also be rolled out incrementally.

[3] Continuity of operations planning (COOP) refers to the internal effort of an organization to assure that the capability exists to continue essential functions in response to a comprehensive array of potential operational interruptions.

Acquisition Approach

Acknowledging the need for careful planning of this large national DMAC capability, the NOAA IOOS Program will utilize the acquisition method prescribed by NOAA and the Department of Commerce and will incorporate some approaches from NASA and DoD as well. This ConOps is the first step on an acquisition path. It defines, at a high level, the NOAA IOOS program and the scope and functionality to be obtained at the national level, viz. the national DMAC. The ConOps will assist the stakeholder community with understanding what is planned and will give them a basis for providing input that can be used to further refine those plans.

The next step will be developing an analysis of approaches. This analysis will identify and analyze various alternatives to meet the IOOS DMAC requirements. Potential alternatives may include remaining in the current state; gradually expanding the DIF into DMAC; using the DIF as a pilot DMAC, but competitively acquiring the production capability; and leveraging and weaving various existing resources into a DMAC. NOAA will analyze the approaches and select the one that is most practicable. This decision will direct the production of an analysis of alternatives (AoA) scheduled for completion in FY 2009, which will identify various alternatives to obtaining the capabilities associated with the selected approach.

Parallel and related to work on the analysis of approaches will be the development of an IOOS business case that will address the Office of Management and Budget Form 300 requirements. Both the AoA and the business case will address the financial requirements and return on investment of the IOOS program. This will in turn lead to the development and documentation of a specific acquisition strategy.

If the analysis indicates a need for an acquisition, the current notional NOAA acquisition plan calls for a two-step acquisition process. The first step is the competitive acquisition of a system integrator (SI). The SI will be given about one calendar year to assist with the technical analysis of alternatives and prepare system design documents. As in any analysis, this effort will include attaining an understanding of requirements and current capabilities.

The second step will occur once the overall design is completed. Using the integrator’s preliminary design, NOAA will competitively acquire a DMAC development contractor. The SI will continue to support NOAA in releasing a competitive request for proposals (RFP) for DMAC development, deployment, and operation. Current plans envision incorporating some form of competitive prototyping as a part of that acquisition effort. Specifically, considering RFP responses, the NOAA IOOS Program will provide selected vendors with limited funding to develop a demonstration of their solution. After evaluating the demonstrations, the NOAA IOOS Program will select the best solution and award a final contract.

Upon contract award, NOAA and the developer will complete the analysis and design, which will include developing a rollout plan.

Appendix A
Observing Organizations

This appendix contains a table listing observing organizations and, for each, showing the systems used, programs supported, and data collected. This appendix was created using existing documentation. It is not a complete list; rather, it is a working document, intended to promote discussion and to be further refined.

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
Caribbean Regional Association (CaRA)	being developed						
National Oceanic and Atmospheric Administration (NOAA)	Coral Health and Monitoring Program (NOAA/OAR)	Integrated Coral Observing Network (ICON), formerly Coral Reef Early Warning System (CREWS)	http://www.coral.noaa.gov/	data || http://www.coral.noaa.gov/	Air Temperature, Wind Speed/Direction, Barometric Pressure, Photosynthetically Active Radiation (PAR), Ultraviolet Radiation (UVR), Salinity, Sea Temperature	US Coral Reefs	
Central and Northern California Ocean Observing System (CeNCOOS)	California Center for Integrative Coastal Ocean Research and Education (CICORE)	Hyperspectral Imagery, Coastal Time Series, Underway Acquisition, Bathymetry	http://www.cicore.org/	Archived & Near Real Time at CICORE website	Hyperspectral Imagery (aircraft overflights), Water Temperature, Conductivity, Spectral Absorption and Attenuation Coefficients, Pigment Concentrations, Water Leaving Radiances, Photosynthetically Active Radiation (PAR), Irradiance, Water Temperature, Salinity, Beam-c, Nutrients, Phytoplankton Composition, Zooplankton Composition	California coast	
Central and Northern California Ocean Observing System (CeNCOOS)	Center for Integrated Marine Technologies	Shipboard Data, Mooring Data	http://cimt.ucsc.edu/	http://cimt.ucsc.edu/data_portal.htm	120khz Echosounder, 200khz Echosounder, 600khz Echosounder, Flow-through Thermosalinograph, Turbidity, and Fluorometry, Marine Mammal and Seabird Observations, Large Mammal tracking via Satellite Tags, Macro/Micro Nutrients, Zooplankton abundance, distribution, and Community Structure, Conductivity, Temperature, Fluorescence, Total Suspended Solids, Chromophoric Dissolved Organic Matter (CDOM), Chlorophyll and Phaeopigment Fluorescence, Quantification of HABs through Molecular Probes, Domoic Acid Measurements, Air Temperature, Relative Humidity, Barometric Pressure, Wind Speed/Direction, Buoy Heading, Relative Wind Direction, pCO2, Near-surface (0-300m@8m bins), 300, 150, and 75khz ADCP, Near-surface CTD with Fluorometer and Transmissometer, Near-surface Nitrate, Near-surface O2, Near-surface Optical Backscatter, Near-surface Chlorophyll Fluorescence, Above Surface 10m, 20m Downwelling Irradiance and PAR, Discrete Thermistor (10 Depths), Autonomous Biological Observation system, Passive Acoustics System	California coast	
Central and Northern California Ocean Observing System (CeNCOOS)	Monterey Bay Aquarium Research Institute (MBARI)	MBARI Ocean Observing System (MOOS)	http://www.mbari.org/bog/Projects/MOOS/Default.htm	http://dods.mbari.org/lasOASIS/main.pl?	Current Speed/Direction, Conductivity, Temperature, Water Depth, Nitrate, Photosynthetically Active Radiation (PAR), Downwelling Irradiance, Upwelling Irradiance, Atmospheric Pressure, O2, Optical Back Scatter, CO2, Chlorophyll Fluorescence, Salinity, Optical Clarity, Relative Humidity, Wind Speed/Direction	Monterey Bay	

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
Central and Northern California Ocean Observing System (CeNCOOS)	Naval Postgraduate School	Monterey Inner Shelf Observatory (MISO)	http://www.oc.nps.navy.mil/~stanton/miso/	http://www.oc.nps.navy.mil/~stanton/miso/	Air Temperature, Humidity, Precipitation, Barometric Pressure, Shortwave and Longwave Isolation, Sea Bed sediment forms (structured light camera ad mapping acoustic altimeter), Directional Wave Spectra, Water Depth, Current Vector Velocity Profiles, Surf Zone Morphology Changes Using Quantitative Video	Monterey Bay	
Central and Northern California Ocean Observing System (CeNCOOS)	Bodega Marine Laboratory, University of California at Davis	Bodgea Ocean Observing Node	http://www.bml.ucdavis.edu/boon/	http://www.bml.ucdavis.edu/boon/metadata.html	Air Temperature, Humidity, Precipitation, Winds, Barometric Pressure, Relative Humidity, Surface Currents, Waves, Photosynthetically Active and Radiation, Ocean Salinity, Temperatures, ADCP		
Central and Northern California Ocean Observing System (CeNCOOS)	Coastal Oceans Currents Monitoring Program (COCMP)	HF Radar Network	http://www.cocmp.org/index.html	Multiple feeds. Query http://oceanobs.org/map/index.php for details	Surface Currents	California coast	
Central and Northern California Ocean Observing System (CeNCOOS)	San Francisco State University, Romberg Tiburon Center	San Francisco Bay Environmental Assessment and Monitoring Station	http://oceanobs.org/map/index.php	Multiple links under http://sfbeams.sfsu.edu/download.htm	Water Quality, Weather, Surface Currents, Nutrients	SF Bay	
Central and Northern California Ocean Observing System (CeNCOOS)	University of California Santa Barbara	UCSB Ocean Surface Currents Mapping Project	http://www.icess.ucsb.edu/iog/realtime/index.php	see POC website	surface currents	California Channel Islands	
Central and Northern California Ocean Observing System (CeNCOOS)		Pacific Coast Ocean Observing System (PaCOOS)		http://www.pacoos.org/	Major system within Regional Infrastructure, Specific Data Types, Broad Umbrella for additional Services and Data		
Environmental Protection Agency (EPA)	Beach monitoring, warnings, and closures (program functional area),	EPA's Beach Environmental Assessment and Coastal Health (BEACH)Program	http://www.epa.gov/ waterscience/beaches/2000/		Beach Profile, Water Quality, Advisories and Closings, Local Contacts		
Environmental Protection Agency (EPA)	National Coastal Assessment (NCA) program	EPA's National Coastal Assessment Program	http://www.epa.gov/emap/nca/		Estuarine and Coastal Water Column, Sediment Contaminants and Toxicity, Benthic Macroinvertebrate and Demersal Fish Communities and Contaminants Data		
Environmental Protection Agency (EPA)	National Estuary Program (NEP)	EPA's National Estuary Program	http://www.epa.gov/nep/		Data on 28 Estuary Areas		

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
Great Lakes Observing Systems (GLOS)	University of Wisconsin Milwaukee, Great Lakes WATER Institute	Coastal Stations	http://glos.us/	http://www.glwi.uwm.edu/features/wxstation/	Air Temperature, Winds, Pressure, Precipitation, Relative Humidity, Water Temperature, Solar Radiation, Dissolved Oxygen, Chlorophyll		
Great Lakes Observing Systems (GLOS)	University of Michigan Marine Hydrodynamics Laboratories	Weather Buoys	http://www.engin.umich.edu/dept/name/facilities/mhl/projects/gtbos_2007.html	NDBC	Air Temperature, Water Temperature, Winds, Waves		
Alaska Ocean Observing System (AOOS)	University of Alaska Fairbanks, Institute of Marine Science	GLOBEC LTOP stations in the Northern Gulf of Alaska	http://www.ims.uaf.edu/GLOBEC/intro/index.html	http://www.ims.uaf.edu/GLOBEC/results/	Temperature, Salinity, Sigma t, Current Speed/Direction, Fluorescence, Nitrate, Ammonium, Silicate, Phosphate, Zooplankton (biomass, abundance, species), Fish (biomass, abundance, species)		
Alaska Ocean Observing System (AOOS)	Alaska Satellite Facility, University of Alaska Fairbanks	Synthetic Aperture Radar		http://wind.asf.alaska.edu/windspeed/sar_web/	Coast winds		
Alaska Ocean Observing System (AOOS)	University of Alaska Fairbanks	Sea-Air-Land Modeling and Observing Network (SALMON)		. http://www.ims.uaf.edu/salmon/index.html			
Alaska Ocean Observing System (AOOS)	National Resources Conservation Service (NRCS), U.S. Department of Agriculture	SNOTEL		http://ak.aoos.org/GMT/maps_i.php?START_HERE=AK	wind speed and direction, air temperature, air pressure, precipitation from rain and snow, and solar radiation		
Alaska Ocean Observing System (AOOS)	Prince William Sound Science Center	Prince William Sound Nowcast-Forecast System		http://ak.aoos.org/pws/	Water Temperature, Salinity, Water Level, Tides, Currents, Plankton and nekton net surveys, Wind Speed/Direction, Atmospheric Pressure, Air Temperature, Dew point		
Gulf of Mexico Regional Association	Louisiana Universities Marine Consortium Environmental Monitoring data	Gulf of Mexico Coastal Ocean Observing System (GCOOS)		http://www.lumcon.edu/	Air Temperature, Relative humidity, Wind Speed/Direction, Barometric Pressure, Solar Radiation, Quantum Radiation (PAR), Precipitation (daily), Water Temperature, Water Height, Salinity	GCOOS RIN	
Gulf of Mexico Regional Association	Northern Gulf of Mexico Littoral Initiative	Gulf of Mexico Coastal Ocean Observing System (GCOOS)		http://gcmd.nasa.gov/records/GCMD_gov.noaa.ngdc.G02123.html	Wind Direction, Wind Speed, Wind Gust, Wave Height, Significant Wave Height, Maximum Wave Height, Dominant Wave Direction, Dominant Wave Period, Average Wave period, Atmospheric Pressure, Pressure Tendency, Air Temperature, Water Temperature, Dew point, Visibility, Sky Conditions, Relative Humidity, Current Speed/Direction, Surface Currents, Sea Surface Height, Sea Surface Salinity, Water Level Sediment Composition/Distribution, Sea Surface Temperature, Water Depth, Stream Flow, Precipitation, Salinity, Specific Conductance	GCOOS RIN	
Gulf of Mexico Regional Association	Texas Automated Buoy System	Gulf of Mexico Coastal Ocean Observing System (GCOOS)		http://tabs.gerg.tamu.edu/Tglo/		GCOOS RIN	
Gulf of Mexico Regional Association	Texas Coastal Ocean Observation Network	Gulf of Mexico Coastal Ocean Observing System (GCOOS)		http://lighthouse.tamucc.edu/TCOON/HomePage	Primary Water Level, Water Temperature, Wind Speed/Direction	GCOOS RIN	

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
Gulf of Mexico Regional Association	Wave Current Surge Information System	Gulf of Mexico Coastal Ocean Observing System (GCOOS)		http://wavcis.csi.lsu.edu/	120khz Echosounder, 200khz Echosounder, 600khz Echosounder, Flow-through Thermosalinograph, Turbidity, and Fluorometry, Marine Mammal and Seabird Observations, Large Mammal tracking via Satellite Tags, Macro/Micro Nutrients, Zooplankton abundance, distribution, and Community Structure, Conductivity, Temperature, Fluorescence, Total Suspended Solids, Chromophoric Dissolved Organic Matter (CDOM), Chlorophyll and Phaeopigment Fluorescence, Quantification of HABs through Molecular Probes, Domoic Acid Measurements, Air Temperature, Relative Humidity, Barometric Pressure, Wind Speed/Direction, Buoy Heading, Relative Wind Direction, pCO2, Near-surface (0-300m@8m bins), 300, 150, and 75khz ADCP, Near-surface CTD with Fluorometer and Transmissometer, Near-surface Nitrate, Near-surface O2, Near-surface Optical Backscatter, Near-surface Chlorophyll Fluorescence, Above Surface 10m, 20m Downwelling Irradiance and PAR, Discrete Thermistor (10 Depths), Autonomous Biological Observation system, Passive Acoustics System	GCOOS RIN	
Hawaiian and southern Pacific Regional Association	Hawaii Ocean Time-series program	Insular Pacific-Hawaiian Integrated Ocean Observing System (PacIOOS)		http://hahana.soest.hawaii.edu/hot/hot.html			
Incorporated Research Institutions for Seismology	Incorporated Research Institutions for Seismology (IRIS)	Global Seismic Network (GSN)		http://www.iris.edu/	Waveform (passive, active), Event Catalogs, Channel Responses		
Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)	Alliance for the Chesapeake Bay Citizen Monitoring Program			http://www.alliancechesbay.org/project.cfm?vid=87	Dissolved O2, pH, Water Clarity, Light Attenuation Coefficient, Chlorophyll-a, Pheophytin, Air Temperature, Nutrients, Salinity, Transparency, Suspended Solids	Chesapeake Bay	
Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)	Chesapeake Bay Mouth Monthly			http://www.ccpo.odu.edu/~jay/cheshome.html	Conductivity, Water Temperature, Water Depth	Chesapeake Bay	
Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)	MACOORA Chesapeake Bay Observing System			http://www.cbos.org/	Wind Speed/Direction, Wind Gust, Air Temperature, Relative Humidity, Current Speed/Direction, Conductivity, Water Temperature, Salinity, Dissolved O2, Rainfall, Photosynthetically Active Radiation (PAR), Ocean Color	Chesapeake Bay	

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)	Maryland Department of Natural Resources–Eyes on the Bay			http://mddnr.chesapeakebay.net/eyesonthebay/index.cfm	Water Temperature, Salinity, Dissolved O2, pH, Turbidity, Chlorophyll, Algal Bloom Updates	Chesapeake Bay	
National Aeronautics and Space Administration (NASA)	Earth Observing System	Aqua and Terra Satellites	http://eospso.gsfc.nasa.gov/eos_homepage/description.php	http://eospso.gsfc.nasa.gov/eos_homepage/data_services.php | also see PO DAAC entry	sea surface temperature, ocean color		
National Aeronautics and Space Administration (NASA)	Goddard Space Flight Center	SeaWiFs system	http://oceancolor.gsfc.nasa.gov/SeaWiFS/	requires special arrangements. See http://oceancolor.gsfc.nasa.gov/SeaWiFS/ANNOUNCEMENTS/getting_data.html	ocean color		
National Aeronautics and Space Administration (NASA)	Goddard Space Flight Center	TRMM Satellite		http://disc.sci.gsfc.nasa.gov/data/datapool/TRMM/	tropical rainfall		
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Archive: National Geophysical Data Center (NGDC)		NGDC NOAA National Data Centers; Bolder, CO	Geomagnetic Data and Models; Marine Geology and Geophysics; Natural Hazards; Bathymetry and Global Relief; Defense Meteorological Support Program satellite data; Coastal mapping; Benthic habitat mapping and monitoring; Hydrographic survey (1)Geomagnetic data (surface, airborne, ocean, satellite), Marine Geology and Geophysics data (Bathymetry and fishing maps, coastal relief, coast lines, global relief, GLOBE project, Great Lakes bathymetry, topography and relief, hydrographic survey, international hydrographic digital bathymetry, ocean mapping, measured and estimated bathymetry, multibeam acoustics, state image topography, trackline bathymetry), Natural Hazards (tropical cyclones, earthquakes, tsunami, volcano, wildfire), Bathymetry and Global Relief (bathymetry, topography and relief, marine geophysics, marine geology), Earth Observation (DMSP data), Space Weather (space weather), (4)		
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Commercial fishing statistics		http://www.st.nmfs.noaa.gov/st1/commercial/index.html	Commercial fish catch statistics		
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Habitat Assessments	http://www.nmfs.noaa.gov/habitat/	(multiple sources; search habitat survey site:noaa.gov			

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Living Marine Resources and Ecosystem Surveys	http://www.st.nmfs.noaa.gov/st7/index.html	(multiple sources; search POC website)	Plankton abundance; Abundance and distribution of LMRs & protected species; Population statistics; Salinity; Chlorophyll; Dissolved Inorganic Nutrients; Temperature		
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Marine Recreational Fisheries Statistics Surveys	http://www.st.nmfs.noaa.gov/st1/recreational/index.html	http://www.st.nmfs.noaa.gov/st1/recreational/queries/index.html	Recreation fisheries catch and effort data series		
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	National Observer Program	http://www.st.nmfs.noaa.gov/st4/nop/	http://www.st.nmfs.noaa.gov/st1/commercial/index.html	Abundance and distribution of LMRs & protected species; Population statistics; Fish catch		
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Protected Resources Surveys	http://www.nmfs.noaa.gov/pr/	(multiple sources; search POC website for 'surveys')	Abundance and distribution of LMRs & protected species		
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Fisheries Information Networks	http://www.st.nmfs.noaa.gov/fis/partnerships/fins.html	(see multiple listing on POC entry)	Recreational and commercial fishing statistics; Living marine resources ecosystem surveys; Benthic habitat surveys; Marine species data		
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	Coastal Change Analysis Program (C-CAP)	http://www.csc.noaa.gov/crs/lca/ccap.html	http://www.csc.noaa.gov/crs/lca/locateftp.html	Land use change maps		
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	National Current Observation Program	http://co-ops.nos.noaa.gov/ncop.html	http://co-ops.nos.noaa.gov/station_retrieve.shtml?type=Current+Data	(See PORTS entry)		
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	National Status and Trends Program	http://ccma.nos.noaa.gov/stressors/pollution/nsandt/	See Mussel Watch Project, Benthic Surveillance Project, Bioeffects Assessment Project	varies; pollution and water quality parameters		
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	NERRS SWMP (System-wide Monitoring Program)	http://www.nerrs.noaa.gov/welcome.html	http://cdmo.baruch.sc.edu/QueryPages/googlemap.cfm	Sea Surface winds; Temperature; Salinity; Chlorophyll; Dissolved Inorganic Nutrients(1) (5) Water Temperature, Specific Conductivity, Salinity, Water Depth, Dissolved O2, pH, Turbidity, Wind Speed/Direction, Barometric Pressure, Air Temperature, Relative Humidity, Rainfall, Photosynthetically Active Radiation (PAR)		

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	NWLON (National Water Level Observation Network)	http://tidesandcurrents.noaa.gov/nwlon.html	http://tidesandcurrents.noaa.gov/station_retrieve.shtml	Water level (6 minute, hourly, highs, lows), Water Temperature, Conductivity, wind, Barometric Pressure, Air Temperature, Relative Humidity		
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	PORTS (Physical Oceanographic Real-Time System	http://tidesandcurrents.noaa.gov/ports.html	http://opendap.co-ops.nos.noaa.gov/content/	Water Levels, surface meterology, currents, water temperature		
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite, Data, and Information Service	CoastWatch	http://coastwatch.noaa.gov/cw_index.html	http://coastwatch.noaa.gov/cw_dataprod.html plus six regional nodes	Sea Surface Temperature, Ocean Color, Ocean Surface Winds	six regional nodes covering all US	
National Oceanic and Atmospheric Administration (NOAA)	Atlantic Oceanographic and Meteorological Laboratory (AOML) + international collaboration	Global Ocean Observing System Center - Ship of Opportunity Program: XBT Lines, Thermosalinograph, Argo Profiling Floats	http://www.aoml.noaa.gov/phod/goos.php	Multiple Access points: AOML, NODC, NDBC and US GODAE Server - http://www.usgodae.org/cgi-bin/datalist.pl?generate=summary	GOOS Data sets: ARGO floats, High Density XBT, Low Density XBT, sea surface temp and salinity (thermosalinographs)	Covers Regional, National and Global Data Types	
National Oceanic and Atmospheric Administration (NOAA)	Minerals Management Service (by agreement with commercial oil industry)	Data from oil platforms		http://www.ndbc.noaa.gov/maps/ADCP_WestGulf.shtml	currents, current profiles	Gulf of Mexico	
National Oceanic and Atmospheric Administration (NOAA)	National Data Buoy Center (NDBC)	Moored buoys (Tropical array)	http://tao.noaa.gov/	http://tao.noaa.gov/	Temperature; Salinity; Waves; Currents; Sea Surface Topography; Sea Surface Winds		
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service (NOS)	NOS Data Explorer	See page http://oceanservice.noaa.gov/dataexplorer/welcome.html	http://oceanservice.noaa.gov/dataexplorer/welcome.html	provide access to nautical charting, bathymetry/topography, shoreline, global positioning, tides and currents remotely sensed imagery, marine boundaries, hurricanes, environmental monitoring collected by NOS		
Multiple Agencies	International Arctic Buoy Programme (IABP) http://iabp.apl.washington.edu/	Arctic Ice Buoys	http://www.crrel.usace.army.mil/sid/IMB/	http://www.crrel.usace.army.mil/sid/IMB/	Ice mass balance, thickness, drift and surface meteorology		
National Oceanic and Atmospheric Administration (NOAA)	Atlantic Oceanographic and Meteorological Laboratory (AOML)	Global Drifter Program	http://www.aoml.noaa.gov/phod/dac/gdp_information.html	http://www.aoml.noaa.gov/phod/dac/dacdata.html	Temperature; Salinity; Winds; Currents; Sea surface topography		
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Geostationary Operational Environmental Satellites (GOES)	http://www.oso.noaa.gov/goes/index.htm	multiple access points including http://www.goes.noaa.gov/	Sea surface temperature and marine meteorological parameters		

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
National Oceanic and Atmospheric Administration (NOAA)	Joint Commission on Oceanography and Marine Meteorology (JCOMM)	Global Sea Level Observing System (GLOSS)	http://www.gloss-sealevel.org/	http://www.gloss-sealevel.org/data/	Sea level		
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service (NOS)	Hydrographic survey	http://www.oceanservice.noaa.gov/topics/navops/hydrosurvey/welcome.html	http://www.ngdc.noaa.gov/mgg/bathymetry/hydro.html	Habitat & Bathymetry		
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Polar Operational Environmental Satellite (POES)	http://www.oso.noaa.gov/poes/	Multiple access points: http://www.osdpd.noaa.gov/PSB/PSB.html | CLASS at http://www.nsof.class.noaa.gov/saa/products/welcome | and Coastwatch servers	Sea surface temperatures and imagery.		
National Science Foundation (NSF)		Ocean Research Interactive Observatory Networks (ORION)			Research Data from NSF Ocean Observatories		
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service	ASOS (Automated Surface Observing System)	http://www.nws.noaa.gov/asos/	http://www.ndbc.noaa.gov/rmd.shtml	Surface meteorology		
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service	C-MAN (Coastal Marine Automated Network)	http://www.ndbc.noaa.gov/cman.php	http://www.ndbc.noaa.gov/rmd.shtml	Surface meteorology		
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service	DART (Deep-Ocean Assessment and Reporting of Tsunamis)		http://www.ndbc.noaa.gov/dart.shtml			
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service	NDBC Moored Buoys	http://www.ndbc.noaa.gov/mooredbuoy.shtml	http://www.ndbc.noaa.gov/rmd.shtml	Wind speed & direction, wave period, height, direction; air pressure, sea surface temperature		
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service	VOS (Voluntary Observing Ship Program)	http://www.vos.noaa.gov/	http://www.ndbc.noaa.gov/ship_obs.php	Surface meteorology, surface temperature and salinity		
Northeast Regional Association (NERA)		Coastal Ocean Observation Laboratory		http://marine.rutgers.edu/mrs/			
Northeast Regional Association (NERA)		Coastal Ocean Observing and Analysis system		http://www.neracoos.org/			

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
Northeast Regional Association (NERA)		Gulf of Maine Ocean Observing System		http://www.gomoos.org/			
Northeast Regional Association (NERA)		Martha's Vineyard Coastal Observatory		http://mvcodata.whoi.edu/cgi-bin/mvco/mvco.cgi			
Northeast Regional Association (NERA)		Monitoring Your Sound system					
Northeast Regional Association (NERA)		New Jersey Coastal Monitoring Network		http://cmn.dl.stevens-tech.edu/			
Northwest Regional Association	Bodega Ocean Observing Node	Northwest Association of Networked Ocean Observing Systems (NANOOS)		www-bml.ucdavis.edu/boon/	Surface Current Mapping, Depth Profile, Water Temperature, Salinity, Wind, Meteorological Parameters, Chlorophyll Fluorescence, Water Properties, Plankton		
Northwest Regional Association	Columbia River Estuary Real-Time Observation and Forecasting System	Northwest Association of Networked Ocean Observing Systems (NANOOS)		http://www.ccalmr.ogi.edu/CORIE/	Current Velocity, Current Direction, Water Temperature, Salinity, Water Level, Conductivity, Wind Speed/Direction		
Northwest Regional Association	node of the Coastal Storms Program	Northwest Association of Networked Ocean Observing Systems (NANOOS)		http://www.csc.noaa.gov/csp/pacific_nw/pacific_nw.html	Sea Surface Height, Air Temperature, Winds, Atmospheric Pressure, Specific Conductance, Water Temperature		
Northwest Regional Association	Oregon State University Coastal Observations	Northwest Association of Networked Ocean Observing Systems (NANOOS)		http://agate.coas.oregonstate.edu/index.html	Wind, Water Depth, Sea Surface Temperature, Water Temperature at Depth, Currents, Plankton, Nutrients, O2, Fluorescence, Conductivity, Hydrographic Measurements		
Pacific Marine Environmental Laboratory (PMEL)		Pacific Marine Environmental Laboratory (PMEL)			variety ocean climate and environmental data (1) Ocean Climate (TMAP, CO2, Atmospheric Chemistry, TAO, Chlorofluorocarbons, ARGO profiling floats), Ocean Environment (tsunamis, vents, FOCI, SEBSCC) (5)	Covers Regional, National and Global Services, Varied Systems	
Pacific NW Regional Association							
National Aeronautics and Space Administration (NASA)	Physical Oceanography Distributed Active Archive Center (PO DAAC)	multiple satellite data streams		http://podaac.jpl.nasa.gov/	access to physical oceanography observations from the TOPEX/Poseidon, WindSat, Jason-1, GeoSat and GeoSat Follow-on, and SeaSat observing satellites		
Southeast Regional Association	Carolinas Coastal Ocean Observing and Prediction system	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://www.carocoops.org/carocoops_website/index.php	Water Level, Water Temperature, Barometric Pressure, Air Temperature, Relative humidity, Wind Speed/Direction, Current Speed/Direction, Bottom Currents, Wave Height/Period/Direction, Chlorophyll, NO3 and Br		

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
Southeast Regional Association	Coastal Ocean Research and Monitoring Program	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://www.cormp.org/	Sea Surface Temperature, Salinity, Conductivity, Water Temperature, Pressure, Water Level, Nutrients, Currents, Seabed Elevation, Sediment Grain Size, Turbidity, Photosynthetically Active Radiation (PAR), Colored Dissolved Organic Matter, Particulate Matter, Bentich Ecology (larval fish trap samples, box core and grab samples, underwater surveys)		
Southeast Regional Association	East Florida Shelf Information System	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://efsis.rsmas.miami.edu/			
Southeast Regional Association	FerryMon Program	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://www.unc.edu/ims/paerllab/research/ferrymon/index.html	Surface Water Temperature, Salinity, Dissolved O2, pH, Turbidity, Chlorophyll-a Fluorescence, Nutrients, Diagnostic Pigments		
Southeast Regional Association	Florida Inshore Marine Monitoring and Assessment Program	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://floridamarine.org/features/category_sub.asp?id=3448	Water Temperature, Dissolved O2, Water Depth, Salinity, pH, Nutrients, Chlorophyll a, Bottom Type, Macrobenthos, Sediment Grain Size, Total Organic Carbon, PCBs, Percent Silt-clay, Submerged Aquatic Vegetation (multiple indicator parameters), Sediment Contaminants, Contaminant Residues in Fish, Stable isotopes of Nitrogen in Fish, Presence of Pfiesteria-like Organisms in Sediments, Pesticides		
Southeast Regional Association	Neuse River Remote Monitoring and Data Acquisition Project	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://www.unc.edu/ims/neuse/modmon/	Air Temperature, Water Depth, Barometric Pressure, Water Temperature, Dissolved O2, Wind Speed/Direction, pH, Oxidation-reduction, Specific Conductivity, Salinity, Relative Humidity, Rainfall		
Southeast Regional Association	North Carolina Coastal Ocean Observing System	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://nccoos.org/	currents, water temperature, salinity, dissolved O2, wave height, wave velocity, depth, bottom temperature, air temperature, wind speed/direction, wind gust, relative humidity, barometric pressure, precipitation, shortwave radiation, longwave radiation, density, surf conditions		
Southeast Regional Association	SEAKEYS	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://www.keysmarinelab.org/seakeys.htm	Water Temperature, Wind Speed/Direction, Tides/Water Level, Salinity, Fluorescence, Transmissivity, Barometric Pressure, Air Temperature, Relative humidity, Conductivity, Precipitation, Photosynthetically Active Radiation (PAR)		

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
Southeast Regional Association	South Atlantic Bight Synoptic Offshore Observational Network	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://www.skio.usg.edu:443/research/sabsoon/	Wind Direction/Speed, Air Temperature, Barometric Pressure, Relative Humidity, Rainfall, Long-wave and Short-wave Radiation, Photosynthetically Active Radiation (PAR), Water Depth for Packages, Conductivity (salinity), Water Temperature, Fluorescence (chlorophyll), Downwelling Irradiance (PAR), Current Speed/Direction, Waves/Tides, Fisheries Video		
Southeast Regional Association	South Florida Ocean Measurement Center	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://www.sfomc.org/	Currents, Temperature, Salinity, Water Depth, Acoustics		
Southeast Regional Association	Southeast Atlantic Coastal Ocean Observing System	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://www.seacoos.org/	Sea surface temperature, coastal winds, water level		
Southeast Regional Association	West Florida Coastal Ocean Monitoring and Prediction System	Southeast Coastal Ocean Observing Regional Association (SECOORA)		http://comps.marine.usf.edu/	Wind, Air Temperature, Humidity, Barometric Pressure, Precipitation, Radiation, Visibility, Water level, Water Temperature, Salinity, Current Velocity, Waves, O2, Fluorescence, Turbidity		
Southeastern Universities Research Association (SURA)	integration of large research activities				Chlorophyll, convection, merged sea surface temperature, radiance, sea surface temperature, water level, air pressure at sea level, air temperature, direction of sea water velocity, direction of wind wave velocity, eastward sea water velocity, eastward wind, northward sea water velocity, northward wind, precipitation amount, sea surface temperature, sea water elevation, sea water speed, significant height of wind waves, wind speed, wind wave period	Data from: SEACOOS, NOAA, Bedford Institute of Oceanography, LSU, TAMU, U of Florida, U of Miami (RSMAS), UNC, VIMS	
Southern California Regional Association	California Cooperative Oceanic Fisheries Investigations program	Southern California Coastal Ocean Observing System (SCCOOS)		http://www-mlrg.ucsd.edu/	Water Depth, Water Temperature, Salinity, Dissolved O2, Photosynthetically Active Radiation (PAR), Fluorescence, Transmissivity, Nutrients (NO3, NO2, PO4, SiO3), Phytoplankton Pigments, Primary Production (C14 Uptake), Current Speed/Direction, Zooplankton Biomass (plankton volume, acoustic backscatter), Plankton Tow Samples, Pelagic Seabird Counts, Meteorological Observations, Wave Height/Direction/Water Color		
Southern California Regional Association	Coastal Data Information Program	Southern California Coastal Ocean Observing System (SCCOOS)		http://cdip.ucsd.edu/	Wave Energy, Wave Period, Wave Direction, Wind Speed/Direction, Sea Surface Temperature, Air Temperature, Sea Surface Pressure		

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
Southern California Regional Association	Southern California Coastal Water Research Project Authority	Southern California Coastal Ocean Observing System (SCCOOS)		http://www.sccwrp.org/	Sediment chemistry, Infaunal Biomass and Abundance, Trawl Fish and Invertebrates, Sediment and Water Column Toxicity, Wetland Extent and Quality, Bacterial Water Quality, Toxic Contaminant Source emission Inventories, Wet and Dry Atmospheric Deposition Rates of Toxic Contaminants, Bulk and Surface Microlayer Concentrations of Toxic Contaminants		
Southern California Regional Association	SCCOOS PaCOOS Data				Physical and Biologic Observations to Provide California Current Large Marine Ecosystem Data		
US Army Corps of Engineers (USACE)	Coastal Field Data Collection Program				Wind Speed, Wind Direction, Relative humidity, Barometric Pressure, Air Temperature, Rainfall, Wave Height, Wave Period, Wave Direction, High Resolution Directional Wave Spectrum, Water Depth, Conductivity, Tides, Water Density, Water Temperature Profile, Salinity, Vertical Current Profile, Local Topography, Bathymetry	Specific Topical Data Assembly, Pulls Data from a Variety of Sources to Provide Specific Products and Services Related to Coastal Monitoring	
US Army Corps of Engineers (USACE)	Coastal Field Data Collection Program Wave Gauges				Wave Height, Wave Period, Wave Direction, Water Depth		
US Army Corps of Engineers (USACE)	Field Research Data Program (FRDP)			North Carolina	Wind Speed, Wind Direction, Relative humidity, Barometric Pressure, Air Temperature, Rainfall, Wave Height, Wave Period, Wave Direction, High Resolution Directional Wave Spectrum, Water Depth, Conductivity, Tides, Water Density, Water Temperature Profile, Salinity, Vertical Current Profile, Local Topography, Bathymetry		
US Army Corps of Engineers (USACE)		Hydrographic surveying			Habitat & Bathymetry		
US Geological Survey	National Stream Quality Accounting Network (NSQAN)				Stream Flow (discharge), Water Level (gauge height), Dissolved O2, pH, Specific Conductance, Water Temperature		
US Geological Survey	National Streamflow Information Program (NSIP)				Stream flow; Coastal Sea Level-Topography		
US Geological Survey		Benthic habitat mapping			Habitat & Bathymetry		
US Geological Survey		Coastal change mapping			Habitat & Bathymetry		
US Geological Survey		Coral reef mapping			Habitat & Bathymetry		
US Geological Survey		Coral reef monitoring			Habitat & Bathymetry		
US Geological Survey		Stream gauging			Stream flow		

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
US Geological Survey					Water Flow, Water Quality, Water level, Geo-one Stop, EROS, National Atlas, NBII Meta-data, Natural Hazards (earthquake, flood, hurricane, tsunamis) Data		
US Navy	Altimeter Data Fusions Center (ADFC)				Coastal Sea Level Topography		
US Navy	Fleet Numerical Meteorology and Oceanography Center			https://www.fnmoc.navy.mil/public/	GODAE, Wave Watch, Wave Watch 3, Navy Ocean Data Assimilation, Optimum Thermal Interpretation Data, La Nina and El Nino data, Oceanography, meteorology, Model Performance, Tropical Applications, Satellite, Climatology data		
US Navy	Geodetic Satellite (Geosat) follow-on			http://gfo.bmpcoe.org/gfo/	Waves; Winds		
US Navy	Integrated buoy program				Temperature; Salinity; Waves; Winds; Sea Surface Winds		
US Navy	Naval Oceanographic Office (NAVOCEANO)	Altimeter Data Fusion Center			Ship and airborne hydrographic mapping data; buoy data; Fleet sensor data; Subsurface autonomous mapping, data; Environmental acoustic recording data		
US Navy		Ocean Surface Vector Winds from Space (WindSat)			Winds		
US Navy		Ocean survey ships			Temperature; Salinity; Waves; Currents, Sea surface topography; Winds		
	Access to the National Streamflow Information Program (NSIP) and National Stream Quality Accounting Network (NASQAN) data is provided through the NWISweb interface. Both the real-time and non real-time stream information.	NWISweb Interface					
	Centers for Ocean Sciences Education Excellence (COSEE)						
	includes access to the National Biological Information Infrastructure and the Regional OBIS nodes.	Ocean Biographic Information System (OBIS)					
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Archive: National Oceanographic Data Center (NODC)		NODC, NOAA National Data Centers; Silver Spring, MD	marine biological, buoys, chlorophyll, nutrients, currents, oxygen, plankton, profile, salinity, temperatures, waves, sea level. See http://www.nodc.noaa.gov/General/getdata.html		
	National Oceanographic Partnership Program (NOPP)						
	USGS Earthquake Center	Global Seismic Network (GSN)					

Table A-1. Observing Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data collecting POC	Location (data assembly center/access)	Variable(s) (collected)	Geographic area	Data using (modeling and analysis) organization
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Archive: Comprehensive Large Array Data Stewardship System (CLASS)		Comprehensive Large Array Data Stewardship System (CLASS) [archiving system]	POES and GOES data and will also include NPP, NPOESS, and GOES-R once they become operational.		
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Archive: National Climatic Data Center (NCDC)		NOAA National Data Centers (NCDC), Ashville, NC	Land, Upper Air, Paleoclimatology, Weather Climate Events information and Assessments, Marine (Paleoclimatology, Buoy Data, International Comprehensive Ocean-Atmosphere Data Set, Global Observing Ships, Data Set Documents)		

Appendix B
Modeling and Analysis Organizations

This appendix contains a table listing modeling and analysis organizations and, for each, showing the products and services they provide. This appendix was created using existing documentation. It is not a complete list; rather, it is a working document, intended to promote discussion and to be further refined.

Table B-1. Modeling and Analysis Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data using (modeling and analysis) organization	Data using (modeling and analysis) program	Product	Product offering
Caribbean Regional Association (CaRA)	Being developed					
National Oceanic and Atmospheric Administration (NOAA)	Coral Health and Monitoring Program (NOAA/OAR)	Integrated Coral Observing Network (ICON), formerly Coral Reef Early Warning System (CREWS)				
Central and Northern California Ocean Observing System (CeNCOOS)	California Center for Integrative Coastal Ocean Research and Education (CICORE)	Hyperspectral Imagery, Coastal Time Series, Underway Acquisition, Bathymetry				
Central and Northern California Ocean Observing System (CeNCOOS)	Center for Integrated Marine Technologies	Shipboard Data, Mooring Data				
Central and Northern California Ocean Observing System (CeNCOOS)	Monterey Bay Aquarium Research Institute (MBARI)	MBARI Ocean Observing System (MOOS)				
Central and Northern California Ocean Observing System (CeNCOOS)	Naval Postgraduate School	Monterey Inner Shelf Observatory (MISO)				
Central and Northern California Ocean Observing System (CeNCOOS)	Bodega Marine Laboratory, University of California at Davis	Bodgea Ocean Observing Node				
Central and Northern California Ocean Observing System (CeNCOOS)	Coastal Oceans Currents Monitoring Program (COCMP)	HF Radar Network				
Central and Northern California Ocean Observing System (CeNCOOS)	San Francisco State University, Romberg Tiburon Center	San Francisco Bay Environmental Assessment and Monitoring Station				
Central and Northern California Ocean Observing System (CeNCOOS)	University of California Santa Barbara	UCSB Ocean Surface Currents Mapping Project				
Central and Northern California Ocean Observing System (CeNCOOS)		Pacific Coast Ocean Observing System (PaCOOS)				
Environmental Protection Agency (EPA)	Beach monitoring, warnings, and closures (program functional area),				BEACHES Request and Response	
Environmental Protection Agency (EPA)	National Coastal Assessment (NCA) program				National Coastal Assessment Request and Response	Query by Area for Coastal Assessment Services
Environmental Protection Agency (EPA)	National Estuary Program (NEP)				National Estuarine Program Request and Response	Query by Area for EPA Estuarine Assessment Services
Great Lakes Observing Systems (GLOS)	University of Wisconsin Milwaukee, Great Lakes WATER Institute	Coastal Stations				
Great Lakes Observing Systems (GLOS)	University of Michigan Marine Hydrodynamics Laboratories	Weather Buoys				

Table B-1. Modeling and Analysis Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data using (modeling and analysis) organization	Data using (modeling and analysis) program	Product	Product offering
Alaska Ocean Observing System (AOOS)	University of Alaska Fairbanks, Institute of Marine Science	GLOBEC LTOP stations in the Northern Gulf of Alaska				
Alaska Ocean Observing System (AOOS)	Alaska Satellite Facility, University of Alaska Fairbanks	Synthetic Aperture Radar				
Alaska Ocean Observing System (AOOS)	University of Alaska Fairbanks	Sea-Air-Land Modeling and Observing Network (SALMON)				
Alaska Ocean Observing System (AOOS)	National Resources Conservation Service (NRCS), U.S. Department of Agriculture,	SNOTEL				
Alaska Ocean Observing System (AOOS)	Prince William Sound Science Center	Prince William Sound Nowcast-Forecast System				
Gulf of Mexico Regional Association	Louisiana Universities Marine Consortium Environmental Monitoring data	Gulf of Mexico Coastal Ocean Observing System (GCOOS)				
Gulf of Mexico Regional Association	Northern Gulf of Mexico Littoral Initiative	Gulf of Mexico Coastal Ocean Observing System (GCOOS)				
Gulf of Mexico Regional Association	Texas Automated Buoy System	Gulf of Mexico Coastal Ocean Observing System (GCOOS)				
Gulf of Mexico Regional Association	Texas Coastal Ocean Observation Network	Gulf of Mexico Coastal Ocean Observing System (GCOOS)				
Gulf of Mexico Regional Association	Wave Current Surge Information System	Gulf of Mexico Coastal Ocean Observing System (GCOOS)				
Hawaiian and southern Pacific Regional Association	Hawaii Ocean Time-series program	Insular Pacific-Hawaiian Integrated Ocean Observing System (PacIOOS)				
Incorporated Research Institutions for Seismology	Incorporated Research Institutions for Seismology (IRIS)	Global Seismic Network (GSN)			Incorporated Research Institutions for Seismology Request and Response	Optimized Framework for Access the Seismic Products and Services
Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)	Alliance for the Chesapeake Bay Citizen Monitoring Program					
Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)	Chesapeake Bay Mouth Monthly					
Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)	MACOORA Chesapeake Bay Observing System					
Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA)	Maryland Department of Natural Resources–Eyes on the Bay					
National Aeronautics and Space Administration (NASA)	Earth Observing System	Aqua and Terra Satellites				

Table B-1. Modeling and Analysis Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data using (modeling and analysis) organization	Data using (modeling and analysis) program	Product	Product offering
National Aeronautics and Space Administration (NASA)	Goddard Space Flight Center	SeaWiFs system				
National Aeronautics and Space Administration (NASA)	Goddard Space Flight Center	TRMM Satellite				
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Archive: National Geophysical Data Center (NGDC)			National Geophysical Data Center Request and Response; Geomagnetic models	Optimized Interface for Access to NGDC Products and Services
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Commercial fishing statistics				
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Habitat Assessments				
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Living Marine Resources and Ecosystem Surveys				
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Marine Recreational Fisheries Statistics Surveys				
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	National Observer Program				
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Protected Resources Surveys				
National Oceanic and Atmospheric Administration (NOAA)	National Marine Fisheries Service (NMFS)	Fisheries Information Networks			Ecosystem Management Modeling	
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	Coastal Change Analysis Program (C-CAP)				
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	National Current Observation Program				
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	National Status and Trends Program				
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	NERRS SWMP (System-wide Monitoring Program)				
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	NWLON (National Water Level Observation Network)			National Water Level Observing Network Request and Response	
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service	PORTS (Physical Oceanographic Real-Time System				
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite, Data, and Information Service	CoastWatch				
National Oceanic and Atmospheric Administration (NOAA)	Atlantic Oceanographic and Meteorological Laboratory (AOML) + international collaboration	Global Ocean Observing System Center - Ship of Opportunity Program: XBT Lines, Thermosalinograph, Argo Profiling Floats			Atlantic Oceanographic and Meteorological Laboratory Request and Response	
National Oceanic and Atmospheric Administration (NOAA)	National Data Buoy Center (NDBC)	Minerals and Mining Service current data from oil platforms				
National Oceanic and Atmospheric Administration (NOAA)	National Data Buoy Center (NDBC)	Moored buoys (Tropical array)				

Table B-1. Modeling and Analysis Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data using (modeling and analysis) organization	Data using (modeling and analysis) program	Product	Product offering
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service (NOS)	NOS Data Explorer				
Multiple Agencies	International Arctic Buoy Programme (IABP) http://iabp.apl.washington.edu/	Arctic Ice Buoys				
National Oceanic and Atmospheric Administration (NOAA)	Atlantic Oceanographic and Meteorological Laboratory (AOML)	Global Drifter Program				
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Geostationary Operational Environmental Satellites (GOES)				
National Oceanic and Atmospheric Administration (NOAA)	National Centers for Environmental Prediction (NCEP)	Products of NCEP			WAVEWATCH III	Operational ocean wave predictions
National Oceanic and Atmospheric Administration (NOAA)	Joint Commission on Oceanography and Marine Meteorology (JCOMM)	Global Sea Level Observing System (GLOSS)				
National Oceanic and Atmospheric Administration (NOAA)	National Hurricane Center (NHC)				Sea, Lake and Overland Surges from Hurricanes (SLOSH)	Defines potential maximum surges for a location
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service (NOS)	Hydrographic survey				
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service (NOS)				Harmful Algal Blooms Forecast System (HABS)	
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service (NOS)				General NOAA Operational Modeling Environment (GNOME)	
National Oceanic and Atmospheric Administration (NOAA)	National Ocean Service (NOS)				Operational Forecast System Models	
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Polar Operational Environmental Satellite (POES)				
National Science Foundation (NSF)		Ocean Observatories Initiative (OOI)/Ocean Research Interactive Observatory Networks (ORION)		Optimized Interface for Access to NSF OOI Products and Services	National Science Foundation Oceanographic Research Interactive Observatory Networks Request and Response	Optimized Interface for Research Information Exchange
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service	ASOS (Automated Surface Observing System)				
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service	C-MAN (Coastal Marine Automated Network)				
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service	DART (Deep-Ocean Assessment and Reporting of Tsunamis)				
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service	NDBC Moored Buoys				
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service	VOS (Voluntary Observing Ship Program)				

Table B-1. Modeling and Analysis Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data using (modeling and analysis) organization	Data using (modeling and analysis) program	Product	Product offering
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service				Modular Ocean Model (MOM)	
National Oceanic and Atmospheric Administration (NOAA)	National Weather Service				Hybrid Coordinate Model (HYCOM)	Simulates coastal and open ocean circulation features
Northeast Regional Association (NERA)		Coastal Ocean Observation Laboratory				
Northeast Regional Association (NERA)		Coastal Ocean Observing and Analysis system				
Northeast Regional Association (NERA)		Gulf of Maine Ocean Observing System				
Northeast Regional Association (NERA)		Martha's Vineyard Coastal Observatory				
Northeast Regional Association (NERA)		Monitoring Your Sound system				
Northeast Regional Association (NERA)		New Jersey Coastal Monitoring Network				
Northwest Regional Association	Bodega Ocean Observing Node	Northwest Association of Networked Ocean Observing Systems (NANOOS)				
Northwest Regional Association	Columbia River Estuary Real-Time Observation and Forecasting System	Northwest Association of Networked Ocean Observing Systems (NANOOS)				
Northwest Regional Association	node of the Coastal Storms Program	Northwest Association of Networked Ocean Observing Systems (NANOOS)				
Northwest Regional Association	Oregon State University Coastal Observations	Northwest Association of Networked Ocean Observing Systems (NANOOS)				
Pacific Marine Environmental Laboratory (PMEL)		Pacific Marine Environmental Laboratory (PMEL)			Pacific Marine Environmental Laboratory Request and Response	
Pacific NW Regional Association						
National Aeronautics and Space Administration (NASA)	Physical Oceanography Distributed Active Archive Center (PO DAAC)	multiple satellite data streams				
Southeast Regional Association	Carolinas Coastal Ocean Observing and Prediction system	Southeast Coastal Ocean Observing Regional Association (SECOORA)				
Southeast Regional Association	Coastal Ocean Research and Monitoring Program	Southeast Coastal Ocean Observing Regional Association (SECOORA)				
Southeast Regional Association	East Florida Shelf Information System	Southeast Coastal Ocean Observing Regional Association (SECOORA)				

Table B-1. Modeling and Analysis Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data using (modeling and analysis) organization	Data using (modeling and analysis) program	Product	Product offering
Southeast Regional Association	FerryMon Program	Southeast Coastal Ocean Observing Regional Association (SECOORA)				
Southeast Regional Association	Florida Inshore Marine Monitoring and Assessment Program	Southeast Coastal Ocean Observing Regional Association (SECOORA)				
Southeast Regional Association	Neuse River Remote Monitoring and Data Acquisition Project	Southeast Coastal Ocean Observing Regional Association (SECOORA)				
Southeast Regional Association	North Carolina Coastal Ocean Observing System	Southeast Coastal Ocean Observing Regional Association (SECOORA)				
Southeast Regional Association	SEAKEYS	Southeast Coastal Ocean Observing Regional Association (SECOORA)				
Southeast Regional Association	South Atlantic Bight Synoptic Offshore Observational Network	Southeast Coastal Ocean Observing Regional Association (SECOORA)				
Southeast Regional Association	South Florida Ocean Measurement Center	Southeast Coastal Ocean Observing Regional Association (SECOORA)				
Southeast Regional Association	Southeast Atlantic Coastal Ocean Observing System	Southeast Coastal Ocean Observing Regional Association (SECOORA)				
Southeast Regional Association	West Florida Coastal Ocean Monitoring and Prediction System	Southeast Coastal Ocean Observing Regional Association (SECOORA)				
Southeastern Universities Research Association (SURA)	integration of large research activities				Open IOOS, Grid Computing, Models	Access to the SURA oceanographic research network
Southern California Regional Association	California Cooperative Oceanic Fisheries Investigations program	Southern California Coastal Ocean Observing System (SCCOOS)				
Southern California Regional Association	Coastal Data Information Program	Southern California Coastal Ocean Observing System (SCCOOS)				
Southern California Regional Association	Southern California Coastal Water Research Project Authority	Southern California Coastal Ocean Observing System (SCCOOS)				
Southern California Regional Association	SCCOOS PaCOOS Data					
US Army Corps of Engineers (USACE)	Coastal Field Data Collection Program					
US Army Corps of Engineers (USACE)	Coastal Field Data Collection Program Wave Gauges					
US Army Corps of Engineers (USACE)	Field Research Data Program (FRDP)					

Table B-1. Modeling and Analysis Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data using (modeling and analysis) organization	Data using (modeling and analysis) program	Product	Product offering
US Army Corps of Engineers (USACE)		Hydrographic surveying				
US Geological Survey	National Stream Quality Accounting Network (NSQAN)					Framework for Providing Water Quality Data
US Geological Survey	National Streamflow Information Program (NSIP)					
US Geological Survey		Benthic habitat mapping				
US Geological Survey		Coastal change mapping				
US Geological Survey		Coral reef mapping				
US Geological Survey		Coral reef monitoring				
US Geological Survey		Stream gauging				
US Geological Survey					GEO-one stop	
US Navy	Altimeter Data Fusions Center (ADFC)					
US Navy	Fleet Numerical Meteorology and Oceanography Center				Fleet Numerical Meteorology and Oceanography Center Request and Response	GODAE, Wave Watch, WAVEWATCH III, Navy Ocean Data Assimilation, Optimum Thermal Interpretation Data, La Nina and El Nino data, Oceanography, meteorology, Model Performance, Tropical Applications, Satellite, Climatology Services
US Navy	Geodetic Satellite (Geosat) follow-on					
US Navy	Integrated buoy program					
US Navy	Naval Oceanographic Office (NAVOCEANO)	Altimeter Data Fusion Center				
US Navy		Ocean Surface Vector Winds from Space (WindSat)				
US Navy		Ocean survey ships				
	Access to the National Streamflow Information Program (NSIP) and National Stream Quality Accounting Network (NASQAN) data is provided through the NWISweb interface. both the real-time and non real-time stream information.	NWISweb Interface				
	Centers for Ocean Sciences Education Excellence (COSEE)					
	includes access to the National Biological Information Infrastructure and the Regional OBIS nodes.	Ocean Biographic Information System (OBIS)				

Table B-1. Modeling and Analysis Organizations

Data collecting organization	Data collecting program (system owner/operator)	Data collecting system	Data using (modeling and analysis) organization	Data using (modeling and analysis) program	Product	Product offering
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Archive: National Oceanographic Data Center (NODC)				
	National Oceanographic Partnership Program (NOPP)					
	USGS Earthquake Center	Global Seismic Network (GSN)				
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Archive: Comprehensive Large Array Data Stewardship System (CLASS)				
National Oceanic and Atmospheric Administration (NOAA)	National Environmental Satellite Data and Information Service	Archive: National Climatic Data Center (NCDC)				National archive for climate data. It provides access to marine paleoclimatology, buoy, International Comprehensive Ocean-Atmosphere Data Set Project, Global Positioning Ships, and Data Set Documents.

Appendix C
Core Variables

This appendix identifies the 20 IOOS core variables, as listed in The First U.S. Integrated Ocean Observing System (IOOS) Development Plan, page 20.

1. Temperature
2. Salinity
3. Sea Level
4. Surface currents
5. Ocean color
6. Bathymetry
7. Surface waves
8. Ice distribution
9. Contaminants
10. Dissolved nutrients
11. Fish species
12. Fish abundance
13. Zooplankton species
14. Optical properties
15. Heat flux
16. Bottom character
17. Pathogens
18. Dissolved O2
19. Phytoplankton species
20. Zooplankton abundance

Appendix D
Bibliography

This appendix contains a list of documents and websites that informed the development of the DMAC ConOps.

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Appendix E
Abbreviations and Acronyms

AoA	analysis of alternatives
AOML	Atlantic Oceanographic and Meteorological Laboratory
COOP	continuity of operations
CO-OPS	Center for Operational Oceanographic Products and Services
CREIOS	Coral Reef Ecosystem Integrated Observing System
DAC	data assembly center
DIF	Data Integration Framework
DMAC	data management and communications
FISMA	Federal Information Security Management Act
FOC	full operational capability
FRD	functional requirements document
GCMD	Global Change Master Directory
GEO-IDE	Global Earth Observing–Integrated Data Environment
GEOSS	Global Earth Observing System of Systems
GOOS	Global Ocean Observing System
HABS	Harmful Algal Blooms
IA	information assurance
IOC	initial operational capability
IODE	Intergovernmental Oceanographic Commission International Ocean Data and Information Exchange
IEOS	Integrated Earth Observation System
IOOS	Integrated Ocean Observing System
IWGOO	Inter-agency Working Group on Ocean Observation
JCOMM	Joint Commission on Oceanography and Marine Meteorology
KDP	key decision point
MADIS	Meteorological Assimilation Data Ingest System
MMI	Marine Metadata Interoperability Project
NDBC	National Data Buoy Center

NCDDC	National Coastal Data Development Center
NERRS CDMO	National Estuarine Research Reserve System Centralized Data Management Office
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
NSF	National Science Foundation
NWQMN	National Water Quality Monitoring Network
NWLON	National Water Level Observation Network
NWS	National Weather Service
OBIS	Ocean Biogeographical Information System
OGC	Open Geospatial Consortium
OOI	Ocean Observatories Initiative
OSDPD	Office of Satellite Data Processing and Distribution
PORTS®	Physical Oceanographic Real-Time System
QC	quality control
RFI	request for information
RFP	request for proposals
SEAWIFS	Sea-viewing Wide Field-of-view Sensor
SCOOP	Coastal Ocean Observing and Prediction
SI	systems integrator
SLA	service level agreement
SoA	service oriented architecture
SWIM	Seacoast Watershed Information Manager
SWMP	System-wide Monitoring Program
SURA	Southeastern University Research Association
WMO	World Meteorological Organization
XML	Extensible Markup Language