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# EMBRACING THE FULL SPECTRUM OF IOOS ENVIRONMENTAL INFORMATION FOR MDA

## SUMMIT PROCEEDINGS



The National Office for  
Integrated and Sustained Ocean Observations  
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# Embracing the Full Spectrum of IOOS Environmental Information for MDA

*Summit Proceeding*

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**Editor**

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# 1. INTRODUCTION

## 1.1 Goals and Objectives

This report summarizes the results of a summit organized by the national interagency Office of Global Maritime Situational Awareness and by Ocean.US, the National Office for Integrated and Sustained Ocean Observations. The summit was hosted by the U.S. Environmental Protection Agency at its headquarters in Washington, D.C. on 24-26 September 2007.

The agenda for the summit is given in Appendix 1. The goal of the summit was to engage the Marine Domain Awareness (MDA) and Integrated Ocean Observing System (IOOS) communities in the identification of potential synergies between MDA and IOOS that will provide a framework for future collaboration and help to guide IOOS development in support of the MDA mission. The summit is the first step toward achieving the following objectives:

- Identify ocean information needs for a common operational picture;
- Raise awareness of the environmental information capabilities of IOOS (current and potential);
- Raise awareness of the needs of the MDA community to define requirements for IOOS development;
- Coordinate activities of IOOS providers and MDA users;
- Formulate a strategy for ongoing interactions; and
- Determine how to optimally move IOOS data to Homeland Security customers.

Communications, data access and data distribution among stakeholders are critical to achieving these objectives and were, therefore, the primary focus of the summit. As a means to determine requirements for effective data management and communications, three areas of mutual interest were addressed: (1) interdiction at sea, (2) disaster response (including search and rescue), and (3) port security (U.S. and foreign).

Participants represented many of the stakeholders and are listed in Appendix 2. Summaries of plenary lectures, which provided the framework for section 2 of this report, are given in Appendix 3.

## 1.2 Background

The mission of the Office of Global Maritime Situational Awareness (GMSA) includes contributing to MDA by assessing changes in the maritime environment and the occurrence of activities of interest (activities that warrant a higher level of awareness for the purposes of homeland security, national defense and the safety and efficiency of marine operations). This requires sustained observations and analyses (persistent awareness<sup>1</sup>), to detect anomalies and determine trends quickly and accurately. To these ends, the National GMSA Office is working to achieve the following:

- Develop national maritime common operating pictures as needed using a network-centric information grid for the provision of near real-time information that is dynamically tailored to the specific needs of U.S. agencies (federal, state, local and tribal) and international partners with maritime interests and responsibilities;
- Determine data requirements for the rapid and routine provision of common operating pictures;
- Address and remove policy barriers to information sharing;
- Obtain agreements to share data, develop standards for sharing data and information, and coordinate access to NMP data;
- Ensure information security and accuracy;
- Focus efforts of Enterprise Hubs<sup>2</sup>;
- Guide the ongoing development of the National MDA Concept of Operations and investment strategy.

Ocean.US is the national office for the planning and coordinating the development of an Integrated Ocean Observing System (IOOS) for the U.S.<sup>3</sup> IOOS is a system of systems that integrates data and information on maritime systems from U.S. government agencies and Regional Associations for more rapid detection and timely predictions of changes in the states of maritime environments as needed to improve.

- Predictions of climate change,
- Safety and efficiency of maritime operations,
- Management and mitigation of the impacts of natural hazards,
- Homeland and national security,
- Public health,
- Protection and restoration of marine ecosystems, and
- Sustained use of natural resources.

<sup>1</sup> "Persistently monitor" refers to an ability to conduct continuous monitoring anywhere on the globe. It is not meant to imply that such monitoring can be conducted world-wide simultaneously.

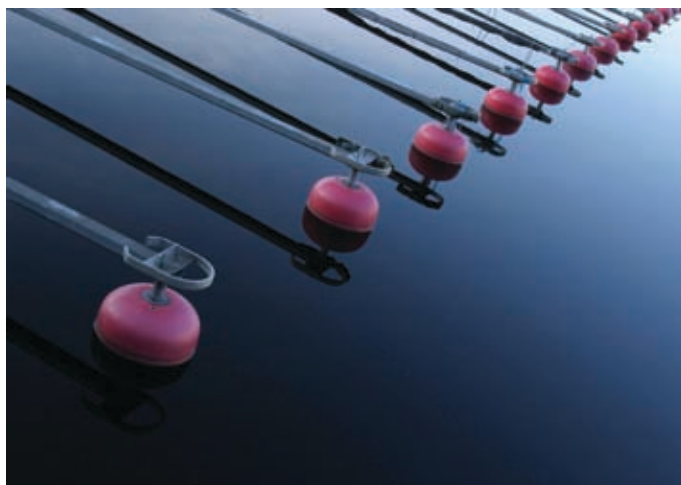
<sup>2</sup> Designation as an Enterprise Hub confer two primary responsibilities: (1) coordinate information flow for the respective subject area both domestically and internationally and (2) facilitate the sharing of related intelligence, information and data within and across Hubs and throughout the maritime community of interest. Enterprise Hubs for Vessels, Cargo, People, Infrastructure and Architecture are proposed from existing organizations that already possess subject matter expertise, a preponderance of the requisite authorities, and knowledge of associated capabilities and procedures. Enterprise Hubs will be linked to intelligence and information providers and able to share pertinent data throughout the Global Maritime Community of Interest.

<sup>3</sup> An Integrated and Sustained Ocean Observing System (IOOS) for the U.S.: Design and Implementation, Ocean.US Report No.2; The First U.S. IOOS Development Plan, Ocean.US Report No.9 ([http://www.ocean.us/oceanus\\_publications](http://www.ocean.us/oceanus_publications)).

Rapid detection of state changes and timely predictions of them require that observations, data management and modeling be efficiently linked to provide data and information on local to global scales in forms and at rates needed by decision makers working to achieve these societal goals. To this end, Ocean.US organized a national workshop on *Building a Consensus: Toward an Integrated and Sustained Ocean Observing System*. Participants from public and private sectors and from research and operational communities identified the following sub-goals for the homeland and national security IOOS goal:<sup>4</sup>

- Improve the effectiveness of maritime homeland security and war-fighting effectiveness abroad, especially mine warfare, port security, amphibious warfare, special operations and antisubmarine warfare.
- Improve the safety and efficiency of operations at sea.
- Establish the capability to detect airborne and waterborne contaminants in ports, harbors, and littoral regions at home and abroad, and the capability to predict the dispersion of those contaminants for planning, mitigation, and remediation.
- Support environmental stewardship.
- Improve system performance at sea through more accurate characterization and prediction of the marine boundary layer.

MDA is the effective understanding of anything associated with the global maritime domain that could impact the security, safety, economy, or environment of the United States.<sup>5</sup> As such, MDA cross cuts these sub-goals. In this context, a major challenge for both the Office of Global Maritime Situational Awareness and Ocean.US is efficient and effective sharing of data and information among stakeholders that constitute communities of interest.<sup>6</sup> The summit is an important step toward addressing this issue.



<sup>4</sup> Ocean.US Report No. 1 ([http://www.ocean.us/oceanus\\_publications](http://www.ocean.us/oceanus_publications))

<sup>5</sup> [http://www.dhs.gov/xprevprot/programs/editorial\\_0753.shtm](http://www.dhs.gov/xprevprot/programs/editorial_0753.shtm)

<sup>6</sup> The Global Maritime Community of Interest (GMCOI) includes federal, state, and local departments and agencies with responsibilities in the maritime domain. Because certain risks and interests are common to government, business, and citizen alike, community membership also includes public, private and commercial stakeholders, as well as foreign governments and international stakeholders.

## 2. SETTING THE STAGE

### 2.1 Achieving Maritime Domain Awareness (MDA)

#### 2.1.1 Strategic Objectives

MDA supports core national defense and security priorities by meeting the following strategic goals:

- Enhance transparency in the maritime domain to detect, deter and defeat threats as early and distant from U.S. interests as possible;
- Enable accurate, dynamic, and confident decisions and responses to the full spectrum of maritime threats; and
- Sustain the full application of the law to ensure freedom of navigation and the efficient flow of commerce.

The *National Plan to Achieve Maritime Domain Awareness*<sup>7</sup> provides a framework for persistent awareness through enhanced and innovative collection of intelligence, the integration of correlated open source information, and the incorporation of automated algorithms for data analysis. To do this, we must reorient and integrate cold war legacy systems with current and emerging capabilities, such as autonomous aerial and underwater vehicles equipped with sensors for near real-time monitoring of the environment and objects within that environment, that enable data integration for a common operating picture. Successful execution of this plan requires a sustained and adaptive national effort based on coordination and collaboration among federal, state, local, tribal and international partners as well as the private sector. The objective is to maximize near-real time awareness of maritime threats.

The primary method for information sharing, situational awareness, and collaborative planning is the national maritime common operating picture (COP). The COP is a “near-real time, dynamically tailorable, network-centric virtual information grid shared by all U.S. Federal, state, and local agencies with maritime interests and responsibilities.” COP data is to be accessible to all users, except when limited by security, policy or regulations.

#### 2.1.2 Creating Common Operating Pictures

Achieving MDA requires integration of data and intelligence from a broad range of sources and the timely analysis and dissemination of the resulting

information facilitate understanding and timely decision making by the responsible bodies. This includes persistent monitoring to provide and update the common operating picture for the following:

- Vessels and craft (tracking and identification of vessel characteristics including flag, type, tonnage, maximum speed, and port of origin);
- Cargo (from a vessel’s manifest, shipment origin, and human intelligence including input from sensors designed to detect threats from chemical, biological, nuclear, radiation, and explosive materials);
- Vessel personnel (crew, passengers, and dock workers);
- All identified maritime areas of interest (focusing surveillance capabilities on particular places including ports, waterways, and sea lanes); and
- The maritime environment (assessments of weather, currents, waves, natural living and non-living resources).

Of these, IOOS development is most relevant to vessels (e.g., interdiction), maritime areas of interest (e.g., port security) and the maritime environment (e.g., disaster response).

#### 2.1.3 Implementation Plans

Presidential Directive NSPD-41/HSPD-13 (signed in December 2004) established a Maritime Security Policy Coordinating Committee to oversee the development of a National Strategy for Maritime Security. The strategy is supported by eight interdependent implementation plans:

- National plan to achieve MDA that lays the foundation for identifying threats as early and as distant from our shores as possible;
- Global maritime intelligence plan for using existing capabilities to integrate available intelligence regarding potential threats to U.S. interests in the maritime domain;
- Maritime operational threat response plan that established roles and responsibilities for coordinated and timely responses of U.S. government agencies to threats against the U.S. and its interests in the maritime domain;
- International outreach and coordination strategy that provides a framework to coordinate all maritime security initiatives undertaken with foreign governments and international organizations and procedures for soliciting international support for enhanced maritime security;

<sup>7</sup> [http://www.dhs.gov/xlibrary/assets/HSPD\\_MDAPlan.pdf](http://www.dhs.gov/xlibrary/assets/HSPD_MDAPlan.pdf)

- Maritime infrastructure recovery plan that recommends procedures and standards for the restoring of maritime infrastructure that has been disrupted by an attack, an accident or a natural hazard;
- Maritime transportation system security plan that responds to the President's call for recommendations for improving national and international regulatory frameworks regarding the maritime domain;
- Maritime commerce security plan that establishes mechanisms for securing the maritime supply chain; and
- Domestic outreach plan for engaging non-federal input to assist with the development and implementation of maritime security policies resulting from NSPD-41/HSPD-13.<sup>8</sup>

Together, the National Strategy for Maritime Security and its supporting plans represent a comprehensive national initiative to enhance the security of the U.S. by preventing hostile or illegal acts within the maritime domain.

#### 2.1.4 Information Sharing Challenges

As stated above, the primary method for information sharing, situational awareness, and collaborative planning is the timely provision of "the national maritime common operating picture" which is to be shared by all U.S. federal, state, and local agencies with maritime interests and responsibilities. Implementing this requires both (1) integration of data from many sources from both public and private sectors and (2) timely dissemination of these pictures to the appropriate decision makers. Critical to both is coordination and collaboration among U.S. government agencies (federal, state, local, and tribal), international partners, and the private sector. There are many challenges to implementing this vision. They include the following:

- Elimination of regulatory barriers to information sharing and interoperability through the establishment of operating protocols, memorandums of understanding and memorandums of agreement necessary for joint, interagency and industry relationships;
- Development of an open architecture for data sharing with governance standards for web-based information storage access while at the same time restricting access privileges to ensure data are only used for specific purpose by those with necessary permissions;
- Establishment of an interoperable communication standards, including the use of DOD's Global Information Grid (GIG) across federal, state and local partners to enable information sharing;

- Establishment of the network-centric, near real-time virtual information grid that can be shared, at appropriate security levels, by federal, state, local, and international agencies with maritime responsibilities.
- Establishment of information assurance capabilities that allow the sharing of information across all levels of classification in both directions between highly classified and law enforcement sensitive sources.

In this context, needs for effective MDA were articulated in plenary by

#### **RDML Lee Metcalf**

(Director, National Office for Global Maritime Situational Awareness),

#### **Mr. Tim Phillips**

(Chief Technology, Office of Global Maritime Intelligence Integration),

#### **Mr. Dana Goward**

(Director, MDA Program Integration),

#### **Mr. Owen Doherty**

(Director, Office of Security, Maritime Administration of the Department of Transportation),

#### **LCDR Todd Boone**

(Office of the Chief of Naval Operations, MPT&E Information Management Division-N6),

#### **Mr. Guy Thomas**

(Science and Technology Advisor, National Office of Global Maritime Situational Awareness), and

#### **Mr. Michael Krieger**

(Director of Information Policy, Department of Defense).

The needs can be summarized as follows:

- Specification of data and information requirements for coastal surveillance;
- Architectures, processes and systems to serve all parties based on system engineering;
- Standards and protocols for interoperability and improved information sharing (access and dissemination) among the Global Maritime Community of Interest;
- Identification of data and information sources;
- Increased transparency in MDA and accountability for information sharing globally;
- Better, more resilient forecasting system between ports; and
- Planning for expanding capabilities and sustainability.

<sup>8</sup> [http://www.dhs.gov/xprevprot/programs/editorial\\_0608.shtm](http://www.dhs.gov/xprevprot/programs/editorial_0608.shtm)



## 2.2 Contribution of the Integrated Ocean Observing System (IOOS) to Achieving Maritime Domain Awareness

### 2.2.1 IOOS Assets

The assets that the effort to establish the IOOS brings to the table for providing required data and information were articulated in plenary by

**Dr. Rick Spinrad**

(Assistant Administrator, NOAA Office of Oceanic and Atmospheric Research, and Chairman of the Interagency Working Group on Ocean Observations),

**Dr. Mary Altalo**

(Director, Ocean.US, National Office for Integrated and Sustained Ocean Observations),

**Dr. Ralph Rayner**

(Deputy Director, Ocean.US),

**RADM Dick West**

(Consortium for Ocean Leadership),

**Dr. Frank Bub**

(Naval Oceanographic Office),

**Mrs. Anne Ball**

(NOAA Coastal Services Center and Chair of the Ocean.US DMAC Steering Team), and

**CAPT Zdenka Willis**

(Director, NOAA IOOS Program Office)

The assets can be summarized as follows:

#### Partnering

- Ocean.US, neutral interagency body to help create partnerships between all sides of MDA and ocean observing;
- Continuing multi-agency partnerships will help progress data interoperability and integration thereby strengthening IOOS;

#### IOOS Architecture and Development<sup>9</sup>

- Efficient coupling of observations and data telemetry, data management and communications, and modeling and analysis to meet the data and information needs of user groups;
- More effective provision of data and information needed to improve predictions of climate change, maritime weather forecasts, and natural hazards and to support decision making for safe and

efficient maritime operations, homeland and national security, public health management, and the sustainability of healthy ecosystems and the living marine resources they support.

- Integration of existing observing system assets by (1) identifying and developing standards and protocols for data management and communications to allow for more interoperability and data sharing, (2) completing a Data Integration Framework to demonstrate the value of data integration, and (3) enabling more accurate and timely forecasts for a wide variety of uses on global, regional and local scales.
- Developing synergy between advances in scientific understanding of scale-dependent variability and technology and the development of operational capabilities to shorten reaction time to threats.

#### International Contribution

- Development of IOOS will significantly improve the capabilities of the Global Ocean Observing System (GOOS) that contributes to the Global Earth Observing System of Systems (GEOSS).

### 2.2.2 IOOS in Support of MDA

Provisional core variables to be monitored, managed and analyzed as part of the IOOS were identified by a group of experts at an Ocean.US national workshop in 2002 (Appendix 4, Tables 1, 2 and 3).<sup>10</sup> In addition to the variables listed in Appendix 4 (Table 1) and high resolution near shore bathymetry, ocean variables relevant to MDA include fields of sea surface waves and currents; sea level; 3-D fields of temperature, salinity and optical properties; and the distribution and abundance of marine organisms from water borne pathogens and plankton to fish and marine mammals. Preoperational and operational programs that have been approved by the ICOSRMI, provide these data and are priorities for incorporating into the initial IOOS are listed in Table 3 (Appendix 4). With few exceptions, these are all relevant to MDA.

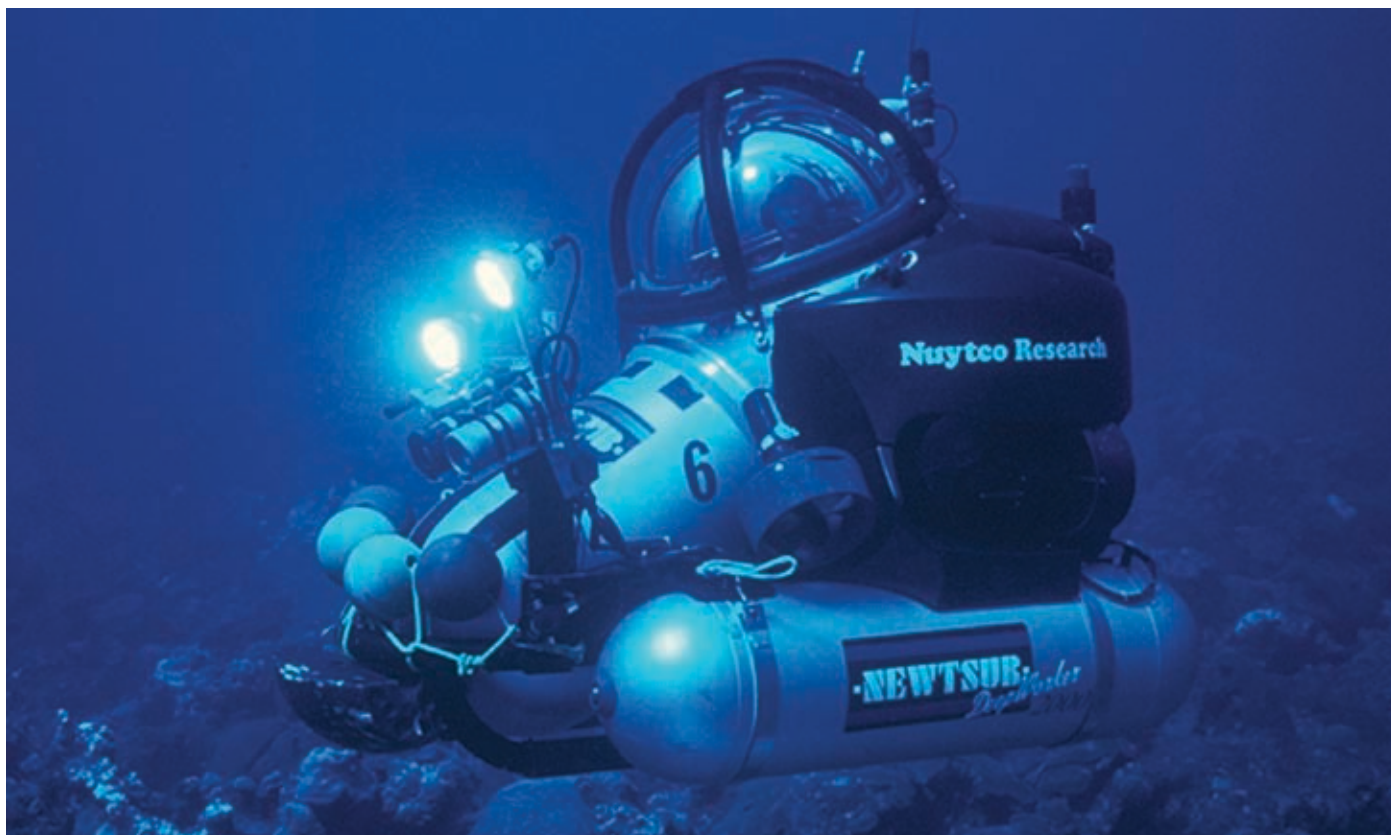
The following enhancements of existing observing system operational capabilities (observing subsystem and data telemetry) in support of MDA are recommended in the addendum to the First IOOS Development Plan:<sup>11</sup>

<sup>9</sup> The First U.S. IOOS Development Plan and the addendum to it ([www.ocean.us/oceanus\\_publications](http://www.ocean.us/oceanus_publications))

<sup>10</sup> Ocean.US Report No. 1 ([http://www.ocean.us/oceanus\\_publications](http://www.ocean.us/oceanus_publications))

<sup>11</sup> Ocean.US Report No. 9A-1 ([http://www.ocean.us/oceanus\\_publications](http://www.ocean.us/oceanus_publications))





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- Optimize the tide gauge network to increase density of real-time measurements of water level in high risk areas;
- Increase stream gauge (continuous, real-time telemetry) coverage in the coastal zone, including near the heads and mouths of rivers for more accurate and timely estimates of freshwater water runoff and associated inputs of sediments, nutrients and pollutants on seasonal scales and during post-storm runoff;
- Using both *in situ* measurements and remote sensing (e.g., rain gauges, Doppler radar, Tropical Rainfall Measuring Mission [TRMM], Global Precipitation Measurement [GPM] Mission), to increase the density of rainfall measurements;
- Establish a consistent, national standard vertical datum to which all vertical measurements (e.g., water level, coastal bathymetry and topography) can be referenced;
- Develop robust methods for blending measurements from remote and *in situ* observations;
- Develop algorithms for extracting higher-resolution surface wind fields from existing satellite scatterometers and future passive polarimetry, especially in close proximity to the shoreline;
- Explore the use of delayed-Doppler and GPS altimetry to improve near shore (< 10 km) sea surface height measurements, and improve models for accurately removing tidal signals;
- Continue to develop, validate and implement Synthetic Aperture Radar (SAR) algorithms for surface vector winds, wave height and direction, ship wakes, buoyant surface plumes and slicks;
- Develop SAR Along-track Interferometry (ATI) and Doppler measurements for high resolution measurement of surface currents in near shore (< 10 km) waters;
- Increase real-time, time-space resolution of wind fields over water, surface current fields, directional wave fields, and sea surface temperature distribution in the Exclusive Economic Zone by integrating remote sensing (HF radar, AVHRR, altimetry, scatterometry, SAR) and *in situ* sensing (ADCPs, Argo floats, surface drifters, NDBC moorings, etc.);
- Develop and implement on-demand, real-time, two way communications (satellite and line-of-sight radio technologies) to meet the command and control requirements of ocean observing systems;
- Develop and implement telecommunications technologies with sufficient bandwidth and establish standards and protocols to meet the requirements for real-time transmission and dissemination of oceanographic observations for multiple applications; and
- Implement the World Meteorological Organization (WMO) Information System (WIS) to meet the requirements of (1) routine collection and automated dissemination of observed data and products; (2) timely delivery of data and products; and (3) ad hoc requests for data and products.

### 3. RESULTS OF BREAKOUT SESSIONS

Working in parallel, three groups were organized (Appendix 5) to begin the process of determining MDA requirements for IOOS data and information. Each group worked independently, developed their own procedures, and achieved different but complementary results as reflected in the summaries below.

#### 3.1 Interdiction at Sea (Co-Chairs: Dana Goward, Mary Altalo, Barbara Heizer, and Guy Thomas)

To facilitate IOOS-MDA partnering, the working group recommended the following actions:

- Assess the timeliness of the distribution of weather reports (voluntary weather reporting to the Coast Guard) and incorporate NOAA data source for discussion at the next NAVY-NOAA meeting next month (Oct. 26) (insure NDBC data needs are communicated). POC: Ray Toll
- Facilitate interaction between NDBC and the Office of Naval Intelligence, and Maritime Intelligence Fusion Centers. Examine utility of linking the NDBC with the nationwide AIS. Examine USCG/NDBC data exchange. POC: Guy Thomas, NOGMSA, Ray Toll, CDR Joel Slotten
- Update the NDBC database hourly or in as close to real-time as possible (more often than 24 hours) for Search and Rescue. POC: Mike Johnson
- Examine NDBC analytical need to assist in MDA and GMSA. Hire an analyst. POC: Rafael Nieves
- Transition space based environmental systems capabilities for surface observations to provide persistence, comprehensive and validated coverage. Assess the utility of reprocessing scatterometry data for detecting ship wakes and man-made objects. POC: Nick Shay
- Install Automatic Identification Systems on NOAA vessels and buoys. POC: Mary Altalo, Zdenka Willis
- Implement dual use of HF radar arrays for ship tracking and input to (or nesting into) environmental models. POC: Nick Shay, Guy Thomas
- Submit a request to the USCG to share data marker buoy data with those who need it, e.g., the ocean prediction center, NDBC and other members of the community. POC: Ray Toll, Joel Slotten, Art Allen
- Assess the use of current profilers and wave riders for operational forecasting. POC: Ray Toll
- Facilitate a meeting to discuss integration of METOC, IOOS and NOGMSA, reciprocal representation. POC: Mary Altalo and Guy Thomas
- Assess the value of passive acoustic detection systems for more effective interdiction.

- Investigate feasibility and cost effectiveness of how a version of the Hybrid Ultralift Airship could support persistent MDA and IOOS sensor packages.

#### 3.2 Disaster Response (Co-Chairs: Tom Malone, Carroll Hood, Art Allen, and John Cooke)

Three case studies were developed to illustrate the kinds of partnerships and technologies that are needed for effective MDA Decision Support where IOOS is the data source and those responsible for MDA are the users (details in Appendix 6). Each case highlights the kinds of partnerships and collaborations needed to implement an integrated approach to MDA. In so doing, they underscore the impact and feasibility of such collaborations, the challenges that must be overcome, and the importance of multi-use tools (High Frequency radar and satellite-based remote sensing) and interactive development of observations and model-based forecasts to the establishment of the Integrated Ocean Observing System. The case studies are as follows:

- IOOS Regional Association Collaboration with the U.S. Coast Guard: Search and Rescue, Hazardous Material Spill Response, and Vessel Tracking (Art Allen, Josh Kohut and Scott Glenn)

Surface current mapping is very important to achieving the societal goals of the Integrated Ocean Observing System (IOOS) as well as to achieving the objectives of Marine Domain Awareness (MDA). The availability and maturity of High-Frequency (HF) radar technology makes reliable surface current mapping now possible. Real-time situational awareness includes nowcasts of current environmental conditions and vessel locations as well as forecasts of the locations of hazardous materials released into the ocean. High Frequency (HF) radar is proving to be an important technology for these purposes. Rapid detection and accurate predictions of the trajectories of objects at or near the surface of the ocean is an important decision support tool for a variety of MDA activities. This case study describes a partnership between an IOOS Regional Association and the USCG that is working to develop HF radar as an operational component of the IOOS in support of Search and Rescue, hazardous substance spill response, surf zone forecasting and vessel tracking.

- IOOS Regional Association Collaboration with the Marine Exchange of Southern California: Safe and Efficient Marine Operations (Julie Thomas and Richard McKenna)

The IOOS user and data provider for this case study are the Marine Exchange of Southern California and the Regional Association for the Southern California Coastal Ocean Observing System (SCCOOS), respectively. This case highlights “best practices” for establishing the kinds of partnerships needed to develop operational IOOS capabilities. The latter focuses on IOOS data and information in support of safe and efficient marine operations in the Southern California Bight. In so doing, it underscores the importance of the following for IOOS development: (1) user guidance for product development, (2) the use of tools that have multiple applications (in this case HF radar), and (3) the interactive development of observations and model-based forecasts.

- IOOS Regional Hazardous Material Spill Response: A Collaboration Between the Naval Research Laboratory and the NOAA Office of Response and Restoration (Robert Arnone and CJ Beegle-Krause)

Reliable projections of the spatial extent, fate and impact of hazardous material spills are important for both emergency spill responses and MDA – and both will benefit from an integrated approach to ocean observations and predictions. This case study highlights

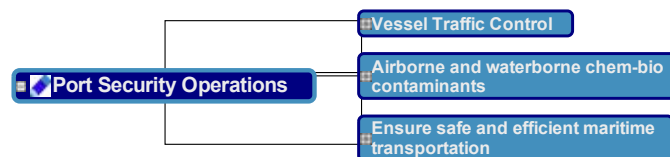
- The utility of a real-time, ocean “weather” capability for MDA and emergency responses to releases of hazardous materials into coastal waters;
- The need for data sets that are interoperable among state and federal agencies;
- The challenges of implementing an integrated approach for the purposes of both spill response and MDA; and
- The need for standard interagency procedures for incorporating advances in scientific understanding and technology into operational systems.

Starting with data and information needed for MDA and to inform decisions for emergency spill response, this case study illustrates the importance of both rapid access to quality controlled data streams and partnerships among and within government agencies as a means to establish an integrated ocean observing and prediction system (IOOS) that enables more effective decision making to achieve the missions of both MDA and emergency spill response.

### 3.3 Port Security (Co-Chairs: David Martin, Ralph Rayner, Deborah Loewer, and Christopher Moore)

A “port” is considered to be an “area from the seaward approaches inward including the internal port complex” where port security involves traffic control,

ensuring safe and efficient maritime transportation, and knowledge of airborne and waterborne contaminants (pathogens and toxic chemicals).



The primary user for the purposes of this exercise is the USCG Port Captain.

The group noted that these operations are often limited by incomplete environmental data provided by sparsely populated, stove-piped port sensing systems which do not support a comprehensive understanding of the impact of the environment on routine operations or rapid responses to incidents important to MDA. It was also noted that full implementation of the IOOS will enable timely provision of “Common Operational Pictures” required for effective responses to incidents. We know this because existing PORTS systems (Appendix 7) have demonstrated that more robust IOOS Port-environmental systems will dramatically and positively impact Port security MDA.

The group focused on IOOS functions as a provider of data and information on the maritime environment and did not explicitly examine other port-relevant MDA activities such as container evaluation and the development of WMD sensors. Accordingly, the discussion was framed in terms of the decision support categories for (1) security, (2) safety, (3) commerce, and (4) environmental stewardship.

Twenty five environmental variables were then evaluated in terms of their importance to each of these pillars (Table 1). Highest priority was given to currents, waves, tides, sea ice and bathymetry. Given this analysis, the immediate priorities are (1) integrate existing, port-based, stove-piped sensor systems so they are interoperable in real time; (2) implement existing PORTS capabilities in as many ports as possible; and (3) enhance PORTS with additional sensors. It was also clear that the port environment must be considered in context of larger regional to global scale forcings.

Two specific actions are recommended:

- Validate the variable versus four pillars matrix analysis with Port Captains and other user groups with the goal of delivering user-defined, high resolution visualizations of time-dependent environmental fields at port scales that can be overlaid with flag-alerts for anomalous or dangerous conditions using, for example, the Digital Nautical Chart® produced by the National Geospatial-Intelligence Agency (an unclassified,



vector-based, digital database containing maritime significant features essential for safe marine navigation).

- Investigate the development of portable environmental information product sensing systems for both U.S. ports (since all of them cannot be fully instrumented) and foreign ports (as a useful adjunct to existing foreign environmental data products).

The group concluded that the IOOS could play a critical enabling role in supporting the MDA decision support mission for port security through the timely provision of integrated environmental information products that have common formats and are readily accessible. This will enable more responsive and responsible decisions to be made in port security matters since these decisions will be more fully informed by environmental considerations.



**Table 1.** Variables that should be observed for port security MDA support ranked in terms of their importance to port security, safety, commerce and environmental stewardship (Level of Importance: 1 – low, 2 – moderate, 3 – high).

Category					
Variable	Security	Safety	Environment	Commerce	TOTAL
1. Currents	3	3	3	3	12
2. Bathymetry	3	3	2	3	11
3. Sea ice	2	3	3	3	11
4. Tides	2	3	2	3	10
5. Waves	2	3	2	3	10
6. Water temperature	3	3	2	1	9
7. Electro-optical infrared	3	3	2	1	9
8. Fresh water input	2	2	3	2	9
9. Optical properties	2	2	3	1	8
10. Harmful algal blooms	1	3	3	1	8
11. Bottom imagery	3	2	2	1	8
12. Salinity	3	1	2	1	7
13. Bottom type	3	1	2	1	7
14. Fog	2	3	1	1	7
15. Marine mammals	1	1	3	2	7
16. Passive acoustics	3	1	2	1	7
17. Water quality	1	2	3	1	7
18. Sound properties	2	1	2	1	6
19. Sea surface winds	1	2	2	1	6
20. Incident solar radiation	1	2	2	1	6
21. Wildlife diversity	1	1	3	1	6
22. Active acoustics	3	1	1	1	6
23. Air temperature	1	1	2	1	5
24. Air pressure	1	1	2	1	5
25. Humidity	1	1	1	1	4

# Appendices

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## Appendix 1 - Provisional Agenda

### An Ocean.US/Global Maritime Situational Awareness Summit “Embracing the Full Spectrum of IOOS Environmental Information for MDA”

#### Day 1- September 24, 2007

- 07:30-08:00** Registration and Coffee  
**08:00-08:10** **Dr. Brian Melzian**, Oceanographer/ Special Assistant to the Director, Director's Office, Atlantic Ecology Division, U.S.Environmental Protection Agency – *Welcome on behalf of EPA HS Team*  
**08:10-08:20** **Dr. Mary Altalo**, Director, Ocean.US – *Goals and Summit Deliverables*

#### **Session 1: Achieving Maritime Domain Awareness (MDA): Strategic Objectives, Mission Areas, Implementation Plans, and Information Sharing Challenges**

- 08:20-08:50** **Rear Admiral Lee Metcalf**, Director, Office of Global Maritime Situation Awareness (OGMSA) – *Overview of Global Maritime Situational Awareness*  
**08:50-09:20** **Tim Phillips**, Chief Technology Officer of Global Maritime and Air Intelligence Integration (GMAII) – *Global Maritime Intelligence Integration*  
**09:20-09:50** **Dana Goward**, Director, MDA Program Integration – *Coast Guard Role in MDA*  
**09:50-10:10** **Owen Doherty**, Director, Office of Security, Department of Transportation/ Maritime Administration – *Maritime Administration's Role in MDA*  
**10:10-10:25** General Discussion\Question and Answer Period  
**10:25-10:40** Break  
**10:40-11:10** **Todd Boone**, LCDR, OPNAV N6 – *Navy Role in MDA*  
**11:10-11:40** **Guy Thomas**, Science and Technology Advisor, OGMSA – *Building the Collaborative Information Environment*  
**11:40-12:10** **Michael E. Krieger**, Director of Information Policy, Department of Defense, Office of the Chief Information Officer (DoD CIO) – *DOD Net Centric Vision and the MDA Data Sharing Communities of Interest (COI)*  
**12:10-12:25** General Discussion\Question and Answer Period  
**12:25-14:00** Lunch (on your own)

#### **Session 2: Contribution of the Integrated Ocean Observing System (IOOS) to Achieving Maritime Domain Awareness**

- 14:00-14:30** **Dr. Richard Spinrad**, Assistant Administrator of NOAA Research and Chair Interagency Working Group (IWGOO) on Ocean Observations – *The Interagency Governance Structure of IOOS*  
**14:30-15:00** **Dr. Mary Altalo**, Director, Ocean.US – *Harvesting the National Investment in Ocean Observing through Integration*  
**15:00-15:30** **Dr. Ralph Rayner**, Deputy Director, Ocean.US – *Integrated Ocean Observing Systems in an International Context*  
**15:30-16:00** **Rear Admiral Richard West**, USN (Ret.), President, Consortium for Oceanographic Research and Education (CORE) – *Thoughts on the Transition of Research to Ops*  
**16:00-16:10** General Discussion\Question and Answer Period  
**16:10-16:20** Break  
**16:20-16:50** **Dr. Frank Bub**, Naval Oceanographic Office (NAVO) and Interagency Modeling and Analysis Steering Team (MAST) – *Operational Modeling and Analysis Challenges in IOOS*



**16:50-17:20** **Anne Ball**- Chair IOOS Data Management and Communications (DMAC) – *IOOS Data Sharing Principles and Data Fusion Conceptual Design*  
**17:20-17:50** **Zdenka Willis**, CAPT USN (Ret.), Director, NOAA IOOS Program Office – *Interoperability Issues within Agencies*  
**17:50- 18:00** **Dr. Mary Altalo** – Terms of Reference for Working Groups and Relationship between Days 2 and 3  
**18:00-18:15** General Discussion\Question and Answer Period  
**18:15- 19:45** Reception at Aria Trattoria

#### **Day 2- September 25, 2007**

**08:00-09:00** Working Groups Charge, Tasking and Deliverables: **Dr. Mary Altalo** and **Scott Beaton**, CAPT, USN (Ret.), Johns Hopkins University, Applied Physics Laboratory  
**09:00-12:30** **Session 3: Understanding MDA Environmental Information Requirements**  
Break into Three Working Groups  
1) Interdiction: **Dana Goward**, **Dr. Mary Altalo** , **Barbara Heizer**, Boeing and Guy Thomas  
2) Disaster Response: **Dr. Tom Malone**, Ocean.US, **Carroll Hood**, Raytheon, **Art Allen**, Coast Guard, and **John Cooke**, NAVSEA  
3) U.S. and Foreign Port Security: **David Martin** (Applied Physics Laboratory University of Washington), **Dr. Ralph Rayner**, **RADM Deborah Loewer** (USN, Ret.), Ph.D., Advanced Acoustic Concepts, **CAPT Christopher S. Moore**, Deputy Director, NOAA IOOS Program Office.  
**12:30-13:30** Lunch (On your own)  
**13:30-17:30** **Session 4: Capabilities to Meet MDA Environmental Information Requirements**  
Working Groups as in Session Three  
**17:30-18:00** **Prepare for Day 3 Morning Report**

#### **Day 3 – September 26, 2007**

**08:00-9:00** Working Groups' Morning Report: Integrating IOOS Information Products Into MDA Environmental Information Needs on MDA Environmental Information Requirements  
**09:00-12:30** **Session 5: Towards and Execution Strategy: Achieving MDA\IOOS Integration through Partnerships**  
**12:30-13:30** Lunch  
**16:30-17:00** **Wrap-up and Close of Summit**

## Appendix 2 - Summit Participants and Contact Information

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## Appendix 3 - Introduction and Overview

### Introduction

**Dr. Mary Altalo**  
**Director, Ocean.US**

Thanks very much to the Environmental Protection Agency for providing such wonderful facilities. On behalf of Ocean.US, the National Interagency Office for the Coordination and Promotion of the integrated ocean observing system, I welcome all of you. At this meeting we have approximately 100 registrants, which was an equal number of ocean environmental information providers as well as MDA users and decision makers. They include representatives from the federal agencies, the states, the local governments, the academic sector, private sector, including industry and non-profit institutions.

The vision for IOOS was created in 1998 when the National Ocean Leadership Council was charged by Congress to create an integrated ocean observing system to provide data and information required for more rapid detection and timely prediction of ocean and coastal state changes for better management and policy decisions. This encompassed identifying and inventorying all of the ocean and coastal observation assets in the United States, integrating them into an interoperable information system of systems focusing these assets on serving management decisions in seven cost-cutting national priority needs. The seven priorities include public health, sustainable natural resource management, climate and weather impact, maritime operations, ecosystem management and national security.

IOOS was envisioned to be an operational system, which would constantly evolve and remain state of the art through the incorporation of new technology and best practices and applications. Transitioning research to applications has always been in our mission.

In order to further update and amplify the pressing decisions and policy information needed by target end-user communities, a series of national implementation conferences and workshops have been held in the year since 2002 including those for public health, optional operations and coastal inundations. In essence these developed the national information requirements or the problem set, which allowed the optimal IOOS configuration. This conference is one of a series and is aimed at surfacing the information needs, assessing the capabilities of the nation to meet with those needs, and setting out recommendations for filling the gap in achieving MDA. The overall goal of our particular conference is a mutual awareness and understanding of the environmental information needs of MDA and the capabilities of IOOS information provider community to meet those needs.

The first day of the summit consists of a series of presentations from the MDA customer community and the IOOS provider community, as well as exposing shared harmonization challenges for data discovery, interoperability, and data fusion.

Days two and three of the Summit will be workshops based around the three interest areas for MDA; interdiction, port security and disaster response. The decision

support scenarios will be used to illustrate the required information and information flow processes. The breakout groups clustered around each application area will define specific requirements, surface existing interagency capabilities, examine barriers to interoperability and fusion, perform gap analysis for the information, and draft high-level execution plans to meet these needs and draft recommendations for follow-on.

**RDML Lee Metcalf**  
**Director, National Office for**  
**Global Maritime Situational**  
**Awareness**

*Overview of Global Maritime*  
*Situational Awareness*

The evolution of Maritime Domain Awareness (MDA) dates back to early mariners. In more recent years, a Presidential Directive (NSPD-41/HSPD-13) was signed in December of 2004, from which was developed a National Strategy to Achieve Maritime Security and a National Plan to Achieve Maritime Domain Awareness. A government framework was also created for sharing information necessary for MDA. The framework needs to allow data to be standardized and shared easily, while adhering to all terms and conditions attached to the data.

MDA is the effective understanding of anything associated with the global maritime domain that could impact the security, safety, economy, or environment of the United States. NOGMSA's goals are to develop a National Maritime Picture, focus efforts of enterprise hubs, and guide the National MDA CONOPS and Investment Strategy.



The challenge becomes how to leverage what already exists as far as coordination, cooperation and information sharing to further build on these capabilities. NOGMSA is working to frame an actionable body to move information into offices in need thereby helping decisions to be made efficiently and effectively. It is the intent of NOGMSA to create a wide framework of agency and group involvement.

**Tim Phillips**  
**Chief Technology Office of**  
**GMAII**

*Global Maritime Intelligence*  
*Integration*

Eight plans are derived from the National Strategy for Maritime Security. The Global Maritime and Air Intelligence Integration (GMAII) Office is the intelligence component of that. The main roles that GMAII is responsible for are to ensure the effective government-wide access to maritime and air information and data critical to intelligence production.

The GMAII mission is to provide policy, planning direction, guidance and oversight and in order to foster the global maritime community of interest. MDA must be a collaboration between the private sector, the non-defense security and intelligence agencies within the federal government. The state, local, tribal and law enforcement needs to be involved as well.

The GMAII office is focused primarily on counter proliferation and counterterrorism. The Office has discovered from analysis of illicit trafficking networks that it provides viable leads to the threat, which is their means, their methods, their enablers and their capabilities. Information must be leveraged and shared with coalition allies, the private sector and the law enforcement community.

A baseline survey of the information community highlighted several next steps. One of the first things in the baseline is the over classification of information. The majority of intelligence is derived not from classified sources, from national technical means or from a person gathering intelligence information. The over classification of information is detrimental to our nation.

The climate of sharing has also changed. GMAII is trying to make more information available to the wider community of interests and we're dedicated to that task.

Strategic objectives have been established to help shape the way ahead. The focus needs to be on strategic initiatives rather than tactical levels. The intelligence community at the national level needs to provide the tools and assets necessary for the military to make tactical decisions and to arrive at operational intelligence where they can use the assets they have to make a difference.

**Dana Goward**  
**Director, MDA Program**  
**Integration**

*U.S. Coast Guard Role in MDA*

The United States has 361 commercial seaports, 95,000 miles of coastline, and the world's largest navy. However, as a maritime nation, the United States remains largely unaware of what goes on in international waters. Many parties are currently involved in maritime regulation, including more than 18 federal agencies and multiple state and local authorities.

For example, state waters extend three nautical miles in most instances. At the same time, under federal law U.S. waters also extend to three nautical miles. However in most instances federal law is enforced up to 12 nautical miles. This is just one example of complication in maritime

regulations. Additionally, there has been a long tradition of maintaining anonymity at sea. Increasing transparency of information presents a huge and necessary cultural shift to ensure the safety, security and stewardship of the maritime domain.

Maritime Domain Awareness is the process of connecting the real world with the decision-makers on the other end and vice versa. The Coast Guard model has a four step process to achieve MDA; collecting existing information, fusing it, analyzing it, and then presenting it to decision makers.

It is important to leverage existing observations that interact with the maritime domain to improve our collections and our understanding, and to improve obtaining the information that's required to fuse, analyze and then produce decision makers.

One of the biggest gaps is in persistence. Monitoring needs to occur over a continuous period of time, so that a baseline "normal" situation can be established. This will allow better awareness of changes in the normal state. Due to the extent of the United State's coastline and waters, broad situational awareness is needed. The ability to penetrate in-between sensors is something routinely exploited by U.S. adversaries.

The need exists for careful detection of vessels wherever they may want to penetrate our 93,000 to 95,000 mile long coast. Small vessels especially may be able to enter U.S. water without detection. Discernment is another key issue for MDA. It is important not only to detect a target, but to determine what type of target it is.

While it is difficult to anticipate the kind of knowledge a user will need, the more people involved in the process will only further our joint endeavor toward MDA.

**Owen Doherty**  
**Director, Office of Security,**  
**Department of Transportation/**  
**Maritime Administration**

*Maritime Administration's Role in MDA*

The focus of this talk addresses the need for information sharing to achieve maritime domain awareness in the transportation community. Due to globalization the maritime transportation system has grown efficiently, especially with the use of containers. An intermodal system has developed, with information going mode to mode. Due to this, a transportation crisis could result when a natural disaster, threat or other hazard occurs, creating a domino effect as the information transfer breaks down. Information sharing also must occur not just among maritime modes but also among rail, highway and other modes of transportation.

Maritime domain awareness is a necessary component to providing the ability to optimize a transportation system. Detailed planning must occur in order to keep up with the velocity of flow through our ports, and to ensure efficient global transportation. The key to information sharing on a transportation site is getting the pertinent information to the industry that owns the transportation system, enabling them to make decisions. This information includes not only operational information but also the ability to archive and analyze the information to influence policies and to help improve the transportation system to meet those challenges that arise with the forecast.

One goal of the Maritime Administration (MARAD, one of the modes of the Department of Transportation) is to look particularly at infrastructure by examining ports and their activities globally. As stated in their mission, MARAD serves "to improve and strengthen the U.S. marine transportation system— including infrastructure, industry and labor – to meet the

economic and security needs of our Nation". There is a great need to be able to forecast what will happen between ports and to make that forecasting system more resilient. For example, if one port closure occurs, there is the need to predict what other terminals will be affected.

As in the case of Hurricane Katrina, MARAD needed to be able to provide information on the security of transportation such as the impact of the disaster. Resiliency in the transportation system is of key importance for national security purposes and to responding to contingencies. Another function of MARAD is to use the ports to move military cargos in and out and maintain a strategic port.

While there is the need to facilitate commerce, the MDA is really the foundation for the national strategy on maritime security. However, another key is the ability to recover from an incident, which is getting more and more attention. In order to achieve MDA, there needs to be transparency and accountability in information sharing for security, transportation, commerce, and environmental purposes.

One MARAD initiative coming from the Ocean Action Plan is America's Marine Highway. This addresses ways to improve more water transportation for a number of reasons, such as for fuel efficiency and environmental issues. For example, there are many inland waterways that are now being better utilized. Improvements in the shipping industry must involve not only water transportation, but also highway and railway shipping modes.

Addressing transportation challenges and then recognizing the importance of including transportation and transportation information sharing is important for marine transportation system safety, for the purpose of our economic security and for the purposes of the environment and national security.

**LCDR Todd Boone**  
**OPNAV N6**

*Navy Role in MDA*

This brief presents a Program Executive Office Command, Control, Communications, Computers and Intelligence (PEO C4I) perspective. PEO C4I does the acquisition, integration and delivery of systems. SPAWAR is the engineering component and SPAWAR system centers conducts research development, testing and evaluation functions.

Maritime domain awareness can be described as global maritime situational awareness plus threat analysis. The U.S. cannot be the lone patrol in the high seas however, and international collaboration is an integral part of the global strategy to partner with like-minded nations for safety and security at sea.

To attain MDA, more advanced collection, fusion, analysis and dissemination tools are needed to help decision makers have a better understanding of their environment faster. MDA essentially is about actionable information. In the maritime domain there are many entities carrying out their assigned missions and acting against all kinds of maritime threats -- safety, security, economic and environmental. All of these maritime entities have information needs. To meet these needs, each entity collects information to process, analyze and distribute to those who need to take action.

Each agency must execute its mission according to its own applicable laws and directives; however, MDA tools such as the common operational picture and shared databases allow an agency acting on its own authority to keep appropriate partners aware of the situation and to coordinate their response. Strong partnerships among MDA partners lead to robust information sharing processes across the maritime community and a mutual benefit to all stakeholders

in the form of greater efficiency and effectiveness. In order to get to the point of more effective understanding of the maritime environment with more persistence, previously inaccessible databases must be made publishable and discoverable to non-traditional customers from law enforcement to interagency departments, and the Department of Defense to international partners.

On May 17, 2007, the Secretary of the Navy (SECNAV) laid out objectives for expeditiously fielding a prototype MDA capability. The intent is to align and leverage existing funding and efforts to field MDA technologies ready for Fleet introduction. SECNAV has been identified as MDA Executive Agent for the Department of Defense. The challenge is in developing a services oriented architecture environment. This includes data providers that publish their products as a service. Customers can then discover the data they need through an application layer in an infrastructure that brings these two together in a secure and responsive environment. Spiral-1 will be a focused effort that leverages currently available technologies, in which integration is the key. Spiral-2 will expand the effort, both in capability and in deployed locations. The key is transition to current Navy TOA programs of record using an open architecture environment.

In the end, MDA is not just one organization's responsibility and it does not just affect one discipline. MDA is however global, joint, interagency and international. MDA is in effect the 21st century version of securing our maritime freedom of navigation in partnership with like-minded nations.

**Guy Thomas**  
**Science and Technology Advisor,**  
**NOGMSA**

*Building the Collaborative  
Information Environment*

Seven working groups were stood up in preparation for NSPD/HSPD. One of them, the technology working group, showed the need to build a roadmap. The concept of operations was written, outlining the need for point defenses around port approaches as well as far reaches.

There is a need to detect, identify, assess, and track. Different commands need different levels of information provided to them, so there is a definite need for a collaborative information environment with a user defined interface (UDOP). This creates a core of common information. This eliminates replicating databases; one database is in place and interfaces are built into it. Different levels of security clearance allow for different levels of access to this database.

Detection of vessels can be further broken down into zones. For example, high seas, exclusive economic zone, approach zone and the ports and coasts. Boat size is also important, and can be divided into categories of boats larger than 65 feet, medium sized boats able to reach near-by countries, and boats launched from shore.

For all boats, voyage histories should be kept. Problems arise when a vessel is non-emitting. There is the need for 95% probability detection for all vessels over 300 tons and the capability to intercept each vessel within four hours. Another challenge is identifying vessels in approach zones in time to react. For port and coast security, Command 21 is a current effort to build the command post to integrate the existing sensors and to understand where increased surveillance is needed.

There is a definite need for a systems engineering study, and the joint capabilities assessment and gap analysis that are a part of it. There now needs to be a systems engineering approach to better understand where available money is, what the cost will be. Overall, there is a great need for global information transparency, and putting tools in place to allow data sharing and fusion.

**Michael Krieger**  
**Director of Information Policy,**  
**Department of Defense**

*DoD Netcentric Vision and the MDA  
Data Sharing Communities of Interest  
(COI)*

Department of Defense (DoD) data sharing focuses on implementation of net-centric data and service strategies. Sharing information provides user with the requisite agility to react as needed. Data needs to be visible, accessible, understandable and trusted. Additionally, making data visible to the unanticipated user is a necessity. Communities are the key component in developing semantics for understandability in data sharing. These communities are groups that have an information sharing problem that needs to be addressed collectively across service or agency boundaries. One early success has been the Maritime Domain Awareness Community of Interest (COI).

The DoD has developed a net-centric services strategy with the goals of providing services by making information and functional capabilities available as appropriately secure services on the network, using existing services to satisfy mission needs before creating duplicative capabilities, and governing the infrastructure and services to establish the policies and processes for a single set of common standards, rules, and shared secure infrastructure and services throughout the DoD Enterprise to ensure



interoperability. Joint governance may be the largest obstacle to creating COI's.

Lessons learned so far have been strong senior leadership is needed to endorse COI activities, governance is needed to minimize unintended duplication and resolve conflicts, and that technology is easy; culture and policy are hard.

**Dr. Rick Spinrad**  
**Assistant Administrator of NOAA**  
**Research and Chair, IWGOO**

*The Interagency Governance  
Structure of IOOS*

For an integrated ocean observing system to be fully operable and consistent among the different participating agencies it must have a successful interagency governance structure. Some of the challenges to the integrated system include acquiring and making the data interoperable from existing systems, coordination of different federal agencies, and providing consistency with the US President's Ocean Action Plan as well as the international initiative.

The Ocean Action Plan which was signed by the President three years ago specifically defined the Integrated Ocean Observing System (IOOS) and Ocean.US produced the Integrated Ocean Observing Development Plan. It was the first annual Integrated Ocean Observing Plan and is referred to as the development plan. Completing this plan within the Ocean Action Plan gave the field credibility and became the driver to gain a support base to do a number of things. Strengthening that even further allowed a greater connection to the international initiative, the Global Earth Observation System of Systems (GEOSS). This system is intended to globally monitor the earth and the US component still must overcome the main challenges of coordination, integration, and interoperability, but essentially this system can

fulfill a broad array of societal observations.

The organizational body formed out of the Ocean Action Plan is the Joint Subcommittee on Ocean Science and Technology (JSOST). The Interagency Working Group on Ocean Observation (IWGOO) is a formal body focusing on the ocean observations, plans, programs, budgets, challenges and reports the information to the JSOST. The IWGOO is also responsible for the budgets, personnel, and funding of Ocean.US which is consistent with the objectives in developing an Integrated Ocean Observing System.

About two years ago the Senate Appropriations Report for NOAA required the development of a strategic plan for IOOS. At this time the interagency working group was formed and it was very encouraging that the group came together to complete a plan in an interagency context. The IWGOO completed the strategic plan and it represents a strong statement with actionable items for what will be done with the Integrated Ocean Observing System. The IWGOO is also working on a statement to be released soon that will define the relationship between the Ocean Observatories Initiative (OOI) and IOOS.

There are many challenges for the IWGOO. Agencies may view their participation in the interagency working group differently. Some agencies view it as a place where the most senior leadership of the organization can work towards long-term planning budget development and some view this as a place to get programs coordinated. This varied level of representation can in fact complicate the decision making process and becomes a real challenge for managing the different expectations of involvement within the working group.

Ocean.US was started seven years ago specifically because

there was no place where the agencies could work together about coordination of programs and planning. Priorities have been advancing the strategic plan, using it as a guide for programmatic development, strengthening partnerships and getting out in front of the interagency coordination through demonstrating capabilities and building programs. Some of the challenges for the IWGOO include determining the roles and responsibilities, funding, and personnel issues for Ocean.US. Moving forward it will be important to continue advancement of the strategic plan, strengthening the partnerships, and advancing technologies.

Another challenge is the technical side of IOOS. It is not easy to integrate data from many sources and ensure that standards and quality control mechanisms are well identified to provide the data in formats, rates and frequencies that are useful for a broad array of applications. This is also not a U.S. interagency prime; this is a global problem which again is where that coordination with the Intergovernmental Oceanographic Commission becomes extremely valuable.

There are also significant benefits for having an integrated working group. The interagency collaboration will facilitate development of programs, and interagency partnerships that can stimulate multi-agency projects such a multi-static high frequency radar system. It's a lot easier to mitigate the risk within agencies by spreading the risk. And that means if an agency chooses to go forward with a particular observational program but is not sure it wants to spend large amounts of money toward that program by partnering and effectively cost sharing, that risk can be mitigated. That's the pooling of agency strengths which Ocean.US assists by identifying targeting opportunities for doing that sort of thing.

There has been great progress in the last couple of years in moving towards a concept of operations for the interagency working group that really builds on the nature of the relationships working on a policy and programs and is starting to get down to the budget level. The working group will be a critically important factor in moving IOOS forward ensuring all the federal agencies are involved and working together through partnerships.

**Dr. Mary Altalo**  
**Director, Ocean.US**

*Harvesting the National Investment in Ocean Observing through Integration*

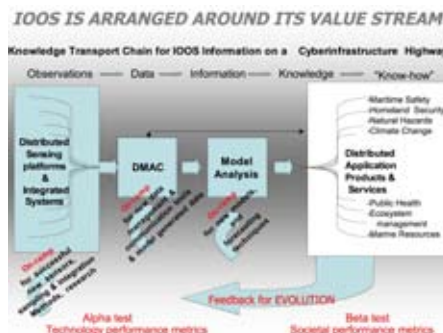
Ocean.US is an interagency planning office created to integrate ocean and coastal observing system assets. The Integrated Ocean Observing System (IOOS) is user driven, and is focused on answering the seven societal goals (slide).

1. Predict climate change and effects
2. Mitigate natural hazards
3. Improve maritime operations
4. Improve national security
5. Reduce public health risks
6. Protect/restore coastal ecosystems
7. Enable sustained use of coastal and ocean resources

IOOS is a valuable combination of federal and non-federal assets, with a commitment to free and open access of information on a local and global scale. The IOOS coastal component gathers information on a regional local scale through a National Backbone enhanced by Regional System contributions (slide).



IOOS operates on three major components; observations, modeling and analysis, and applications, and is arranged around its value stream (slide).



Physical, chemical and biological variables are measured and were inventoried for the first time in 2007 (slide).

**Core Variables**

**Physical**

- Sea surface winds
- Sea surface waves
- Sea surface currents
- Sea level
- Stream flows
- Temperature, Salinity
- High Res Bathymetry
- Ice distribution

**Multidisciplinary**

- Optical properties
- Bottom character/ Benthic habitats

**Chemical**

- Dissolved inorganic nutrient
- Contaminants
- Dissolved oxygen

**Biological**

- Fish species, abundance
- Zooplankton species, abundance
- Phytoplankton species, biomass (ocean color)
- Pathogens

IOOS alone contains over 44,000 observations, taken by over 13 partner agencies. While this is a significant list, gaps still remain in IOOS. In order to meeting National Mission Requirements, requirements need to be examined by societal goal area. Once major issues are identified in each goal area, the major product needs can be defined. Parameter requirements can then be connected to the appropriate temporal and spatial resolution, and further on to the program and agency responsible for tracking each parameter.

**Dr. Ralph Rayner**  
**Deputy Director, Ocean.US**

*Integrated Ocean Observing Systems in an International Context*

The Global Earth Observing System of Systems (GEOSS) is a global network of earth observing systems tasked with continually improving existing global systems and encouraging and accommodating new components. The responsibilities of the GEOSS are to provide integration of existing thematic initiatives, to determine gaps in the systems and work to fill those gaps, and to eliminate duplication among the systems. Each nation's ocean contribution to GEOSS forms the Global Ocean Observing System (GOOS), and although the United States contributes the most to GOOS, the next largest contributors are France, Australia, and Russia.

The GOOS is a multinational system committed to establishing global ocean observation and forecasting while upholding specific standards that countries must adhere to in order to contribute to the system. GOOS ultimately benefits several key societal goals including: global climate change; predicting climate variability; protecting and managing marine ecosystems; complying with international agreements; protecting life and property on the coast and at sea; and providing information to a variety of uses and users. The GOOS is implemented by the Joint technical Committee for Oceanography and Marine Technology (JCOMM), and this body also is responsible for managing the GOOS standards, interoperability, and consistent service provision. Different countries have their own systems for ocean observing and for standardizing metadata.

The European Parliament adopted a system called the Infrastructure for Spatial Information in the European Community (INSPIRE) in 2007 to impose common standards

for metadata, interoperability, discovery, viewing, downloading and transformation of all geospatial data. Europe probably has the most developed regional capability federating the activities of different Member States. Gaps still exist with other regional systems ranging from catalogs of national programs to others only existing by name. Furthermore, gaps are created with disconnect between other national systems, private systems, and port systems due to a wide range in level of development and varying degrees of implementation.

In order for the GOOS to be efficient and fully operable, the gaps with other less developed systems (Africa, Middle East, India etc.) need to be closed in connection with the more developed systems in Europe, Japan, and Australia. The accessibility to real-time data needs to be improved and there need to be improvements in the overall accessibility to hard to find data and data in semi-closed research systems.

#### **RADM Dick West Consortium for Ocean Leadership**

##### *Thoughts on the Transition of Research to Operations*

Working toward complete Maritime Domain Awareness will require utilizing the Integrated Ocean Observing System (IOOS) to provide the data and operations necessary to perform assessments such as forecasts and observations. A fully operable IOOS will integrate the regional systems and allow research data to be fully interoperable for a wide variety of operational needs. In most situations, real-time data and a fully integrated system allow for assessments to have a higher degree of spatial and temporal variables, greater impact from sensor or weapon performance, and a better reaction time to threats. Limiting factors to accomplishing

this include the lack of accessible data due to security issues, lack of fully developed databases, and compatibility issues with data collection. Another limiting factor, and consequently the most important, is the difficult transition from research information to an operational system. Possible solutions to making such a transition easier include co-locating researchers and operations staff and keeping inter-agency cooperation a high priority. Being able to develop that transition from research to usable information will contribute to building IOOS stronger and more usable for the different customers including the military and assisting them with what they need to have Maritime Domain Awareness.

#### **Dr. Frank Bub NAVO**

##### *Operational Modeling and Analysis in the Integrated Ocean Observing System (IOOS)*

The Modeling and Analysis Steering Team (MAST) was formed through a steering team comprised of several federal agency representatives. They developed a strategic plan that intended to build and expand the national operational modeling capabilities. The plan focuses efforts on addressing the seven societal goals, working with the Data Management and Communications committee, and producing information that is of use to various customers particularly within the IOOS system on a daily or routine basis.

The steering team is charged with a number of tasks and will be collaborating with many different partners. These partnerships with the IOOS agencies, regional associations, states, academia, and private industry allow production of models that will span all the way from the national level down to regional levels. The team intends to produce an inventory of existing operational models and assess their capabilities and skills, and integrate

observations and modeling through test beds, observing system experiments and observing system simulation experiments.

One of the approaches that MAST hopes to take is using community modeling networks where the Naval Oceanographic Office (NAVOCEANO) would provide information on a global model to the regional organizations. MAST would also provide assistance in terms of establishing their modeling capabilities of higher resolution. The intention is to develop an action plan and to develop justification for funding towards a national modeling effort. To set up a successful modeling system there are several needs and requirements. It takes a significant degree of investment especially as the demand for accuracy and future forecasting increases. Most models are run right now to 48 or 72 hours and more frequently requests are for 5, 7 or even 30 days out. Models also extend into different fields including meteorology and integrating the two types of data together would be ideal.

The Naval Oceanographic Office (NAVOCEANO) is working on establishing an ocean forecasting capability. This is very similar to weather forecasting and having the ability to provide forecasts to our customers, particularly the Navy. This requires assessing the models to determine if they are providing sufficient data, addressing the customer's needs and identifying weaknesses in the models. NAVOCEANO has an intricate structure where data is collected – from surface data, satellite data or in situ data. The data is processed and fed into different models. They run on two large computers including unclassified, which are KRAKEN and BABBAGE. Many of the customers right now require classified information so it can be difficult to ensure that the modeling products are conducted through a trusted gateway system. NAVOCEANO has a nesting approach to modeling, in other words they run global models



at relatively low resolutions; provide boundary and initial conditions for higher resolution models until information is given for a specific local area.

NAVOCEANO provides many models that are up and running today. One question that may be asked is why models are needed if there is so much data? Sometimes more is needed than just data to answer a specific question, pinpoint patterns or show the state of an area.

There are many different types of products that can be delivered through modeling. The MAST efforts are intended to integrate different agency work and to consistently improve capability and amount of future forecasting. One example of how this relates to an actual situation. Back in January of 2007, an aircraft went down in the Indonesian area. When it went down there was nobody in the area. NAVOCEANO was contacted and was asked to determine where the aircraft might have gone down. A piece of wreckage washed up on the shore. A hindtest based on an NCOM model -- in this case it was an East Asia NCOM model -- was projected backwards 10 days from when wreckage washed up on shore. When projected backwards 10 days the model showed possible locations based on ocean surface currents from where the piece had washed up on shore. At the same time the National Transportation Safety Board had a contact. Their final contact was one day before the pinger died -- the pinger had a 50-day life-- one day before it died it was found nearby. The model projected well and shows how this kind of application might be useful.

**Anne Ball**  
**Chair, IOOS DMAC**

*IOOS Data Sharing Principles and Data Fusion Conceptual Design*

The Data Management and Communication (DMAC) Steering

Team is one of three Integrated Ocean Observing System (IOOS) sub-systems, the observing sub-system where data gets collected. The DMAC system is where all the standards and protocols help transfer data that has been collected over to the modeling and analysis sub-system and out to the public. DMAC is one of the three major sub-systems of Ocean.US.

The DMAC consists of several participating organizations including federal agencies, national programs such as the National Science Foundation's ORION program, international programs such as Global Earth Observation System of Systems (GEOSS) and the Global Ocean Observing System (GOOS), and about 11 of the regional associations. This team effort includes several expert teams, some caucuses, a working group and an interagency oversight working group. The individual team members consist of representatives from government, academia, and public and non-profit organizations. Its task is to coordinate and oversee DMAC standard evolution and to identify and provide recommendations on gaps between these standards and protocols, and identify gaps that need to be filled in order to make DMAC a reality.

As with any data management and communications group, developing data standards is the key to building a successful data system. Currently the steering team is working to identify the standards that are needed to build DMAC and trying to coordinate with other standard processes and bodies to leverage their activities, to learn from them, and to share with them.

The standards process consists of three status levels including submitted, proposed and recommended. Once a standard has been submitted to DMAC for consideration, experts teams review it, and if it is appropriate for DMAC it is upgraded to proposed. At the proposed level, DMAC encourages organizations to test the standard

and consider whether it works for them. At this point, the proposed standard would be available for the IOOS community and the public to provide comments. After the standards have undergone rigorous scrutiny, DMAC will require or encourage the standard to be used and then it would be moved up to the "recommended" status.

With most other initiatives, DMAC also has its share of challenges. Some of the prominent issues include having multiple discovery services and undefined metadata fields and formats. The multiple discovery services, such as the Global Change Master Directory that NASA developed; the National Spatial Data Infrastructure Clearinghouse System by the FGDC and the Ocean Biogeographical Information System, represent some of the multiple options available to find data. One of the expert teams is researching portals to see if that technology can be used in determining the strongest services. For the metadata issues, there is often a need for different types, of information to understand or use different observation types so data fields need to be standardized. Also, metadata is often written in a variety of formats. The metadata and data discovery expert team worked with the Marine Metadata Interoperability Project, or MMI to create a content standard comparison matrix. The fields still need to be thoroughly reviewed but what has been developed is currently viewable online.

The DMAC is also working on several future projects. Different customers require data in different formats. Some want maps while others require the direct data stream itself. The steering team is working to provide the same data but in different presentation modes to help users get to the information they want more quickly. Another project is called Sensor With Interoperable Metadata or SWIM. Currently in its proposal stage, this project will define and standardize what information will be stored as

data is being collected. A third project is a Federal Geographic Data Committee project on emergency metadata. This project comes from the problems experienced during hurricane Katrina. It looks at data two different ways. One is determining the bare minimum information needed for documentation when under an emergency situation. The second is to determine the necessary minimum information needed to assess whether there is an emergency situation.

As the DMAC continues to progress forward to bring together the global and coastal components of IOOS, the committee will continue to work with additional partners including NASA, EPA and with GEOSS on international standards. With future projects and overcoming challenges, the DMAC aims to link the observing system to the users through multidisciplinary data from a range of sensors and platforms. This ultimate goal will bring real time data to users.

**Zdenka Willis**  
**Director, NOAA IOOS Program Office**

*Interoperability Issues within Agencies*

For the Integrated Ocean Observing System (IOOS), or any other component of the Global Earth Observation System of Systems (GEOSS) to be successful, it will require all partners to work closely together to build the many components of IOOS and make it operational. Even more importantly, we must all work in unison and with a common vision to articulate the critical importance of this endeavor so that we ensure IOOS gets support from Congress, and ultimately the end users and benefactors of this information.

The National Oceanic and Atmospheric Administration (NOAA) reviewed the IOOS to determine what has been done and

what needs to be done to support a national effort. Two elements developed out of this review. The first was to organize more full time support since there were many people doing things part-time and one solution NOAA determined was to develop a program office. Secondly, there was a need for a risk reduction project which developed into the data integration framework.

NOAA set up an IOOS executing office to provide leadership where it is appropriate and build capabilities to contribute to the national IOOS. A NOAA IOOS development plan has been drafted and released for comment so those both within NOAA and outside of NOAA understand what is going on. Within the development plan it was determined what activities would be tackled from a scientific and programmatic perspective that would contribute to the seven societal goals.

Integration is so important to an interagency effort yet is a broad and undefined term. The NOAA IOOS office defined integration as a long-term data series, coordinated in space and time. After that they completed an analysis of different problems and chose four modeling areas. Pilot projects were initiated, but first data flows had to be traced.

The office completed five interoperability tests. Many of the differences in data were as simple as the example of time – some use 15:00 others say 3:00 p.m. and then some others said plus 8:00. It is this inconsistency that the data integration framework is trying to solve with the pilot projects. The first set of tests was mostly about the ease of getting information and data. The second set of tests that is expected to be run in the near future will focus additionally on the compatibility, interoperability, and integratability of the individual data sets acquired from the distributed sources.

Standards are difficult to describe because there is not just one. In order to more easily expedite the development and implementation of the data integration framework (DIF), NOAA IOOS is working to define a set of standards and protocols for several of the data management functional categories. For the initial DIF, only data transport and access, metadata, and to some degree QA/QC and IT Security will be addressed. Within each of these functional categories, there need to be standards and protocols (and possibly multiple ones) for each of the types of data. For example, transport of time series data may have a different protocol than that for transport of grid data.

The Data Management and Communication Steering Team officially kicked off in September 2007 by Ocean.US and NOAA. It is a team consisting of experts across the United States, with the goal of developing standards for the IOOS data. Underneath that steering team are expert working groups that have titles like metadata, transport, archive and caucuses that are functionally based -- education, industry and international.

The other thing that this program is very committed to do is to try to get this program into a more traditional acquisition program that is at the \$500 million level over five years.

## Appendix 4 - IOOS Core Variables and Associated Federal Programs

**Table 1.** Non-ocean and Great Lake variables required to quantify important drivers of change in ocean and coastal systems. Atmospheric measurements over ocean and coastal systems and measurements of surface water transports from land are considered part of the IOOS.

Atmospheric	Terrestrial	Human Use
Wind vectors Air temperature Atmospheric pressure Precipitations (wet, dry) Humidity Aerosol concentration Ambient noise Atmospheric visibility Cloud cover	River & stream flows Ground water discharge Mass transports of sediments, nutrients, and contaminants	Beach usage Point source discharges Fish & shellfish catch Commercial fish catch Recreational boating Generation of underwater sound

**Table 2.** Provisional IOOS core variables for the National Backbone and their relevance to the seven societal goals of the IOOS (indicated by “X”). Physical variables are ranked high because they are required to achieve all seven societal goals. Variables in bold were also identified by an IOC Panel as core variables using a similar procedure. This list of variables is augmented by data on atmospheric, land-based and anthropogenic forcings in Table 1.

CORE VARIABLES	Weather & Climate	Marine Operations	Natural Hazards	National Security	Public Health	Healthy Ecosystems	Sustained Resources
<b>Salinity</b>	X	X	X	X	X	X	X
<b>Temperature</b>	X	X		X	X	X	X
<b>Bathymetry</b>	X	X	X	X	X	X	X
<b>Sea Level</b>	X	X	X	X		X	X
<b>Surface waves</b>	X	X	X	X	X	X	X
<b>Surface currents</b>	X	X	X	X	X	X	X
Ice distribution	X	X	X	X			
Contaminants				X	X	X	X
<b>Dissolved Nutrients</b>					X	X	X
Fish species						X	X
Fish abundance						X	X
Zooplankton species					X	X	X
<b>Optical properties</b>				X	X	X	X
Heat flux	X					X	X
<b>Ocean color</b>	X	X			X	X	X
<b>Bottom character</b>	X	X				X	X
<b>Pathogens</b>				X	X	X	X
<b>Dissolved O<sub>2</sub></b>						X	X
Phytoplankton species	X	X		X	X	X	X
Zooplankton abundance						X	X



**Table 3.** Pre-operational and operational programs, listed by core variable and the responsible agency, that are priorities for incorporation into the initial IOOS.

Core Variable	NOAA	Navy	USACE	USGS
Sea surface winds	C-MAN <sup>a</sup> , NWLON <sup>b</sup> NDBC <sup>c</sup> , PORTS <sup>d</sup> , NERRS <sup>e</sup>	Integrated buoy program		
Stream flow				Stream gauging NSIP <sup>f</sup> , NSQAN <sup>g</sup>
Temperature	GOES, POES, NDBC, CoastWatch, C-MAN NWLON, PORTS <sup>d</sup> , LMR-ES <sup>h</sup> , NERRS	Integrated buoy program		
Salinity	LMR-ES, PORTS <sup>d</sup> , NERRS	Integrated buoy program		
Coastal Sea Level- Topography	NWLON, PORTS <sup>d</sup>	ADFC <sup>i</sup>		NSIP
Waves	NDBC	Integrated buoy program	Coastal Field Data Collection Program	
Currents	NDBC, PORTS <sup>d</sup> , National Current Observation Program			
Dissolved Inorganic Nutrients	LMR-ES Habitat assessment, NERRS			
Chlorophyll	LMR-ES, NERRS			
Habitat & Bathymetry	Hydrographic Survey Coral reef mapping Coral reef monitoring Coastal mapping Topographic change mapping Benthic habitat mapping Habitat assessment Coastal change assessment mapping		Hydrographic Surveying	Coral reef mapping & monitoring Coastal change mapping Benthic habitat mapping
Plankton Abundance	LMR Surveys Ecosystem Surveys			
Abundance & distribution of LMRs & protected species	LMR Surveys Ecosystem Surveys Protected Resources Surveys National observer			
Population Statistics <sup>j</sup>	LMR-ES National observer			
Fish Catch	National observer Recreational fisheries Commercial statistics			

<sup>a</sup> Coastal-Marine Automated Network,

<sup>b</sup> National Water Level Observation Network,

<sup>c</sup> National Data Buoy Center (moored meteorological sensors),

<sup>d</sup> Physical Oceanographic Real-Time System,

<sup>e</sup> National Estuarine Research Reserve System,

<sup>f</sup> National Streamflow Information Program,

<sup>g</sup> National Stream Quality Accounting Network,

<sup>h</sup> Living Marine Resources-Ecosystems Survey,

<sup>i</sup> Altimeter Data Fusions Center,

<sup>j</sup> Population statistics = sex, weight, length, and stomach contents of fish species.

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## Appendix 6 - Working Group 2 Case Studies

### **MDA Decision Support for Disaster Response**

#### **IOOS Regional Association Collaboration with the U.S. Coast Guard Search and Rescue, HazMat, and Vessel Tracking**

**Art Allen (USCG), Josh Kohut and Scott Glenn (Rutgers University)**

#### 1. Introduction

##### 1.1 Objectives

This case study highlights the kinds of partnerships and collaborations needed to implement an integrated approach to monitoring and predicting changes in surface current and wave environments of the Nation's coastal waters on national, regional and local scales – from the coastal ocean to semi-enclosed estuaries. In so doing, it underscores the importance and feasibility of such collaborations as well as the importance of multi-use tools (High Frequency radar in this case) and the interactive development of observations and model-based forecasts to the establishment of the Integrated Ocean Observing System.

##### 1.2 Background

Surface current mapping is very important to achieving the societal goals of the Integrated Ocean Observing System (IOOS) as well as to achieving the objectives of Marine Domain Awareness (MDA). The availability and maturity of High-Frequency (HF) radar technology makes reliable surface current mapping now possible.

Rapid detection and accurate predictions of the trajectories of objects at or near the surface of

the ocean are important decision support tools for a variety of MDA activities including

- Search and Rescue (SAR),
- HazMat,
- Surf zone forecasting, and
- Vessel tracking.

Real-time situational awareness includes nowcasts of current environmental conditions and vessel locations as well as forecasts of the locations of hazardous materials released into the ocean. High Frequency (HF) radar is proving to be an important technology for these purposes.

HF Radar rose to the level of a transformational technology for coastal ocean research and applications in the late 1990's. Individual radars map the radial component of the current towards or away from each radar site. By combining the radial currents from small networks of 2 to 3 Radars often operated by individual university researchers, sea surface current fields were produced in real time and distributed over the World Wide Web. The U.S. Coast Guard (USCG) Research and Development Center first expressed interest in using the HF Radar data for SAR based on the time series of current maps collected during the passage of Hurricane Floyd along the New Jersey coast in September of 1999. They found that current fields from the HF Radar network during the storm significantly reduced the size of the search area using existing tools applied in a research mode. However, the USCG concluded that, while the technology did provide improved guidance, the data footprint available in 1999 was too small to be operationally significant. Nevertheless, a vision for the future

emerged. The vision included the need to (1) expand HF Radar technologies to enable surface current mapping over larger regions for the entire nation and (2) improve the Search And Rescue tools to benefit fully from the new data streams.

Soon thereafter the USCG began developing the Search and Rescue Optimal Planning System (SAROPS) and assembled a team of HF Radar operators and database experts for the first tests of HF Radar in SAROPS in 2002 and again in 2004. Coast Guard partners included the University of Connecticut, University of Rhode Island, Rutgers, and Applied Science Associates – a partnership that proved to be an important step toward the formation of an IOOS Regional Association (RA) for the Middle Atlantic region (Cape Cod to Cape Hatteras). It was demonstrated that predicted trajectories using an experimental model and assimilated HF radar data were more accurate than those provided by existing operational methodology using the closest NOAA station or climatologies. The new HF Radar methodologies were put to the test in 2004 an effort to find a lost autonomous underwater glider in the apex of the NYB. The Civil Air Patrol volunteered to send out a search aircraft on a training mission limited to 1 tank of fuel. In collaboration with the USCG R&D Center, a cluster of virtual drifters with a random dispersion was deployed in the HF radar current fields at the glider's last known location and allowed to drift for the 10 days the glider was lost. A search box sized for 1 tank of fuel was defined. The glider was found by the search plane inside the box, the location was radioed to a communications plane that then



informed a recovery vessel that was waiting nearby. Less than \$2,000 in fuel costs were spent to find and recover a lost glider costing over \$100,000.

## 2. Promoting Connectivity Among Agencies

In 2003, Ocean.US launched the Surface Current Mapping Initiative (SCMI) which brought together the nation's HF radar operators with representatives from the USCG R&D Center to explore pathways to develop a national HF radar capability. Issues of common data formats, data quality assurance and quality control (QA/QC), operational support requirements for a national network, frequency allocations, and radar sighting were discussed, recommendations developed, and experts identified. Recommendations for addressing these issues are given in Ocean.US Report No. 7.<sup>12</sup> Among others, SCMI recommended the establishment of regional centers responsible for the operation and maintenance regional HF radar networks as part of IOOS Regional Coastal Ocean Observing Systems (RCOOSs).

In 2004, the Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA) identified HF radar as an important integrating component of their RCOOS. A Mid-Atlantic HF Radar network would provide high resolution nested coverage on scales from the New York Bight to coastal estuaries and harbors. For the Mid-Atlantic region and in the context of the regional landscape outlined in the SCMI plan, the HF radar operators from Cape Cod to Cape Hatteras have formed the Middle Atlantic High Frequency Radar Consortium (MAHFRC) to establish, operate and maintain the HF radar network, including system hardware, data management, and product delivery. Partners in the

consortium include University of Massachusetts, Dartmouth; University of Rhode Island; United States Coast Guard R&D Center; University of Connecticut; Stevens Institute of Technology; Rutgers University; University of Delaware; University of Maryland; NASA, Wallops Island; Old Dominion University; NOAA, Chesapeake Bay Program; and the University of North Carolina, Chapel Hill.

During this same period, the USCG began employing an Environmental Data Server in support of SAROPS (developed by Applied Science Associates, ASA) that provides rapid access to environmental data as well as atmospheric forecasts from NOAA, Navy and MACOORA. The datasets, in particular the surface winds and surface currents, are made available to a Coast Guard Search and Rescue planner through a computer Graphical User Interface. This development was an important step toward establishing connectivity between observations and applications as well as among the various stakeholders.

## 3. Demonstration Project

The SCMI, establishment of MACOORA and the developing SAROPS set the stage for an IOOS demonstration project on a regional scale: the phased implementation of a regional scale HF Radar network that is scaleable to both the national and international level. Although the shoreline of the Mid-Atlantic Bight (MAB) is instrumented with more HF radar systems than any other region in the country<sup>13</sup>, they are operated in small clusters at different resolutions by a variety of groups, each with different funding profiles and different interests. Thus, the MAB is an excellent test-bed for developing an interoperable, regional network of HF radars as part of an IOOS that provides data and information required for

MDA. MACOORA provides a forum for this distributed group of HF radar operators to set priorities with decision makers responsible for safe and efficient marine operations and for MDA. The HF Radar Consortium demonstration project will enable these operators to provide MACOORA regional decision support tools for a variety of applications. In particular, HF radar data and forecasts will be made available to SAROPS operators and decision makers in the MDA arena as needed via the USCG Environmental Data Server.

MAHFRC has proposed a 4-phased project (FY 2007 – 2010) that will establish and operate a regional network for the MAB:

- Phase 1 relies heavily on the existing infrastructure with minimal investment to keep it up and running on a regional scale;
- Phase 2 has additional technicians with site support to increase system uptime;
- Phase 3 brings the entire network up to SCMI standards for personnel support; and
- Phase 4 fills data gaps with additional systems and maintains the SCMI personnel standards.

Phase 4 has a requested funding level that will ensure system continuous operation across the entire region with a fully nested approach.

This phased approach will extensively leverage the existing radar infrastructure, including a NOAA investment in a HF radar regional computer server. It will also enable collaboration with the SE Coastal Ocean Regional Association (SECOORA) to our south through the North Carolina sites and North East Regional Association (NERACOOS) and

<sup>12</sup> [www.ocean.us/documents/docs/scmi\\_reports.pdf](http://www.ocean.us/documents/docs/scmi_reports.pdf)

<sup>13</sup> As of October, 2007, there are 26 HF radar sites in the MAB (19 deployed and 7 funded).



Canadian Coast Guard fund HF sites to our north on the Cape Cod and Gulf of Maine.. The phased approach enables a product (nowcasts and forecasts of surface current fields) to be generated now on a regular basis with radars of opportunity. This will jumpstart the process of building a full scale regional network by making a demonstration product available for users to evaluate, identifying the key needs and gaps, and using this experience to direct further investment. To ensure future growth, the ONR-sponsored Radiowave Oceanography Workshop (ROW) provides an international forum for new HF Radar technology developers to interact with scientists. Similarly, the NOAA-sponsored Radar Operators Working Group (ROWG) provides an international forum for HF radar operators to share ideas and distribute workloads.

#### 4. Connectivity Between and Within Agencies: From Data to Applications

With support from Navy and NOAA, collaborations among research and operational agencies have made the Mid-Atlantic Bight the most heavily HF radar instrumented region in the world – and laid the foundation for the establishment of MACOORA. Collaborations that

have made these possible include the following:

- Ocean.US Surface Current Mapping Initiative, SCMI (NPS Monterey, Ocean.US, UConn, USCG, OSU, Rutgers University, NOAA, University of Alaska Fairbanks, University of Miami, UCSB, and University of South Florida).
- Coordination of broadcasts to allow multiple radars to share the same frequency without interfering with each other, a critical step for the development of a national network (SCMI, NOAA, Navy, National Telecommunications Information Agency, and Office of Radio Frequency Management);
- Development of the Environmental Data Server (USCG and ASA) that provides Coast Guard Search and Rescue planners immediate access to environmental data products in SAROPS.
- Real time collections of HF radar data and tracking the reliability of each system nationally (NOAA, SIO, Rutgers)
- Validation of the HF radar measurements and model derived current fields using GPS tracked surface drifters and testing the skill of HF radar methodologies (USCG, Civil Air Patrol, University of Connecticut, University of Rhode Island, Rutgers University, ASA and Anteon);
- Demonstration of the value of HF radar to NOAA HazMat (NOAA, Rutgers and CODAR Ocean Sensors)
- Nearshore wave and alongshore currents products to aid surf zone forecasts (NWS, NOAA-Sea Grant, Rutgers and Stevens Institute)
- Development of vessel tracking capability using HF radar (ONR, DoD, DHS, Rutgers, CODAR Ocean Sensors and Applied Mathematics, Inc.)
- Skill assessments of HF radar network data assimilation-numerical model based

ensemble forecasts (USCG, Rutgers and URI)

- International coordination (NOAA, Radiowave Operators Working Group)

#### 5. Challenges and Solutions

Successful completion of the MAHFRC project described above will set the stage for the formulation of a national plan that scales up this regional pilot based on lessons learned. This should include a business plan for sufficient and sustained funding to maintain and improve a national HF radar network including installation and sustained operations (personnel, spare parts, redundancy, etc.). The plan must also address key technical and sighting issues including the following:

- Understand and quantify the errors of the HF radar systems and develop the quality control and quality assurance needed to provide data and derived products;
- Establish radio frequencies allocations for HF radar;
- Complete the establishment of coastal sites for the placement of HF radars with the objective of establishing 100% coverage for the entire U.S. coastline (including obtaining their approval as 'Aids to Navigation' to allow sites to be established at all former CG lighthouses); and
- Continue the development of
  - ☐ remote HF site technologies;
  - ☐ statistical and numerical model based methods of using HF data to forecast surface current fields;
  - ☐ shipping tracking capabilities; and
  - ☐ wave and very near-shore surface current measurements.

Addressing these challenges will enable the U.S. to monitor surface current and wave fields that will not only contribute to more effective MDA, it will improve the safety and efficiency of marine operations,

reduce public health risks, and contribute to the development of ecosystem-based approaches to managing water quality and fisheries.

## **IOOS Regional Collaboration with the Marine Exchange of Southern California Safe and Efficient Marine Operations**

**Julie Thomas (Scripps Institution of Oceanography) and Richard McKenna (Marine Exchange of Southern California)**

### **1. Introduction**

#### **1.1 Objectives**

The IOOS user and data provider for this case study are the Marine Exchange of Southern California<sup>14</sup> and the Regional Association for the Southern California Coastal Ocean Observing System (SCCOOS), respectively. SCCOOS in this case includes the Coastal Data Information Program (CDIP), a long-term wave monitoring program jointly sponsored by the Army Corps of Engineers and the State of California. The objective of this case study is to highlight “best practices” for establishing the kinds of partnerships needed to develop operational IOOS capabilities. In this case the latter focuses on IOOS data and information in support of safe and efficient marine operations within the SCCOOS domain.<sup>15</sup> In so doing, it underscores the importance of the following to the establishment of an Integrated Ocean Observing System that serves the data and information needs of user groups: (1) user guidance for product development,

(2) multi-use tools (in this case for currents and waves measured by High Frequency radar), and (3) the interactive development of observations and model-based forecasts.

### **1.2 Background**

The Marine Exchange of Southern California is a non-profit organization dedicated to the safe and efficient flow of maritime commerce throughout the region. It serves as a broker of SCCOOS information through the Marine Exchange website, and facilitates, through its non-profit role, matching SCCOOS capabilities to the needs of the maritime community. The Exchange has two primary responsibilities:

- (1) The provision of ship data (ship schedules, destinations, ETDs, ETAs, locations and traffic patterns) for the ports of Los Angeles, Long Beach, Hueneme and San Diego;
- (2) In partnership with the USCG, operation of the Vessel Traffic Service (VTS) for the Los Angeles-Long Beach Port complex (the busiest intermodal seaport in the U.S.).

In addition to its basic VTS role of regulating commercial traffic, the Marine Exchange plays an important role in surveillance, search and rescue and law enforcement support. Its links to the Maritime Industry provide a synergy to the Maritime Domain Awareness posture by aiding the Coast Guard in getting to the right entity in times of elevated concerns or extraordinary circumstances. Thus, the Marine Exchange provides data and information which are vital for decision-making in times of crisis.

SCCOOS is one of eleven regional coastal ocean observing systems that are part of the U.S. IOOS. The observing system brings together coastal observations in the Southern California Bight to provide data and information needed to address issues of climate change, ecosystem preservation and management, coastal water quality, maritime operations, coastal hazards and national security. As a science-based decision support system, SCCOOS works interactively with local, state and federal agencies, resource managers, industry, policy makers, educators, scientists and the general public to provide data, models and products that advance our understanding of the current and future state of our coastal and global environment.<sup>16</sup>

### **2. The Role of SCCOOS in this Case Study**

In collaboration with the Coastal Data and Information Program (CDIP) of the Scripps Institution of Oceanography, SCCOOS provides real-time surface currents, waves, and sea surface temperature as well as marine meteorological observations (wind speed and direction, barometric pressure, air temperature, and precipitation). The Marine Exchange works closely with SCCOOS to ensure that data and information are provided in forms and at rates for decision makers responsible for safe and efficient marine operations in the region including those responsible for search and rescue (USCG), navigation (pilots and operators of ships, ferries, and small craft), anchor management, and water quality management. The decision support tools described below are used operationally by the Marine Exchange.

<sup>14</sup> <http://www.mxcocal.org>

<sup>15</sup> <http://www.sccoos.org>

<sup>16</sup> Products and services provided by or supported by SCCOOS data are available online: <http://www.sccoos.org/interactive-map/>.



Data and information on waves are provided by CDIP and include the following decision support tools:

- Model prediction points for 100m grid (nowcasts updated hourly, forecast updated every 12 hours);<sup>17</sup>
- Real-time wave observations (updated every 30 minutes);<sup>18</sup> Real-time wave spectral-refraction model nowcast (updated hourly);<sup>19</sup>
- Real-time along coast wave model nowcast (updated hourly);<sup>20</sup>
- 3 day forecast (updated every 12 hours);<sup>21</sup> and
- 3 day forecast of the potential flooding index (updated every 12 hours).<sup>22</sup>

CDIP is operational 24x7. There is always someone who is “on call” with pager/cell. These data are transmitted to NDBC and distributed to the NWS offices via the GTS. Reliability of the wave buoy measurements is in the 97-99% range. In addition to the above, given a couple of hours notice, full wave spectra information can be provided for any latitude/longitude.

Data and information on surface currents, sea surface temperature and marine meteorology are provided by SCCOOS and include the following decision support tools:

- Real-time surface current fields (2 km grid spacing, updated every hour)<sup>23</sup>

- Near real-time surface current fields (6 km grid spacing updated every 3 hours)<sup>24</sup>
- Real-time meteorological observations (atmospheric pressure, precipitation, relative humidity, air temperature, wind speed, and wind direction)<sup>25</sup>
- Real-time sea surface temperature<sup>26</sup>
- Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) modeled wind fields (5 km grid spacing, 48 hour forecast updated every 12 hours)<sup>27</sup>

Surface currents based on High Frequency (HF) radar data are provided online in real-time. HF radar linkage is provided on the Marine Exchange website and is available for U.S. Coast Guard search and rescue operations, oil spill trajectory predictions and small craft navigation. SCCOOS also acts as a secondary provider for many data measurements. For example, COAMPS modeled wind generated by the Naval Research Laboratory is provided in an online, interactive and graphical format by SCCOOS.

The Southern California Surface Current Mapping System will reach full build-out in approximately 2009. Vessel tracking using HF radar is in its experimental stages. With further validation, this tool will enhance existing capabilities, and through liaison with the US Coast Guard and decision

makers, it will provide valuable information during hazmat and SAR incidents. Efforts are currently underway to streamline/unify the various products into a single comprehensive presentation, including a data delivery solution for total vector output. This data delivery solution will most likely be hourly files in network Common Data Form (NetCDF).

### 3. Promoting Connectivity Among Organizations: Data to Applications

The SCCOOS and CDIP efforts are multi-agency programs. SCCOOS and CDIP have a history of funding from NOAA, State of California and the Army Corps of Engineers. As the Marine Exchange of Southern California holds a major role in the operations for the Port of Los Angeles/Long Beach, including its connection to industry, it is recognized that this partnership is advantageous.

SCCOOS/CDIP as a regional association has received national attention for product display and data dissemination. CDIP first deployed a wave buoy in the San Pedro area in February 1981. SCCOOS deployed the first HF Radar site in the area in July 2006. Since deployment of these two systems, the data have been online and accessible to the Marine Exchange and other users.

<sup>17</sup> [http://cdip.ucsd.edu/?nav=recent&sub=observed&moplist=San\\_Pedro\\_Harbor](http://cdip.ucsd.edu/?nav=recent&sub=observed&moplist=San_Pedro_Harbor)

<sup>18</sup> [http://cdip.ucsd.edu/?nav=recent&sub=observed&pub=public&map\\_stati=1,2,3&stn=092&stream=p1&xitem=pm](http://cdip.ucsd.edu/?nav=recent&sub=observed&pub=public&map_stati=1,2,3&stn=092&stream=p1&xitem=pm)

<sup>19</sup> [http://cdip.ucsd.edu/?nav=recent&sub=nowcast&pub=public&map\\_stati=1,2,3&xitem=spc](http://cdip.ucsd.edu/?nav=recent&sub=nowcast&pub=public&map_stati=1,2,3&xitem=spc)

<sup>20</sup> [http://cdip.ucsd.edu/?nav=recent&sub=nowcast&pub=public&map\\_stati=1,2,3&xitem=coast\\_hs](http://cdip.ucsd.edu/?nav=recent&sub=nowcast&pub=public&map_stati=1,2,3&xitem=coast_hs)

<sup>21</sup> [http://cdip.ucsd.edu/?nav=recent&sub=forecast&pub=public&map\\_stati=1,2,3&xitem=fp\\_orc\\_000](http://cdip.ucsd.edu/?nav=recent&sub=forecast&pub=public&map_stati=1,2,3&xitem=fp_orc_000)

<sup>22</sup> [http://cdip.ucsd.edu/?nav=recent&sub=forecast&pub=public&map\\_stati=1,2,3&xitem=tide&xindex=010](http://cdip.ucsd.edu/?nav=recent&sub=forecast&pub=public&map_stati=1,2,3&xitem=tide&xindex=010)

<sup>23</sup> <http://www.sccoos.org/data/hfrnet/?ll=33.70206404131936,-118.22044372558594&zz=11&type=0&sta=&info=0&avgs=1&currents=1&marks=0&res=2km>

<sup>24</sup> <http://www.sccoos.org/data/hfrnet/?ll=33.70206404131936,-118.22044372558594&zz=11&type=0&sta=&info=0&avgs=1&currents=1&marks=0&res=6km>

<sup>25</sup> <http://www.sccoos.org/data/mets/>

<sup>26</sup> <http://www.sccoos.org/data/mets/?sta=&chan=SST>

<sup>27</sup> <http://www.sccoos.org/data/winds/48hr/?r=3>

#### 4. Challenges and Solutions

One of the main challenges is assuring that the appropriate Emergency Managers are aware of the data and products. For example, turnover within the Coast Guard does not always allow for continuity of communications. One of the advantages of posting the data through the Marine Exchange is that they serve as a central point for information, facilitating inter-agency communication. The Exchange has a vast audience of users within the Port district. Thus, outreach is of foremost importance. Presentations and interactive discussion are planned for Port meetings, including the Harbor Safety Committee meetings and others.

#### **Hazardous Material Spill Response**

**Robert Arnone (Naval Research Laboratory) and CJ Beegle-Krause (NOAA, Office of Response and Restoration)**<sup>28</sup>

##### 1. Introduction

National Security Presidential Directive 41 (Homeland Security Presidential Directive 13 Maritime Security Policy, NSPD-41/HSPD-13) requires the development of a national Maritime Security Strategy, and directed the Maritime Domain Awareness Senior Steering Group (MDA SSG) to develop and submit to the President a National Plan to Improve MDA. It defined MDA as “the effective understanding of anything associated with the global maritime environment that could impact the security, safety,

economy, or environment of the United States.” Rapid detection of hazardous material spills and timely forecasts of their fate and effects is an important aspect of MDA. (From the Maritime Domain Awareness Technology Roadmap Report, MDA Technology Working Group, 8 September 2005)

“..., during [spill] events, NOAA is counted on to provide detailed information and reliable projections related to an oil spill’s location and trajectory. The agency’s ability to observe the ocean environment and obtain timely information on tides, currents, and related oceanic conditions is directly related to the accuracy of the information and forecasts that are provided to incident responders. Our readiness is therefore in no small way affected by the presence and reliability of ocean observing assets, which are critically important for the collection and integration of this data.” (From testimony by Dr. William Conner [Chief, Emergency Response Division, National Ocean Service, NOAA] before the Transportation and Infrastructure Subcommittee on Coast Guard and Maritime Transportation, U.S. House of Representatives, 19 November 2007).

As indicated by these quotes, reliable projections of the spatial extent, fate and impact of hazardous material spills are important for both emergency spill responses and MDA – and both will benefit from an integrated approach to ocean observations and predictions.

#### 1.1 Objectives of the Case Study

Given the goals of improving Marine Domain Awareness (MDA) and the effectiveness of scientific support for emergency response under the National Response Plan<sup>29</sup> and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP)<sup>30</sup>, this case study highlights

- (1) the utility of a real-time, ocean “weather” capability for MDA and emergency responses to releases of hazardous materials into coastal waters;
- (2) the need for data sets that are interoperable among state and federal agencies;
- (3) the challenges of implementing an integrated approach for the purposes of both spill response and MDA; and
- (4) the need for standard interagency procedures for incorporating advances in scientific understanding and technology into operational systems.

Starting with data and information needed to inform decisions for emergency spill response and MDA, this case study illustrates the importance of both rapid access to quality controlled data streams and partnerships among and within government agencies as a means to establish an integrated ocean observing and prediction system (IOOS) that enables more effective decision making to achieve the missions of both MDA and emergency spill response.

<sup>28</sup> Although released by NOAA, the information in this paper does not reflect, represent, or form any part of the policies of NOAA or the Department of Commerce. Further, release by NOAA does not imply that NOAA or the Department of Commerce agree with the information contained herein.”

<sup>29</sup> Letter of Agreement for The National Response Plan was signed in December, 2004 (<http://www.dhs.gov/xlibrary/assets/NRPbaseplan.pdf>). The National Response Framework (<http://www.fema.gov/emergency/nrf/>) will replace the National Response Plan which remains in effect at this writing.

<sup>30</sup> <http://www.epa.gov/oilspill/ncpover.htm>

## 1.2 Background

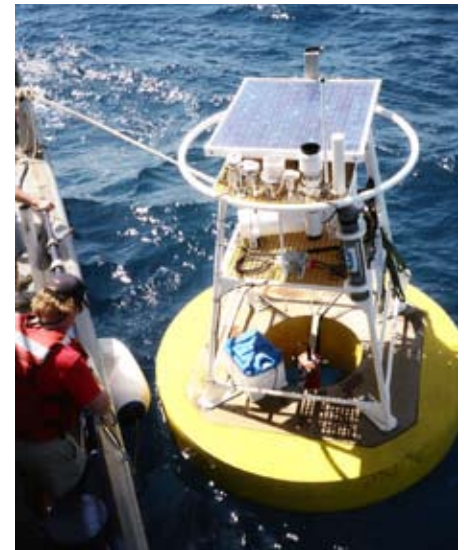
Spills of hazardous chemicals (including oil) may result from accidents associated with maritime operations, intentional releases by terrorists, or natural disasters such as earthquakes or hurricanes. The risks from such spills depend on their spatial extent, physical-chemical properties, the amount and type of release (source estimate) and their fate (changes in distribution, concentration, and physical-chemical properties) as they are transported and dispersed in the maritime environment. The ability to rapidly determine their spatial extent (defined here as detection) and to accurately predict their fate and impact are important capabilities for both emergency spill response and the full realization of MDA.

A real-time, situational awareness of “ocean weather” (local to mesoscale marine meteorological and oceanographic conditions) is needed that will enable more timely and informed decisions for more effective management and mitigation of spills. Real-time situational awareness includes hindcasts, nowcasts and forecasts of ocean weather and forecasts of the fate and impact of hazardous materials that are updated according to the operational planning period and decision makers’ needs.

Rapid determination of spatial extent and timely forecasts of the fate and potential impacts of spills that inform decision makers require an integrated approach to data acquisition, verification, assimilation and modeling that utilizes all relevant and quality controlled data and information regardless of which agency, program or institution collects and processes them. Present capabilities (both institutional and technical) for addressing these requirements are limited by

- (1) the speed with which marine environmental conditions can be characterized in the impacted area,
- (2) the fact that spills often occur in environments that are not well monitored (severely under sampled), and
- (3) the inefficient use of new scientific knowledge and technologies to improve operational capabilities in both (1) and (2).

In regard to (3), mechanisms for efficient use of advances in science and technology for operational purposes are needed for both MDA and emergency response. Many new capabilities are emerging through ocean research by academic institutions, government agencies and private enterprise. However, the application of these advances for spill response and MDA have not been realized by decision makers either because they remain in an R&D mode or they are ready for use in an operational mode but interagency procedures have not been established for making the transition.



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For example, major research efforts, such as the NRL's Integration of Ocean Modeling and Remote Sensing project used in this case study, are yielding a bounty of interesting possibilities, but transitioning data streams used in a research mode for their operational use by decision makers faces many challenges. Policies, procedures and investments are needed for both research and the transition process so the two activities interact synergistically and are not competing for funding. Research, information technology and operational communities need to work more closely to establish these mechanisms. Efforts directed at providing the timely and accurate information for dynamic decision support will best serve our national needs.<sup>31</sup>

<sup>31</sup> Beegle-Krause, C.J., W. Munns, A. Merten, W. Lehr, J. Tintoré, J. Baker, G. Chini, N. E. Kinner, T. Collier, and C. Vörösmarty. 2007. Emergency Response in Coastal Waters: Scientific Support for Dynamic Decision Making. Submitted to EOS, American Geophysical Union.



## 2. Forecasting Spill Trajectories

Forecasts of the fate and potential impacts of spills inform decision makers during real and potential spill events. Trajectory models, such as the General NOAA Operational Modeling Environment,<sup>32</sup> (GNOME) use model-based forecasts of current fields for this purpose.

### Examples of the Use of Circulation Fields for Spill Response

- In 1979, blowout of the IXTOC exploratory well in 3 meters of water released a volume of oil every two weeks (that was nearly equivalent to the Exxon Valdez spill) until the well was capped 9 months later. Operational forecasts of circulation would have enabled more effective mitigation. In 2003 a drilling riser break at a BP development well in 1875 m of water in the Gulf of Mexico had the potential of leading to a deepwater well blowout. If a blowout were to occur, the process to drill a relief well could take up to 6 weeks once the drilling ship was in position. Trajectory forecasting to estimate where the oil and gas could surface based on predicted current fields would be important if a blowout were to occur.
- In 2005, the Tanker Barge DBL-152 encountered hurricane debris off the coast of Louisiana resulting in damage to the barge and the eventual release of the full cargo of 3 million gallons of slurry oil. This type of oil is denser than seawater, hence the spill was on the bottom in about 45 feet of water on the Louisiana-Texas shelf. Oil resting on the sea bed is difficult to visualize, so modeling was key to assisting the response. During the response, the NOAA Gulf of Mexico model and the Texas A&M Gulf of Mexico model were both used with NOAA's spill trajectory model (the General NOAA Oil Modeling Environment or GNOME) to locate the submerged oil and estimate the long-term transport of oil.

Since all model-based forecasts have errors associated with them and the uncertainty of such forecasts is both time- and space-dependent, a suite of models is desirable to assist the HazMat trajectory analyst to provide best estimates with uncertainty bounds for offshore incidents. HazMat is also working with NAVO to ensure that their operational hydrodynamic models are compatible with GNOME with the objective of using ensemble modeling approaches to improve the accuracy of forecasts and the uncertainty associated with them. Considering domestic and international spill incidents, the NRL Intra-Americas Sea Ocean Nowcast/Forecast System for coastal prediction<sup>33</sup> could be used to provide forecasts of current fields for the U.S. or neighboring countries (see section 3 below).

NOAA HazMat is a 24x7 operation with time points for trajectory products. In order to be used operationally by NOAA HazMat, hydrodynamic models must be easy to access and examine, and the data must be downloadable (not a picture on a Web Site). Large domain hydrodynamic models require the ability for the user to subset (cut out with the required resolution) the specific area and time period needed with minimal download and input time. For example, if a trajectory simulation is required, the predicted trajectories must be completed and made available to the incident's Unified Command within 2 hours of notification and as needed thereafter. Thus, efficient communication procedures must

be in place for a particular model's predictions to be useful during a response.

Emergency spill responses are always resource limited in terms of both personnel and funding. Thus, the quest to ensure efficient communications often leads to a "stovepipe" approach to data gathering and information delivery that (1) decreases the possibility of a break in the chain of data and information delivery but is often not comprehensive (i.e., a 'vertical' approach that does not assemble all of the data and information that may be available from other programs, agencies or institutions) and (2) limits the use of ensemble modeling. These problems are exacerbated by the reality that most spills are local in scope (e.g., during 2002-2003, 1,651 known oils spills of 10,000 gallons or more occurred in Texas coastal waters<sup>34</sup>) and require some level of customized modeling. Hence, the need for an IOOS that provides rapid access to all relevant data from many sources.

## 3. The NRL Real-Time Demonstration Project and MDA

As part of a demonstration project coordinated through the NASA-Reason project (Earth Applications) and the Naval Research Laboratory, the Oceanography Division of NRL has developed techniques for combining data streams from satellite-remote sensing and numerical models to provide real time coastal products 24/7 for the Gulf of Mexico.<sup>35</sup> The project is designed to demonstrate an

<sup>32</sup> GNOME is the spill trajectory model used by NOAA's Emergency Response Division (ERD) of the Office of Response and Restoration) during spill events. During spill response, the ERD trajectory analyst selects the physics that are most appropriate for the spill and sets up the model accordingly. This includes selection of the appropriate hydrodynamic model for the currents and a wind forecast from the NOAA National Weather Service. (GNOME is grid-independent to allow trajectory analysts to utilize circulation models developed by NOAA as well as by groups outside of NOAA.) These data are utilized by GNOME for predicting the spill trajectory. Once a prediction is made, it is validated by observations. If the current and wind predictions are accurate, and if the wind stress and diffusion parameters are set accurately in GNOME, then GNOME will generate very good trajectories. A 48-hour prediction of where the oil will go can be expected to be within 1-2 miles. If the model and observations differ, hindcast model runs are made to tune the model to the local conditions before the next forecast is made. The forecast winds and currents are usually not accurate enough to generate trajectories within 1 mile of accuracy after 48 hours. This is why GNOME supports user-specified uncertainty bounds, which are set according to the uncertainty in the input data. This is also why the GNOME input data must be continuously updated, and the model is rerun at least once a day during the event (<http://response.restoration.noaa.gov/>).

<sup>33</sup> [http://ams.confex.com/ams/32BC31RSC/techprogram/paper\\_64664.htm](http://ams.confex.com/ams/32BC31RSC/techprogram/paper_64664.htm); <http://www.cosis.net/abstracts/EGU04/07707/EGU04-A-07707.pdf>

<sup>34</sup> [http://www.texasep.org/html/wql/wql\\_5cst\\_gulf.html](http://www.texasep.org/html/wql/wql_5cst_gulf.html)

<sup>35</sup> Arnore, R., C. Hall, T. McPherson, D. Sko, J. Sandidge, B. Casey, S. Ladner, R. Parsons, P. Martinovich, R. Gould, A. R. Parsons. 2006. "NASA-Reason Verification, Validation and Benchmark Report Sensor to User-Applying NASA/EOS Data to Coastal Zone Management Applications Developed from Integrated Analyses."

“ocean weather” capability (local to mesoscale marine meteorological and oceanographic conditions) by exploiting cutting edge research to define the physical and bio-optical properties of the coastal waters. Currently, over 2000 products are available daily in a pre-operational mode through an OPeN DAP server. However, it is likely that only a small number will be selected for transition to operational product lines by NAVO. Examples of the kinds of products that are relevant (3.1) or potentially relevant (3.2) to both MDA and spill response, and are being served pre-operationally 24x7, are given below.

### 3.1 Ocean Circulation Models

The Intra-Americas Sea Ocean Nowcast/Forecast System (IASNFS) encompasses the Caribbean Sea, Gulf of Mexico, Straits of Florida, and part of the western North Atlantic Ocean. The system consists of a 1/24° (4-5 km) grid, 41 level, data assimilating ocean model and continually assimilates 3-D ocean temperature and salinity data generated by the Modular Ocean Data Assimilation System (MODAS) using real-time sea surface height from satellite altimetry (GFO, Jason-2, and ERS-2) and sea surface temperature from AVHRR. The Navy Operational Global Atmospheric Prediction System (NOGAPS) provides nowcasts and forecasts of surface wind stress, sea level, and air-sea heat flux for surface forcing, and open boundary conditions (sea surface height, temperature, salinity and currents) are provided by the Navy Coastal Ocean Model (NCOM).

IASNFS includes inter-model nesting of high resolution models for the Northern Gulf of Mexico (NGOM, 1 km grid resolution).

Global ocean models provide the boundary conditions for these finer resolution coastal models that assimilate high resolution satellite sea surface temperature and sea surface height and near shore salinity from satellite ocean color in a pre-operational mode to characterize circulation regimes for near-shore estuarine and harbors. Model outputs include daily 3-D nowcasts and forecasts (24 and 48 hour at hourly updates) of currents, temperature and salinity. Similar ocean circulation models are used for Navy operations routinely similar to weather models. The 3-D forecast of ocean currents could be used to improve the skill of trajectory models used for forecasting surface and subsurface spills.

### 3.2 Potential Future Applications

Coastal monitoring and prediction are presently part of Navy operations and can be extended to MDA and NOAA HazMat for US coastal waters on an operational basis. NRL is currently working on new products for NASA demonstrations and Navy applications. Bio-optical modeling of coastal waters described below is a case in point. Although these may not be relevant to the HazMat mission at this time, they demonstrate data assimilation and modeling capabilities that may be used for a variety of applications including determining the spatial extent of spills and their fate and impact.

Combined satellite and ocean model products with spatial resolutions of 1000 to 250m (e.g., Figures 1 and 2) illustrate capabilities that enable multi-scale modeling from the local scale of estuarine ecosystems and harbors

to larger scales meso-scale ocean features (rings and eddies and Loop Current).<sup>36</sup> Satellite products are limited by cloud cover. Improved statistical methods have been developed by combining temporal satellite data with data assimilation techniques to fill in data gaps and provide daily satellite products for continuous monitoring coastal waters.

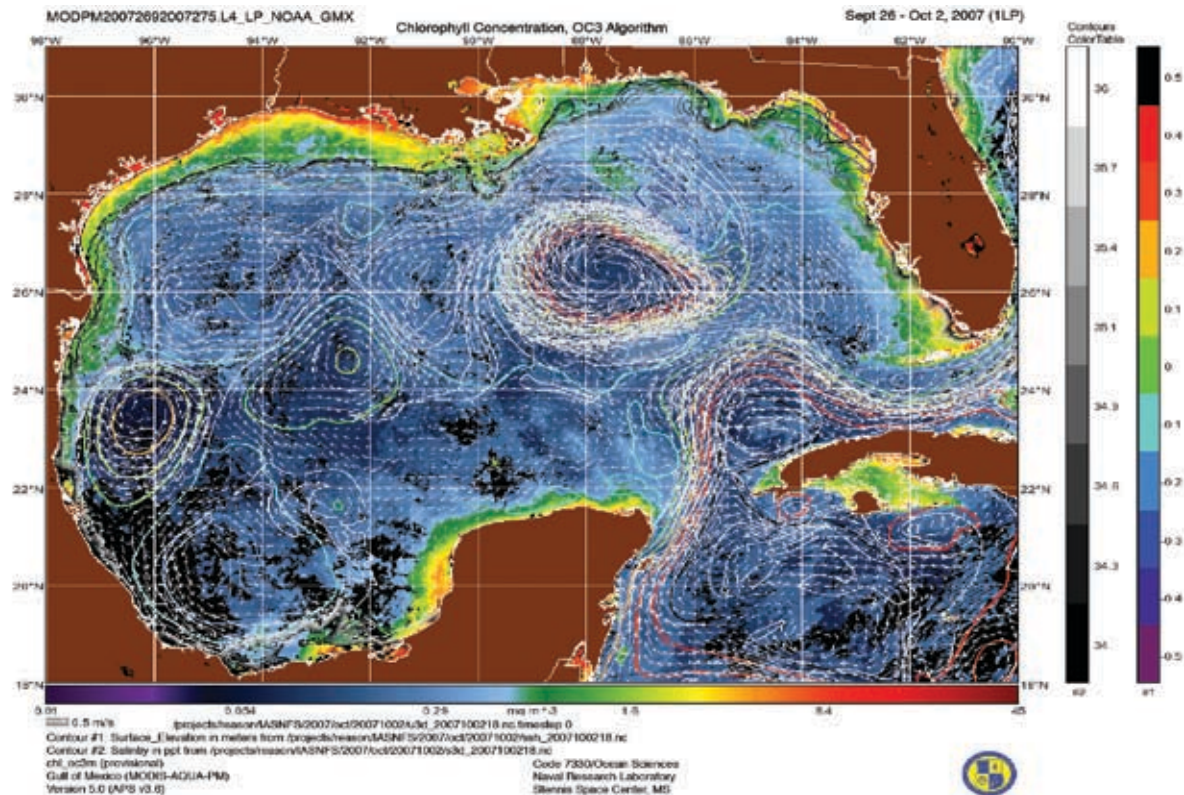
A 24-hour forecast of surface bio-optical properties is also being evaluated through the demonstration by combining satellite chlorophyll and backscattering products with forecast circulation for the Northern Gulf of Mexico. The satellite particle concentration product (backscattering coefficient) is advected forward using the numerical models to determine the 24-hour forecast corresponding to the satellite image. These forecast products are compared with the next day satellite product to determine the uncertainty of the forecast and are produced daily as part of the demonstration to provide an ocean forecast of “surface” ecology conditions.<sup>37</sup> The bio-optical forecasts provide new capability to assess the trajectory of how ecosystems may be influenced by spills of hazardous materials. The forecast from the advected satellite properties can indicate if biologically active or inactive waters (chlorophyll rich or elevated particle concentrations) will be entering an area impacted by a spill. If coupled to an ecological model that can be used to predict the distribution and abundance of biological resources, this capability could be used to guide adaptive sampling for natural resource contamination (from ships, deployment of ‘rover’ buoys, and geostationary satellites) during and following spill events.

<sup>36</sup> Arnone, R.A. and A.R. Parsons. 2004. Real-time use of ocean color remote sensing for coastal monitoring. In *Remote Sensing of the Coastal Environments*. R.L. Miller, C.E. Del Castillo, and B.A. McKee, Chapter 14. Kluwer academic. Springer Publishing

<sup>37</sup> Arnone, R.A., B. Casey, D. Ko, P. Flynn, L. Carrillo, and S. Ladner. 2007. Forecasting coastal optical properties using Ocean Color and coastal circulation models. *SPIE Optics and Photonics*, 10 p.p.

Lastly, the 3-D bio-optical structure (chlorophyll and particle backscattering) of the Northern Gulf of Mexico is modeled by combining the 3-D temperature and salinity fields from NGOM with the surface satellite bio-optical properties. Daily 3-D ocean weather is modeled by linking surface satellite chlorophyll to the 3-D ocean model of mixed layer depth and stratification intensity.<sup>38</sup> The daily 3-D volume of the bio-optical and physical properties are being developed and available daily (figure 3). These ocean weather products enable new capability to determine possible sinks for surface containments and help guide ship measurement and sampling programs.

**Figure 1.** A basin scale example of the coupling between models and data streams from remote sensors for the Gulf of Mexico. Real-time satellite and numerical model data are available daily for characterizing the physical and biological conditions in terms of sea surface currents, chlorophyll, height, and salinity (Oct 2, 2007). The fusion of data shows the locations of the Loop current (A) and the warm core eddy (B). (Arnone and Parsons, 2005). This nowcast and forecast of conditions is available daily 24/ 7 for the “surface” waters at spatial resolutions to 250m for selected areas.

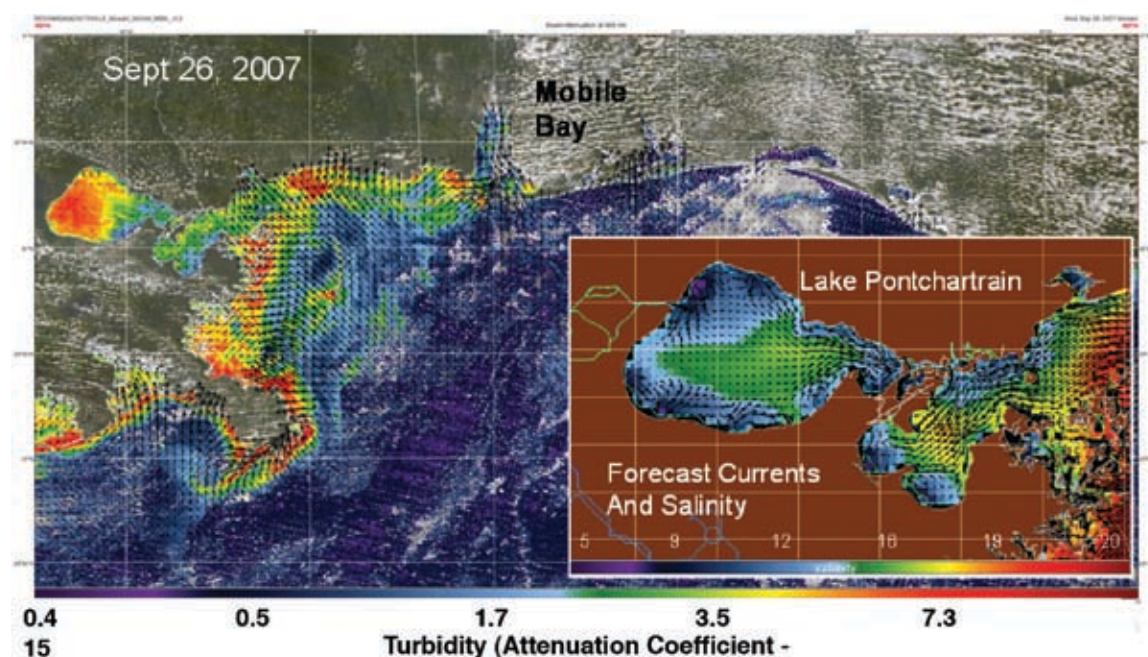


The demonstration of “ocean weather” for the Gulf of Mexico is available through the NRL website and the Open Dap Server (<http://Colbolt:8000/reason>). Access is currently limited to a small number of IP addresses (.mil, .noaa, .epa, and .nasa). NCDDC is developing methods to expand access to additional users and to make retrieval easier.

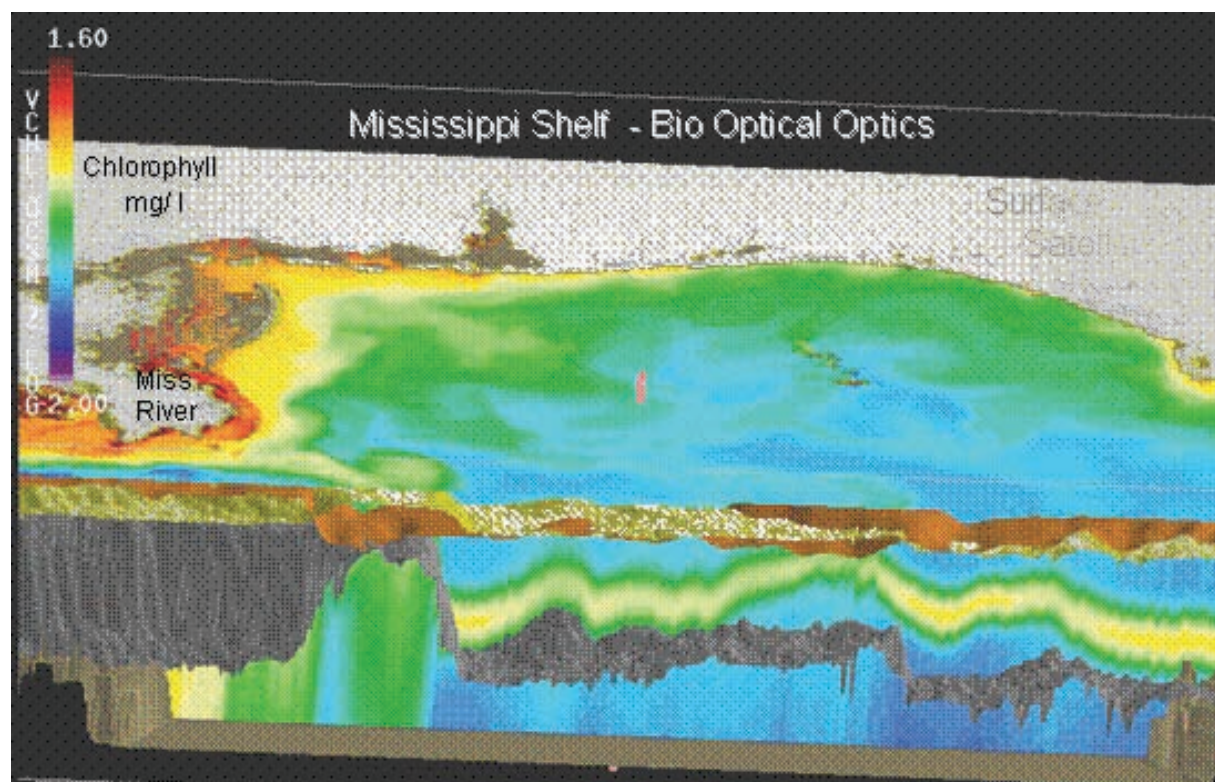
<sup>38</sup> Arnone et al., 2007 *ibid*



**Figure 2:** High resolution satellite imagery from MODIS 250 m coupled with surface tidal currents are available daily to monitor coastal processes. Time and spatial scales of processes are high in the coastal zone. The nowcasts and predictions of the circulation model and satellite products are available for hourly forecast for 24 hours. The insert of Lake Pontchartrain and surrounding waters represents predicted surface currents and surface salinity.



**Figure 3:** This example of the daily 3-D bio-optical volume (chlorophyll) of the Northern Gulf of Mexico is generated daily by vertically extending the surface satellite bio-optical products through coupling with the model's physical properties and in situ bio-optical measurements. (Arnone et al 2007).



#### 4. Improving and Expanding Operational Capabilities for MDA and Emergency Spill Response

The NRL project demonstrates a capability for monitoring and forecasting “ocean weather” over a range of scales (e.g., Gulf of Mexico to coastal ecosystems) in real time, 24x7 that significantly enhance the present capabilities based on limited buoy- and ship-based observations and provides a prediction capability which extends the limited “point” nowcast observation such as buoy reports into a completely 3-D ocean domain. The demonstration project provides a framework for the integration and fusion of coastal predictive data streams, from which enhanced capability can be formulated. This is the initial step in a fully coupled “ocean prediction” capability. The goal is to transition the IASNFS with its data assimilation capabilities and nested models into an operational mode as a decision support tool for MDA and emergency spill response. The challenges to such a transition can be divided into three broad categories:

- (1) Understanding Federal mandates and coordinating development of an optimal connection between research and operations to support data acquisition and analyses;
- (2) Developing the required infrastructure through interagency collaboration; and
- (3) Scientific and operational technical challenges of the data error estimates, data flow and system reliability.

##### 4.1 Optimally connecting research and operations

The biggest challenges here are largely cultural and political:

- How can we enable groups that do not have a history of collaborating with each other to do so in a meaningful way?

- How do we address issues of accountability and funding for efforts that involve interagency collaboration and coordination in a tight budget environment?
- Individual clients for these integrated data streams are numerous, and each has unique aspects to their needs. For example, NOAA HazMat is a small office with national and international response duties. The Gulf of Mexico is only one area of their responsibility, and the demonstration project is only one of the data streams in the Gulf of Mexico that they wish to connect to. Hence national level coordination for data management and communications is necessary to prevent the next generation of stove-pipe systems.

These are arguably the greatest challenges of developing an integrated approach that benefits from exchanges of data, information and expertise across the “stove pipes” around which we are currently organized. Building and sustaining a community process through funding and continued engagement will be challenging, but it has the potential to lift (advance) operational oceanography in the U.S. to the next level. This connectivity is a “heavy lift” because the system breaks down with a single broken link in the DMAC chain. Making these new connections through the walls of the stovepipes is necessary, and neither easy nor glamorous.

##### 4.2 Establishing Coastal Prediction Infrastructure

Establishing the infrastructure and assembling the data used to support real-time “ocean weather” is a major challenge. The present demonstration of satellites and ocean models in the Gulf represents a significant integration of continuous data streams and data fields with backup capability. For example, the IASNFS predictions of the state of the upper ocean for the Gulf of Mexico uses outputs

from global and basin scale modes for boundary conditions daily and ingests real-time ocean and atmospheric data streams of (1) satellite altimetry, sea surface temperature and salinity (from ocean color); (2) atmospheric fields (vector winds, atmospheric pressure); and (3) surface water runoff from gauged rivers and streams. If one of the fields is delayed or missing the processing uses alternative data feeds to fill in data gaps. Achieving this level of integration in real-time has been and is a major challenge.

The Naval Oceanographic Office and NRL currently have the data sources but are not responsible for high resolution nests within US coastal waters, although they have the necessary data feeds. A potential solution is to exploit NRL capabilities in different US coastal waters as a prototype for potential MDA/ NOAA – Hazmat operations. Another potential solution is to coordinate NRL, NAVO, NOAA NCEP and NOAA CSDL open ocean and coastal prediction capabilities for the development of a joint system to best serve our nation.

##### 4.3 Linking Advances in Research to Improvement and Expansion of Operational Capabilities

Intergovernmental procedures need to be established to transition research models into an operational mode based on the data and information requirements of decision makers engaged MDA and emergency spill response. Such procedures should include use of the following criteria:

- Provides predictions (hind, now- or fore-casts), with established reliability (i.e., generalized “error bars”), used by decision makers;
- Provides such predictions in forms and at rates approved by the decision makers (on a schedule or on demand);
- Performs modeling operations, including quality control, under



the auspices of a sponsor in a robust, institutionalized fashion; and

- Meets performance standards agreed to by both model operators and decision makers.

The challenge is to establish procedures for (1) using advances in ocean science and technology to improve and expand operational capabilities as needed and as the necessary funding becomes available, (2) testing these in an pre-operational mode, (3) obtaining the funding for sustained incorporation into the integrated systems, (4) specifying and using performance metrics for new operational capabilities, and (5) making modifications based on performance. One approach is to use (1) to initiate a development spiral to implement (2)-(5) in an iterative fashion. This is a continual process that requires sustained financial support and trust between research and operational communities – recognizing that one cannot exist without the other.

Both Navy and NOAA have procedures for transitioning systems to operational status, but testing using the criteria given above takes time and funding. Can we develop a capability to express large uncertainty in new systems, and reduce that uncertainty over time through testing so that state-of-the-art research systems can be run side-by-side with operationally certified systems? Building decision support systems to take advantage of a variety of data streams with varieties in uncertainty levels could help us more quickly transition research systems to serve the public more quickly. Helping clients understand which of their data streams is “operationally certified” as opposed to “in transition” will not be an easy task. Professional forecasters in the NOAA NWS look at a variety of model predictions,

and make their forecast from their understanding of the different strengths and weaknesses of each model’s predictions. NOAA HazMat is working toward expanding their access to coastal ocean predictions that can be leveraged for emergency response either as predictive fields or as guidance for site specific forecasts.

#### 4.4 Specifying and Agreeing on an Architecture for Data Integration and Fusion

- (1) Although data are often available, they can not be “easily” assessed and used for operations. Methods of display and customization of products are not easily retrievable. This includes methods to interact with data types and data retrievable methods. Solutions to fuse and manage the integrated data sources must be straightforward and uncomplicated. The fields that characterize ocean weather are dynamic so that GIS systems may not be useful. More convenient methods and open access data display systems such as Google Earth may play an important role to support a wide variety of users, but even Google Earth is not configured well for oceanography. A system such as GeoModeler<sup>39</sup> that connects 4-D representation with GIS may be the direction we are heading.
- (2) Validation of the ocean weather products and data is a challenge. What are the uncertainties of observations and predictions? Similar to numerical weather forecasts, reliability and uncertainty of predictions change both in time and space. Knowledge of these uncertainties is critical for tactical decision making and to the decision making process. Models and satellite

products require validation and methods to establish their uncertainty. Ensemble modeling approaches are often used to estimate uncertainty. The challenge is to characterize the uncertainty of nowcasts and forecasts as well as for the oceanographic and atmospheric fields they depend on.

- (3) The use of Observing System Simulation Experiments (OSSEs) and Observing System Experiments (OSEs) to optimize sampling schemes to improve both the accuracy of forecasts and the cost-effectiveness of observational programs is a major and expensive challenge. Emerging research in model ensembles for defining the uncertainty of predictions will enable improvements in the cost-effectiveness of observational programs needed to initialize and update model-based nowcasts and forecasts of ocean weather.
- (4) Methods of ocean data assimilation and validation of satellite algorithms are challenging. This involves the use of test beds to determine how data can effectively be used to improve the skill of model-based prediction. This includes where data should be acquired to reduce the model prediction error (i.e. adaptive sampling).
- (5) A major challenge is to determine the utility of coastal ocean data through the use of performance metrics. A possible metric is determination of the number of operational products for which data streams are required. This is a simple yet realistic evaluation of the product value.

<sup>39</sup> Vance, T., N. Merati, S. Mesick, C. Moore, and D. Wright. 2007. GeoModeler: Tightly linking spatially-explicit models and data with a GIS for analysis and geovisualization. Proceedings of the Association for Computing Machinery International Symposium on Advances in Geographic Information Systems, November 7-9, 2007, Seattle, Washington.



## Appendix 7 - Ocean Observing and Port and Maritime Security

### Mark E. Luther

Observations and predictive models of ocean environmental conditions in the vicinity of ports and harbors are a critical component of any comprehensive maritime domain awareness system. Real-time observations and predictions of winds, waves, currents, water levels, temperature, and salinity are necessary for safe and efficient ship movements in and out of port on a routine basis as well as for response to and mitigation of natural and human-induced catastrophes. Such information is most useful when integrated with other data on ship navigation, resources at risk, locations of response assets, and other maritime security information, in a comprehensive decision support tool.

Risk is a function both of probability of an occurrence and the consequences of an occurrence. Calamity due to natural and accidental causes is much more probable and the consequences just as severe as those from a terrorist act. Examples such as the Tampa Bay Sunshine Skyway Bridge disaster in 1980 or the destruction of northern Gulf ports by Hurricane Katrina in 2005 illustrate this point. Any comprehensive maritime security solution must respond to and mitigate natural, accidental and terrorist threats.

#### PORTS: The Tampa Bay Example

The USF College of Marine Science has operated the Tampa Bay Physical Oceanographic Real-Time System (TB-PORTS) in cooperation with the NOAA National Ocean Service since 1993 (see <http://ompl.marine.usf.edu/PORTS>). PORTS

provides information on ocean environmental variables in real-time to harbor pilots, port authorities, the US Coast Guard, and environmental managers in Tampa Bay, and is a component of the new Vessel Traffic Service for the bay. TB-PORTS was the first of its kind and forms part of the National Backbone of the US Integrated Ocean Observing System (see <http://www.ocean.us>). A hydrodynamic circulation model of the bay utilizes the real-time data stream to simulate and predict these ocean variables for the entire bay. The model can simulate and predict trajectories of substances either naturally or intentionally introduced into the bay. Predicted trajectories, currents, waves, and water levels can be ingested into the Florida Marine Spill Analysis System, a decision support tool for spill response and planning developed by the Florida Fish and Wildlife Research Institute and the Florida Bureau of Emergency Response. We propose to integrate the above systems with other information products, such as meteorological forecasts and other operational maritime security information systems, to build a comprehensive maritime domain awareness system, using Tampa Bay as a prototype system. Additional sensors can be added to the existing TB-PORTS sites or at new sites as required by other components of the comprehensive maritime domain awareness system. The hydrodynamic model system will be implemented in a hardened, operational nowcast-forecast mode with on-demand trajectory predictions through a web-based interface. The prototype system will be developed within a standard Automated Identification System

(AIS) with state of the art, database-driven, Geographical Information System (GIS) tools that adhere to nationally and internationally accepted standards and protocols, so that the system can be readily transported to other ports and harbors. We will work closely with end-users (or potential end-users) of the comprehensive maritime domain awareness system to develop decision support tools to guide response to natural, accidental, and terrorist threats. We will explore potential partnerships with commercial providers of maritime information products where such partnerships are warranted for the distribution of information products developed herein to end-users. The resources and infrastructure available in Tampa Bay do not exist in any other port, making the bay an excellent testbed for development of this technology.

The real-time environmental observations and model simulations of present and future conditions form layers of a comprehensive Tampa Bay Maritime Domain Awareness System (TBMDAS). Possible layers of such a system are outlined on the next page.

Components of a Comprehensive Maritime Domain Awareness System	
Layer	Contents
1	Standard ECDIS
2	AIS display
3	Radar display – shore-based or shipboard – ID's non-AIS vessel traffic
4	Met/Ocean – modeled/observed nowcast/forecast - available at mouse-click or as overlay – powered by PORTS data, hydro and met models
5	Set/Drift info - available at mouse-click or as overlay – function of vessel draft, hull/superstructure configuration, and met/ocean data and nowcast/forecast
6	Red light/Green light for vessel maneuvers based on Layer 5 info
7	Potential target info (i.e. ammonia tanker)
8	Potential threat info
9	Resources at risk info including on-demand predictions of spill trajectories (i.e. what will be damaged by ammonia release/HAZMAT spill etc.)
9	Response assets info (patrol boats, boom locations, etc)
10	Contingency/mitigation plan

## Appendix 8 - Acronyms

<b>AIS</b>	Automated Identification System	<b>NDBC</b>	National Data Buoy Center
<b>ASA</b>	Applied Science Associates	<b>NERACOOS</b>	North Eastern Regional Association Coastal Ocean Observation System
<b>ATI</b>	Along-Track Interferometry	<b>NGOM</b>	Northern Gulf of Mexico
<b>AVHRR</b>	Advanced Very High Resolution Radiometer	<b>NOAA</b>	National Oceanic and Atmospheric Administration
<b>CDIP</b>	Coastal Data Information Program	<b>NOAA CSDL</b>	National Oceanic and Atmospheric Administration Coastal Survey Development Lab
<b>COAMPS</b>	Coupled Ocean/Atmosphere Mesoscale Prediction System	<b>NOGAPS</b>	Navy Operational Global Atmospheric Prediction System
<b>CODAR</b>	Coastal Ocean Dynamics Applications Radar	<b>NOGMSA</b>	National Office of Global Maritime Situational Awareness
<b>COI</b>	Community of Interest	<b>NRL</b>	Naval Research Laboratory
<b>CONOPS</b>	Concept of Operation	<b>NSPD-41</b>	National Security Presidential Directive
<b>COP</b>	Common Operative Picture	<b>NWS</b>	National Weather Service
<b>CORE</b>	Consortium for Oceanographic Research and Education	<b>OGMSA</b>	Office of Global Maritime Situational Awareness
<b>DHS</b>	Department of Homeland Security	<b>ONR</b>	Office of Naval Research
<b>DIF</b>	Data Integration Framework	<b>OOI</b>	Ocean Observatories Initiative
<b>DMAC</b>	Data Management and Communication	<b>OPeNDAP</b>	Open-Source Project for a Network Data Access Protocol
<b>DOD</b>	Department of Defense	<b>OPNAV N6</b>	Office of the Chief of Naval Operations
<b>DoD CIO</b>	Department of Defense Chief Information Officer	<b>OSSE</b>	Observation System Simulation Experiments
<b>ECDIS</b>	Electronic Chart Display and Information System	<b>PEO C4I</b>	Program Executive Office Command, Control, Communication, Computers, Intelligence
<b>EPA HS Team</b>	Environmental Protection Agency something	<b>PORTS</b>	Physical Oceanographic Real-Time System
<b>FGDC</b>	Federal Geographic Data Committee	<b>QA/QC</b>	Quality Assurance/Quality Control
<b>GEOS</b>	Global Earth Observation System of Systems	<b>R&amp;D</b>	Research & Development
<b>GFO</b>	Geosat Follow On	<b>RA</b>	Regional Association
<b>GIG</b>	Global Information Grid	<b>RCOOS</b>	Regional Coastal Ocean Observing System
<b>GMAII</b>	Global Maritime and Air Intelligence Integration	<b>ROW</b>	Radiowave Oceanography Workshop
<b>GMSA</b>	Global Maritime Situational Awareness	<b>ROWG</b>	Radar Operators Working Group
<b>GNOME</b>	General NOAA Operational Modeling Environment	<b>SAR</b>	Synthetic Aperture Radar
<b>GOOS</b>	Global Ocean Observing System	<b>SR</b>	Search and Rescue
<b>GPM</b>	Global Precipitation Measurement	<b>SAROPS</b>	Search and Rescue Optimal Planning System
<b>GPS</b>	Global Positioning System	<b>SCCOOS</b>	South Carolina Coastal Ocean Observing System
<b>HAZMAT</b>	Hazardous Materials	<b>SCMI</b>	Surface Current Mapping Initiative
<b>HF</b>	High Frequency	<b>SECNAV</b>	Secretary of the Navy
<b>HSPD-13</b>	Homeland Security Presidential Directive	<b>SPAWAR</b>	Space & Naval Warfare Systems Command
<b>IASNFS</b>	Intra-Americas Sea Ocean Nowcast/Forecast System	<b>SWIM</b>	Sensor with Interoperable Metadata
<b>ICOSRMI</b>	Interagency Committee on Ocean Science and Resource Management	<b>TBMDAS</b>	Tampa Bay Maritime Domain Awareness System
<b>INSPIRE</b>	Infrastructure for Spatial Information in the European Community	<b>TB-PORTS</b>	Tampa Bay Physical Oceanographic Real-Time System
<b>IOC</b>	Intergovernmental Oceanographic Commission	<b>TRMM</b>	Tropical Rainfall Measuring Mission
<b>IOOS</b>	Integrated Ocean Observing System	<b>UConn</b>	University of Connecticut
<b>IWGOO</b>	Interagency Working Group on Ocean Observations	<b>UCSB</b>	University of California Santa Barbara
<b>JCOMM</b>	Joint WMO/IOC Technical Committee for Oceanography and Marine Technology	<b>UDOP</b>	User Defined Operational Picture
<b>JSOST</b>	Joint Subcommittee on Ocean Science and Technology	<b>URI</b>	University of Rhode Island
<b>MAB</b>	Mid-Atlantic Bight	<b>USCG</b>	US Coast Guard
<b>MACOORA</b>	Mid-Atlantic Coastal Ocean Observing Regional Association	<b>USN</b>	US Navy
<b>MAHFRIC</b>	Middle Atlantic High Frequency Radar Consortium	<b>VTS</b>	Vessel Traffic Service
<b>MARAD</b>	Maritime Administration	<b>WMD</b>	Weapons of Mass Destruction
<b>MAST</b>	Modeling and Analysis Steering Team	<b>WMO</b>	World Meteorological Organization
<b>MDA</b>	Maritime Domain Awareness		
<b>METOC</b>	Meteorological and Oceanographic		
<b>MMI</b>	Marine Metadata and Interoperability		
<b>MODAS</b>	Modular Ocean Data Assimilation System		
<b>NASA</b>	National Aeronautics and Space Administration		
<b>NAVO</b>	Naval Oceanographic Office		
<b>NCDDC</b>	National Coastal Data Development Center		
<b>NCOM</b>	Navy Coastal Ocean Model		
<b>NCP</b>	National Contingency Plan		















