CHAPTER THREE: REQUIREMENTS & USER ENGAGEMENT

1. Introduction

What did we know about user requirements 10 years ago and how does that compare to today? The Airlie House Workshop in 2002 formulated a scientific, technical and, governance structure for a U.S. IOOS® program, but the needs of end-users were not well understood at that time. Over the past ten years, the Regional Associations (RAs) have engaged with users of all types, resulting in a much improved understanding of the wide range of users, their interests, and the types of data, products, and information they need to improve decision-making for themselves, their businesses, and their communities.

Many stakeholders are involved in the planning, construction, operation, and use of U.S. IOOS:

- Providers of observing system infrastructure, including those who manufacture sensors and platforms; operators who deploy, run, and maintain them; those building, launching and operating satellite systems; those providing the cyberinfrastructure that exchanges data and products across U.S. IOOS components; and those who develop and maintain data management systems, software tools and models used to turn U.S. IOOS data into useful information
- Intermediate users who add value by taking U.S. IOOS data or information and tailoring them for specific end-uses
- End-users who use value-added products generated in whole or in part from U.S. IOOS data and information as an input to their activities or businesses to derive specific scientific, societal or business benefits

End-users of U.S. IOOS data and information fall into five main types:

- Operational end-users who use ocean data and products to support decision-making related to safety, emergency response, and economic efficiency
- Science end-users whose research relies on sustained observations of the ocean
- Policy end-users who require sustained ocean information to support policy formulation, monitoring of compliance, and assessment of policy effectiveness
- Public end-users interested in products relevant to their safety or leisure activities
- Education end-users who teach ocean science formally (K-16) and informally

Many users are beginning to see that a mature U.S. IOOS can deliver broad and multiple benefits to them, but the program is not yet mature. Over the next decade, the engagement process must ensure that new data providers continue to be entrained; the program addresses changing requirements as the state of the oceans and Great Lakes change; and the information on providers, users, and requirements continues to be consolidated and used to inform decisions on the development of the U.S. IOOS. In all these engagement activities, the RAs will remain at the forefront of the effort to evolve the coastal module of U.S. IOOS.

2. User Requirements

As opposed to ten years ago, sources of information on user requirements today are extensive, as shown in Table 6.

Table 6. Documentation of IOOS User Requirements

U.S. IOOS Summit community white papers (For requirements associated with SAR, HABs, waves, offshore renewable energy, and ocean acidification, see Allen, Anderson, Bailey, Birkemeier, Hall, and Gledhill papers, respectively)
Price, H. and L. Rosenfeld. 2012. Synthesis of Regional IOOS Build-Out Plans for the Next Decade. Washington, DC., which includes 27 common products needed by users in 11 RAs
National Operational Wave Observation Plan (2009), which includes plans for a surface-wave monitoring network to meet the maritime user community's needs
Plan to Meet the Nation's Needs for Surface Current Mapping (2009), which delineates plans for a national network of high-frequency radar stations to support search-and-rescue efforts and oil-spill response, among other societal needs
U.S. Integrated Ocean Observing System: A Blueprint for Full Capability Version 1.0 (November 2010), which "identifies, describes, and organizes the specific functional activities to be developed and executed by U.S. IOOS partners". Additionally, the U.S. IOOS Office is developing a series of perspective papers, including one on user requirements and gap analysis
Requirements for Global Implementation of the Strategic Plan for Coastal GOOS, Panel for Integrated Coastal Observation (PICO-I) (2012)
Attaining an Operational Marine Biodiversity Observation Network (BON) Workshop (2011)
Toward a National Animal Telemetry Observing Network (ATN) Workshop Synthesis Report (2011)
NOAA Ocean and Great Lakes Acidification Research Plan (2010)

The RAs are systematically organizing user requirements from these and other sources, including engagement of the regional offices of many of the U.S.IOOS Federal partner agencies. The requirements, for both data and products, are summarized from the 10-year Build-Out Plans of the 11 RAs in five major user categories: Marine Operations, Coastal Hazards, Ecosystems and Fisheries, Water Quality, and Long-term Variability (Price and Rosenfeld, 2012). This report summarizes the requirements in a table that presents the 27 common products required by users across all 11 RAs. A table showing the common products required is shown in Appendix F.

3. User Engagement and Its Challenges

To understand user requirements with the specificity needed to transition ocean observations from the research stage to operations, users, and providers must be fully engaged. Successful user engagement is an iterative process, with eight steps presented in Figure 6. Although a purely circular process is depicted, many of the steps will be revisited during the process. If all the steps are carried out sufficiently, a natural by-product will be advocacy (Step 8). The users will better understand what the enterprise is trying to accomplish, both as a whole and for them as a user group. This understanding, coupled with successful provision of data and products, will lead to user-initiated advocacy for the enterprise, effectively turning end users into U.S. IOOS advocates.

Figure 6. The Steps Required for Successful User Engagement

Each of the steps presents challenges, many of them related to communication and coordination. How can the requirements of users be better communicated to observers and data providers? How can potential users be made more aware of data and products available through U.S. IOOS? How can different federal agencies, countries and RAs better coordinate to meet the diverse array of user requirements? How can we prioritize activities to address user requirements?

There are also technological, financial and ideological challenges in meeting user requirements. Many users want biochemical measurements, but the system's initial focus has been primarily on physical measurements. Due to lack of resources, users are often asked to supply funds in order to see their requirements fulfilled. There are cultural challenges that arise from different communities working together: the research and operational communities; the public, private industry and university sectors; different federal agencies; and different countries. These communities have defensibly different views on user requirements and priorities. Hearing and merging all of their views into a coherent program requires rigorous involvement in all steps of the user engagement process, and in overcoming their challenges.

Step 1. Identify the users.

This seemingly straightforward step has been a major undertaking, but considerable progress has been made over the past decade to identify users and build relationships.

Challenge. This challenge has been met, but the range of users that are and could be served by U.S. IOOS is so extensive it is difficult to know how to serve all of them.

Step 2. Prioritize the users and/or the products.

Existing and potential users of U.S. IOOS are extensive, which follows from U.S. IOOS having a purposefully broad scope. However, limited resources require that we prioritize who we are going to serve and/or what products and services the system will provide.

Challenge. There are cultural differences among U.S. IOOS user communities, and they have different views on user requirements.

Setting priorities for an enterprise with the scope of U.S. IOOS is a daunting task. The current economy requires that choices be made, but the existing U.S. Federal budget process is not conducive to developing U.S. IOOS-wide funding priorities.

At the global scale, there is increasing recognition that the U.S. will have to rely on foreign sources of satellite data to meet our requirements. The Committee on Earth Observation Satellites (CEOS *http://www.ceos.org*), which is a part of GEO *http://www.earthobservations.org*) is coordinating environmental satellite observations of the Earth. With limited resources, how do we ensure the widest range of U.S. local, regional, national, and global requirements is met?

The United States' ocean observing community has never been more organized, disciplined and collaborative towards common national goals and objectives than it is now, but challenges remain at the interfaces of the various communities. Many Federal agencies have operational needs that could be addressed by other U.S. IOOS partners. An improved mechanism is needed to facilitate broader sharing and partnering across the U.S. IOOS enterprise. Since the non-Federal observing system is being implemented mostly through academic institutions, the academic value structure -- based on publication and grant proposals -- needs to be more widely understood and integrated into IOOS planning.

Step 3. Define user requirements.

Defining user requirements is an iterative step that can only be executed if adequate human resources are committed. Each user's decision processes and operational needs must be fully understood.

Challenge. It is a legislative mandate for U.S. IOOS to be based on the needs of users (Ocean.US, 2002), but documenting user needs is not straightforward. Which users should be included? How should their requirements be prioritized?

The timing of engagement with end-users to understand their needs must be considered. Requirements have a shelf life. If the resources are not available to act on requirements, then documenting them may have the negative impacts of raising expectations of users when nothing can be done; and wasting effort because the requirements may change and need to be revisited. Catastrophic events cause sudden and dramatic changes in user requirements, often without an increase in necessary resources. User requirements will change with time, changing technology, and unforeseen events. The requirements documentation process must be able to accommodate this.

Different types of users have very different requirements. An operational model may require a continuous, near real-time data stream, whereas the public's needs are more episodic and usually require interpretation -- a product -- rather than a data stream. User requirements extend to the data dissemination process; active communication between users and data providers is crucial to establish efficient, user-friendly data and product distribution. Improved mechanisms are needed for collaboration among users, researchers, and private industry to ensure the development of meaningful products. We need to engage more intermediate users who bridge the gap between providers and users. We need increased private enterprise activity to fill the gaps in U.S. IOOS.

The present system has been built largely around collecting and modeling physical oceanographic parameters, but a large and growing segment of potential users requires biological and biogeochemical observations. There have even been efforts to incorporate biological measurements, but these have been driven largely by leveraging available technology rather than as direct responses to the highest priority user needs for biological data. The investment in sensor development and modeling necessary to optimize the observing system for biological and chemical questions is still lacking. Such investment towards products beyond the purely physical models will be required.

There is also a spatial mismatch between the observing system and many desired applications. U.S. IOOS was initially built primarily to support large scale global oceanographic models, with kilometer-scale resolution and the coastal shelf as a boundary condition. Many of the U.S. IOOS user needs are located much closer to shore and on much smaller spatial scales. While the spatial resolution of the models continues to improve, and there are some nascent efforts to move the model's boundary conditions closer to shore, there is still much fundamental technical work to be done before many user community needs can be addressed.

Step 4. Develop Solutions.

This stage focuses on partnering of the RAs and IOOC agencies with private enterprise, non-governmental organizations, and/or local, tribal, state partners. A key to success is keeping the user engaged and understanding that several iterations will likely be necessary before users are satisfied. Since this step can take months or years, user requirements will evolve during the process, requiring adjustments to the solutions.

Challenge. The Research-to-Operations (R2O) transition process has always been difficult, earning it the nickname of "Crossing the Valley of Death," but it is a fundamental part of U.S. IOOS. There are many examples of a strong "push" from research communities to operationalize their products, but a lesser "pull" from the users. No organized process exists to foster a strong and consistent "pull" from the operational communities, but this is needed to improve transition of the products that are most needed by users. We need a formal process for user-driven product development.

The RAs have significant experience in user-driven, product development approaches. (See *http://www.usnfra.org/products.html* for 71 RA created products.) The RAs often serve as the linchpin between data generators, data product developers and users in their region. Improvements are needed to shift these processes from a cooperative approach (working together toward independent goals) to a more coordinated approach (working together toward common goals).

The governance structure for an expanded product development process could include a number of supporting structures, including user councils, thematic product working groups, a stakeholder engagement council, and leveraged use of existing stakeholder networks. A partnership between the U.S. IOOS Program Office and the IOOS Association could engage all U.S. IOOS Federal agencies and RAs to populate and support a User Engagement Council charged with defining and fostering a U.S. IOOS R2O strategy.

Step 5. Conduct Outreach.

In the private sector, this step is called marketing. Products will not be used if users are not aware of them. This step is most often cut from public sector development programs. It is highly important, but requires infusion of human resources and funding.

Challenge. There must be more investment in building a community of informal education specialists who can promote the use of U.S. IOOS information to achieve ocean literacy. U.S. IOOS must facilitate the development of new strategies for virtual social structures that encourage communication and sharing of ideas across disciplines (Thoroughgood et al, 2013). For outreach to the general public, data dissemination must move beyond web pages and take advantage of expanding media technologies, such as smart phone applications and twitter feeds, to make data and products more easily available to public users.

NOAA's Sea Grant extension services provide agents with ocean expertise who interact directly with specific stakeholder groups; the Sea Grant system should be used to improve stakeholder engagement within U.S. IOOS.

Additional resources for the existing IOOS Association Education and Outreach Council would support an increase in engagement with formal and informal educators, undergraduate and graduate level students, and the general public. These outreach efforts to put understandable information into the hands of the public are just as important as the DMAC subsystem that puts quality data into the hands of users.

Step 6. Assess and Maintain Products.

Follow-up assessments are required to ensure any U.S. IOOS data, product, or service continues to meet the user's need. Maintenance is critical to keep user groups, their requirements, and the associated resources to meet them up-to-date with the changing states of the ocean and Great Lakes. When accounting for resource needs, long-term costs of maintaining user engagement must be included.

Challenge. Many 'levels' of products are available for U.S. IOOS stakeholders, ranging from minimally processed data to decision-support tools. The challenge is to build more robust assessment, maintenance, and product updates into the U.S. IOOS structure.

Step 7. Provide Training.

Training of the technicians, programmers, scientists, educators, and others who will be needed for a mature U.S. IOOS is required. This step in engagement is often overlooked and hence under-planned and under-resourced.

Challenge. Dedicated human resources are required to conduct meaningful outreach and training. NOAA's Sea Grant extension services can serve as models for, and support, stakeholder engagement within U.S. IOOS to ensure that data and product dissemination meets user requirements and is user-friendly.

Step 8. Increase Advocacy.

There is a need to develop and maintain advocacy for U.S. IOOS.

Challenge. U.S. IOOS is a line item in the NOAA budget, but it remains a largely unfunded federal mandate. The existing approach of individual agency ocean observing programs addressing agency-unique missions with uncoordinated agency budgets is inadequate. This fragmented Federal approach lies at the heart of the U.S. IOOS challenge to thrive.

Advocacy will develop naturally if stakeholders and users are actively engaged and their requirements are being met. But a proactive advocacy strategy is also needed. There are many users that have come to rely on U.S. IOOS products without providing any support for the system. The ocean observing community is not adept at turning that supportive relationship into advocacy for continued or expanded funding.

Significant, well-qualified human resources are necessary to maintain effective user engagement. U.S. IOOS must recognize the importance of this process and support implementation of a user engagement infrastructure in order to meet the vision of U.S. IOOS for the next decade.

Table 7. The Steps of User Engagement, Challenges & Potential Approaches

#	ENGAGEMENT STEPS	CHALLENGES	PROPOSED APPROACHES
1	Identify Users	1: How can we identify the users of U.S. IOOS?	1: Organize information about users, their requirements and available products into a "marketplace"
2	Prioritize Users and/or New Products Lines	2A: How can different Federal agencies, different countries and different RAs agree on priorities since resources are not available to meet all user requirements? 2B: How are cultural challenges involved with different communities working together, and what are their different attitudes/ perceptions of user requirements?	2A(i): Develop an "Action Agenda" for U.S. IOOS that prioritizes near-term investments and steps along the path to a fully operational system 2A(ii): Devote a portion of each IOOC meeting agenda to resolving coordination issues 2B: The IOOC agencies should provide recognition, incentives and/or rewards for partnerships across cultural interfaces
3	Define Requirements	3A: How can the requirements of users be better documented and communicated to U.S. IOOS stakeholders? 3B: How to address the mismatch between many of the user needs and the technical capabilities of the observing system?	3A: Institutionalize a process to identify, vet, and prioritize user requirements -- make it clear to users what is available, and clear to data providers where the gaps and opportunities are 3B: U.S. IOOS needs to invest in development of the necessary biological and chemical sensors to meet established user requirements
4	Develop Solutions	4: How can we ensure that users are properly engaged in the transition from research to operations for observational data streams and models?	4A: Organize existing U.S. IOOS user engagement efforts into an ad hoc User Engagement Council 4B: Open up the Federal agency 'pull' opportunities 4C: Incentives for private industry
5	Effective Outreach	5: How can the public and other potential users be made more aware of the data available through IOOS?	5: Increase support to the IOOS Association's Education and Outreach Council
6	Assess and Maintain Products	6: How can we ensure that U.S. IOOS products continue to meet user needs?	6: Establish product metrics
7	Provide Training	7: How can we ensure that U.S. IOOS products are used?	7: Provide marketing and training
8	Increase Advocacy	8A: How can we develop and maintain advocacy for U.S. IOOS? 8B: How can we address funding issues which can result in user alienation and loss of existing observational resources?	8A: IOOC Federal agencies increase their branding for U.S. IOOS 8B: The IOOS Association coordinates with the business community on advocacy training for IOOS personnel; the IOOC should open Federal agency cooperation avenues at the regional level

4. An Assessment of User Engagements

Successfully defining user requirements is an iterative process characterized by mutual understanding, commitment, and trust between the user and provider. The "corporate culture" of U.S. IOOS must be one where user engagement is a top priority, and these efforts must be funded at a significant enough level to make a difference.

At the level of the Global Module of U.S. IOOS, engagement is usually conducted within the spheres of Federal agencies and their consultants and contractors. At the level of the Coastal component, the U.S. IOOS Program Office and the agencies of the IOOC are, in effect, serving two masters. The contributions by Federal agencies are assets supporting their own missions and these need to be better integrated into U.S. IOOS, both to more fully represent all the user groups and to improve entrainment of the data, products, and information from these agencies into the U.S. IOOS enterprise.

The RAs have devoted significant resources over the past decade to user engagement on the local, regional and national scales, establishing strong relationships with many users. The level of user engagement has ranged from excellent to mediocre, as illustrated in the examples below.

Example 1. Turning Users into Data Providers

There is always a shortage of in-situ data for the assimilation and validation of coastal ocean circulation models. In the Northeast Region, the Environmental Monitors on Lobster Traps (see *http://emolt.org*) project addressed that problem by working with lobstermen to place sensors on their traps. Start-up funds were provided by NOAA's Northeast Consortium. Maintaining the program requires only low-cost replacement probes approximately every five years, and a few months of personnel time each year to process the data. There is now more than a decade of hourly bottom temperatures at dozens of fixed locations from this program. Salinity sensors, bottom-current meters, acoustic listening devices, tide-gauges, and underwater cameras that provide a time series of biological activity have also been deployed on the traps. The fishermen also assist with deployment and recovery of student-built satellite-tracked drifters in order to help document surface current flow (see *http://www.nefsc.noaa.gov/drifter*). In addition to providing data for coastal ocean circulation models, the project has engaged many fishermen in the process of monitoring their environment. These fishermen have the biggest stake in preserving our coastal marine resources, and are most knowledgeable of the local waters. This is an excellent example of developing a solution to a data deficiency, which resulted in engaging users by turning them into data providers.

Example 2. Research to Operations (R2O) Success Is Not Enough

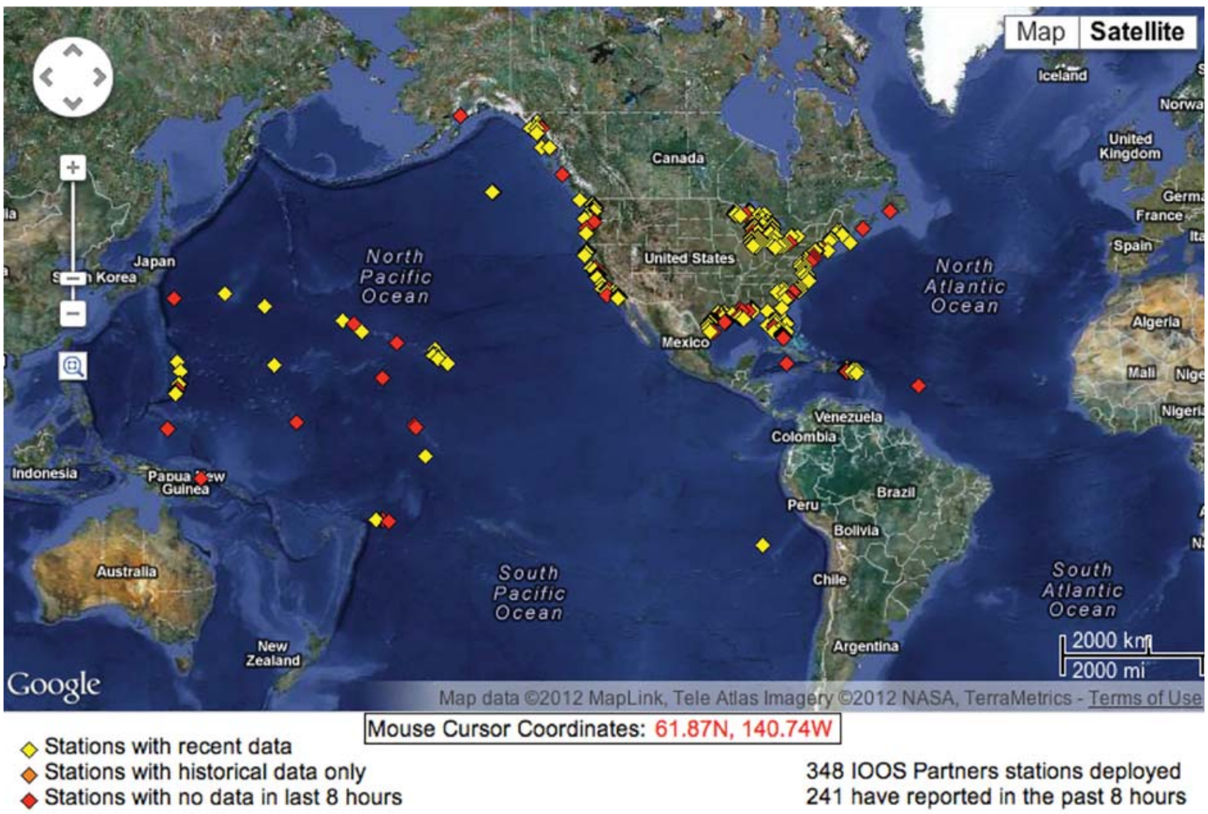
Small networks of HF radars operated by academic institutions appeared around the nation in the 1990's. Based on early successes, in 2001 a best-practices workshop was convened and by 2007 individual academic systems were combined into an aggregate network. Today the U.S. IOOS has established a National HF Radar Network based on the U.S. Surface Current Mapping Plan. The Network supports the operation of approximately 120 HF Radars along the U.S. coast. The Network supports the aggregation of the radial surface currents, produces total vector maps, and the dissemination of surface current fields to a broad range of users including the U.S. Coast Guard. Results of a four-day test in July 2009 showed that when HF radar data were ingested into the U.S. Coast Guard's Search and Rescue system, the search area was greatly decreased. The use of HF radar data is currently integrated in to Coast Guard Search and Rescue on a national level, but even this research-to-operations (R2O) success has not led to needed resources for expansion in the HF radar assets distributed around the nation's shorelines (Glenn, Barrick, 2012)

Example 3. Changing "corporate culture"

Early in the formulation of the U.S. IOOS vision, the National Data Buoy Center (NDBC) took on the task of becoming a central Data Assembly Center (DAC) collecting data from regional ocean observing systems, providing quality control, and distributing the data in realtime via the Global Telecommunications System (GTS), their website, via netCDF files, and via Sensor Observation Service. There are about 400 non-Federal observing stations in the coastal ocean and Great Lakes that contribute to the data stream disseminated via GTS (Figure 7). The NDBC efforts in collecting, managing and disseminating data from both Federal IOOS efforts and from Regional Associations illustrates how a Federal agency can change its "corporate culture" to entrain itself into the greater vision of the national U.S. IOOS enterprise.

Figure 7. Stations in the IOOS DAC Operated by NDBC.

This shows stations at 2200 CT on 26 August 2012
(available at <http://www.ndbc.noaa.gov/obs.shtml> by selecting "IOOS Partners").



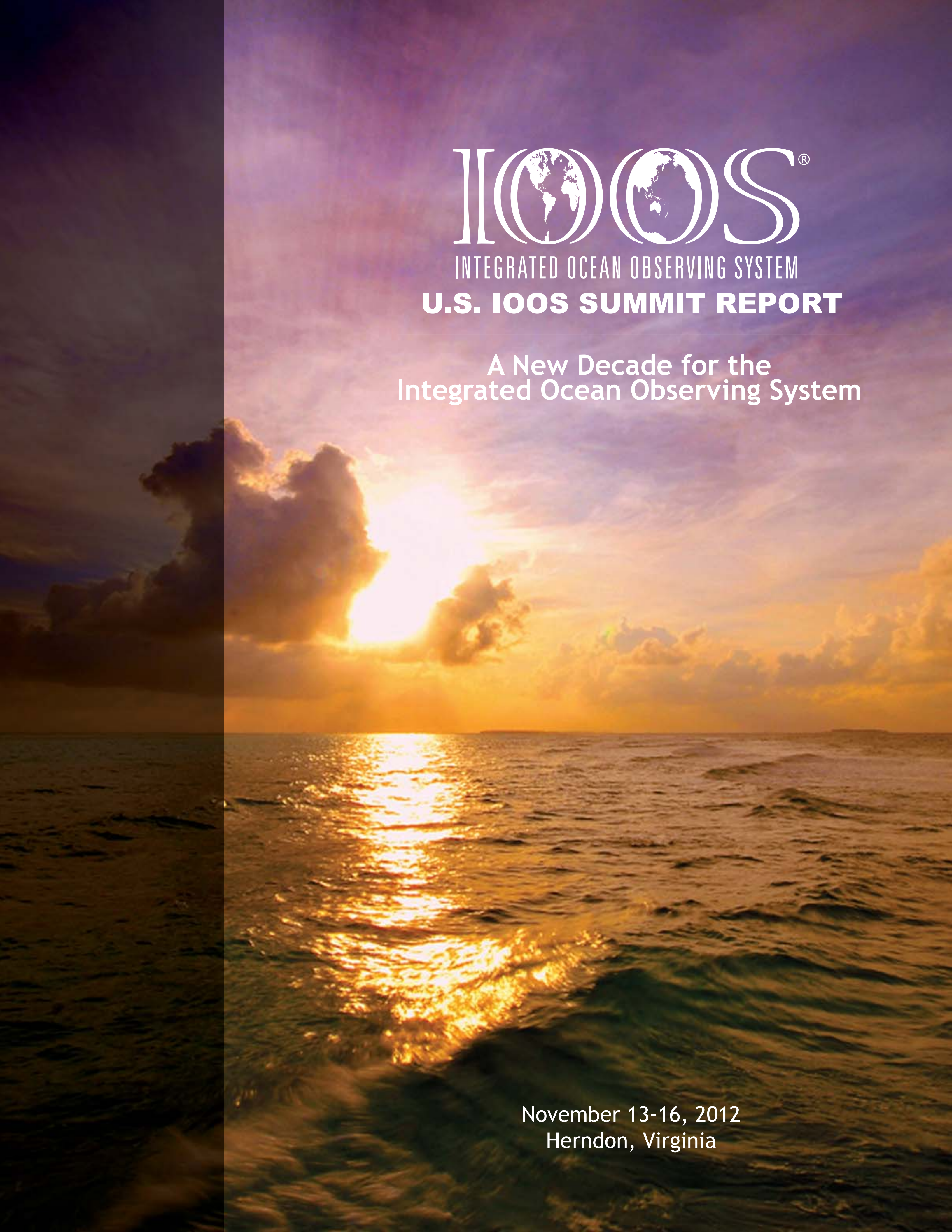
Example 4. Data is not enough; it must be integrated

The Gulf of Maine buoy array of NERACOOS has provided continuous oceanographic measurements for over a decade. There are now seven buoys in the array sited at coastal shelf depths ranging from 50 to 250 meters and providing temperature measurements at 3 to 7 depths throughout the water column. Analysis of this time series shows statistically significant warming trends at all depths for all locations, providing the first depth-resolved rates of temperature variability for the U.S. East Coast from continuous data. Ecosystem data are lacking, however, so there is no telling what impact this warming condition is having on the ecosystem. User engagement is successful when the data are integrated in new ways to provide new understandings or new information for decision-making. The impact of data is limited without human resources funded for analysis and for making the results available to broader user groups.

Example 5. Catastrophes radically change users requirements

Sudden catastrophic events, such as Hurricane Katrina and the 2010 Deepwater Horizon oil spill, can have sudden and profound impacts on user requirements. Twice in just five years, the GCOOS efforts were altered from a steady pace of engagement, entrainment and building solid commitments with users and providers, to an on-demand, urgency-driven engagement process with myriad new stakeholders. Ongoing projects, such as the development of a Harmful Algal Bloom (HAB) Integrated Observing System, were postponed in order to deal with emergency situations. Engagement personnel, many of whom were volunteers facing their own major losses associated with these events, were stretched thin, and the dramatic shifts in stakeholder needs still reverberate through the engagement process today. Both of these events imposed a prioritization scheme on a response and monitoring system that had no mechanism for establishing priorities, and illustrated how vital an effective prioritization process can be. Other changes in the environment and climate, such as increases in hurricane intensity, habitat losses from sea level rise, new invasive species, and increases in HABs will also impact user needs for data, products and information. It is imperative that the system be designed to recognize and respond quickly to changing user needs.

In summary, these examples illustrate both the successes and limitations of the existing U.S. IOOS user engagement efforts, and argue for improved processes and an infusion of additional resources if we are to meet the U.S. IOOS vision for the next decade.



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INTEGRATED OCEAN OBSERVING SYSTEM

U.S. IOOS SUMMIT REPORT

A New Decade for the Integrated Ocean Observing System

November 13-16, 2012
Herndon, Virginia

IOOC

The Interagency Ocean Observation Committee (IOOC) was created by The Integrated Coastal and Ocean Observation System Act of 2009 and oversees efforts to develop the U.S. Integrated Ocean Observing System. Led by three federal Co-Chairs and supported by agency representatives and support staff, the Committee carries out various provisions of the Act for implementing procedural, technical, and scientific requirements to ensure full execution of the system. Interagency collaboration is essential to achieve ocean science and technology priorities and, in particular, for planning and coordination of the System.

U.S. IOOS®

The U.S. Integrated Ocean Observing System (IOOS) is a national-regional partnership working to provide new tools and forecasts to improve safety, enhance the economy, and protect our environment. Integrated ocean information is now available in near real time, as well as retrospectively. Easier and better access to this information is improving our ability to understand and predict coastal events - such as storms, wave heights, and sea level change. Such knowledge is needed for everything from retail to development planning.

August 2013
U.S. IOOS Summit Report: A New Decade for the Integrated Ocean Observing System

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