

**ADVANCING OCEAN EXPLORATION 2020 and NATIONAL FORUM 2014 RECOMMENDATIONS**  
**Perspectives from the Ocean Exploration Community**  
**and the Office of Ocean Exploration and Research**

During its second meeting in La Jolla, the Ocean Exploration Advisory Board (OEAB) asked for a summary of progress toward advancing *Ocean Exploration 2020* report recommendations. The Office of Ocean Exploration and Research (OER) took a two-part approach to respond. First, we worked with Jerry Schubel, President and CEO of the Aquarium of the Pacific and co-host of *Ocean Exploration 2020*, to solicit external perspectives on progress toward a national ocean exploration program since *OE 2020*. We asked these experts to review a particular *OE 2020* report recommendation, to reflect on progress made in that particular area since the first Forum, and to identify challenges that remain. Second, we have prepared a short summary of how the *OE 2020* and National Forum 2014 report recommendations have shaped OER activities.

**Background**

The authorizing legislation for NOAA's ocean exploration program, Public Law 111-11, asks the agency to "establish an ocean exploration forum to encourage partnerships and promote communication" among stakeholders to "enhance the scientific and technical expertise and relevance of the national program."

With its partners at the Aquarium of the Pacific and the National Aquarium in Baltimore, OER organized a first National Ocean Exploration Forum, *Ocean Exploration 2020*, followed by a second, "mini-National Forum" in Baltimore at the National Aquarium in 2014. A third, *Characterizing the Unknown – National Ocean Exploration Forum 2015*, will take place in Baltimore in November. The design of the third National Ocean Exploration Forum is a conscious step forward: the event will focus on federal agency ocean exploration requirements and mission drivers for non-government ocean exploration entities as a framework for identifying how future expeditions will be able to take advantage of a successful national program. OER expects the National Ocean Exploration Forum concept to evolve with the national ocean exploration program and for other members of the community to host similar events in the future.

While *OE 2020* resulted in rich guidance for a national program by defining key characteristics, the September 2014 mini-National Forum, held shortly before the OEAB convened for the first time, discussed on how ocean exploration supports NOAA programs that provide "actionable information" for decision makers based on environmental intelligence. Participants also discussed the evolution of the national program and provided recommendations for the next National Ocean Exploration Forum

While Forum report recommendations themselves are of great value to NOAA and the ocean exploration community, the events are important steps toward building and reinforcing a community that might identify itself as part of a national program.

**External Perspectives**

In this section, experts external to OER share their informal thought about what progress we have made as a community toward developing the attributes *OE 2020* participants identified as important to a successful national ocean exploration program.

**PRIORITIES**

Jerry Schubel

President and CEO

Aquarium of the Pacific at Long Beach

- Since the outset, there has been general agreement that the program should be global in scope, but have a focus, at least initially on U.S. waters, and that priorities should be set by the community while being responsive to national needs.
- Since the *President’s Panel on Ocean Exploration* in 2000 there has been a convergence on geographic and ocean feature priorities. These sources include: the 2003 NRC report *Exploration of the Seas*, the 2012 review of NOAA’s ocean exploration program, *Ocean Exploration’s Second Decade*, the first national ocean exploration forum, *Ocean Exploration 2020*, and the second forum, *National Forum 2014*. These are summarized in the table below.

**A Convergence on Priorities: 2000 - 2014**

<b>Geographic Areas</b>	<b>Ocean Features</b>
Arctic	Water Columns
Antarctic	Trenches
Indo-Pacific	Coral Ecosystems
Central Pacific	Methane Seeps
U.S. EEZ	Marine Life
U.S. Extended Continental Shelf	Seamounts
	Under-Ice Communities
	Deep Water and Climate Change
	Oceans through Time

- Setting of priorities by the community has been institutionalized through a series of forums starting with *Ocean Exploration 2020* in July 2013, the smaller *National Forum 2014* in September of that year, and occasional workshops that bring together ocean explorers and other research scientists together to focus on specific geographic areas, and how best to explore them. Two recent examples are the 2012 “Workshop on Telepresence-Enabled Exploration of the Caribbean Region,” and the 2014 “Workshop on Telepresence-Enabled Exploration of the Eastern Pacific Ocean,” both hosted by the Ocean Exploration Trust with support from NOAA and foundations.
- An additional priority that has been called for since the President’s Panel is the development of technologies, including platforms and sensors, to provide greater mobility to explore larger areas and volumes at lower cost, and sensors that provide physical, chemical, and biological data to characterize the environments which are being explored and observed. This is an area where great progress has been made in the past few years with the development of AUVs and UAS’s (drones) which can convert any oceanographic research vessel into a ship of exploration, and the growing array of sensors have added a powerful diagnostic capability to visual exploration.

## *PARTNERSHIPS*

Larry Mayer

Director, Center for Coastal and Ocean Mapping

University of New Hampshire

- Under PL-111-11, NOAA has been charged with taking a leadership role in establishing a national program of ocean exploration and thus would be the logical agency to take the lead in establishing formal partnerships for ocean exploration. We have seen some progress along these lines. For example, NOAA has been working with the X-Prize Foundation to establish prizes in ocean-related areas, and we have seen collaborations established between NOAA, Bureau of Ocean Energy Management, and U.S. Geological Survey for exploration of methane seep-rich areas of the Atlantic margin.
- Private foundations continue to support ocean exploration efforts (Schmidt Ocean Institute; Sloan Foundation; Moore Foundation, etc.) and there has been some level of coordination amongst these organizations. But they appear to be coordinating amongst themselves and not with federal agencies or the private sector.
- We have also seen progress on the international front. For example, the National Science Foundation and the Swedish Polar Secretariat have formed a new agreement that supports sharing of ship-time in the Arctic, the highest regional priority for ocean exploration and an area where vessel resources are very scarce.
- An area where we have seen little, if any progress, is in the formal and systematic coordination of ocean exploration activities amongst the various ocean exploration entities, and particularly amongst federal agencies. Given the mandate of PL-111-11 one would hope to see a formal interagency coordinating committee for national ocean exploration activities.
- More than a mandate is required for such an organization to be successful: a willingness on the part of all agencies involved to participate and contribute is essential. This may be the greatest challenge facing the future of U.S. ocean exploration activities.

## *PLATFORMS*

Peter Ortner

Research Professor and Director,

Cooperative Institute for Marine and Atmospheric Studies

- Despite the *OE 2020* report's call for an increased number of platforms, the size of the research vessel fleet continues to shrink. And yet if we use the term "ocean exploration" more broadly, to refer to the broad sense of acquiring data and information we previously did not have, there is progress. The idea is not to simply go to a particular bit of geography where we don't know what we will find, but to collect data over time and space scales impossible with old technology. We can "see" new geography through a different lens.
- For example, ocean observatories may be part of this new ability to collect data over time and

space (I think the jury still is out) but Autonomous Underwater Vehicles (AUVs) Unmanned Aircraft Systems (UAS, or “drones”), and ships of opportunity clearly must be included. Our conventional research fleet simply can’t look across dynamic processes, time, and space in the way that these new technologies can, regardless of how large it is.

- With AUVs and UAS’ (particularly the latter) the challenge is improving weight/power requirements. We are doing better and better in that regard. A particularly exciting development that could radically improve the quality of optical data from UAS-based sensors is “fluid lens analysis”—a mathematical filtering and distortion correction process that allows us to see right through surface wave and light reflection distortion to the surface of coral reefs and other submerged features. (See <http://www.vedphoto.com/fluid-lensing>). This is truly exciting stuff for many applications—enough so that NASA is investing millions.
- New platforms are already proving their worth, but advances in instrumentation are even more impressive. Our ability to combine old and new platforms with smaller, low power, automated sensing systems—primarily optical and acoustic but also to a more limited extent chemical and biochemical sensors greatly expands the concept of “exploration.” Much work remains to be done, but there are a number of promising technologies available or about to be available, including drop probes for an array of chemical parameters (like an XBT, but for much more than just temperature), including Oxygen, pH, Total Alkalinity, and Chlorophyll a. Another promising technology relating to drop probes is the ability to key fully automated launchers holding many probes based on real-time neural network analysis of continuous acoustic current data.
- Platform integration is also gaining traction. Swarms of UAS and/or AUV vehicles that are “smart” and sample as a “team” could optimizing data collection and send it all to a “mother ship” for processing, analysis, and distribution. Some have even suggested this “mother” could be a helicopter based upon a research vessel. Integrating a series of platforms in this way dramatically increases the reach of any research vessel to sample a wider 3-D world around its position.
- Because these new technologies are smaller and much lower cost than traditional research vessels (and some are even accessible to citizen explorers) the cost of access to areas of interest should go down, which helps create opportunities for a greater national ocean exploration “footprint” —new areas explored—despite tightening budgets.

#### TECHNOLOGY

Lance Towers

Director, Advanced Technology Programs

Boeing, Inc.

- The ocean-based community focused on ocean exploration has continued to make technology progress toward the goals and objectives outlined in the *Ocean Exploration 2020* report. However, the rate of progress has basically remained flat. The smaller technology firms and education-based communities have most likely grown the most.

- The budget challenges at the federal level continue to dampen technology and program development that is needed to fully achieve the goals and objectives of the *Ocean Exploration 2020* report.
- Public awareness in areas such as weather predictions dominates investment allocations in technologies and products such as weather satellites.
- The actual investment in deep ocean exploration has remained a small overall percentage of the federal budget. The federal budget focus has dampened the amount of participation by large industry in ocean exploration. To move the needle, so-to-speak, in ocean exploration technology development, a significant increase in federal spending is required in order to pull in the large industry community.
- NOAA may benefit from engaging organizations such as DARPA and ONR on behalf of the national ocean exploration program. Both DARPA and ONR develop technologies that operate in the ocean environment. Many of these technologies are fully applicable to the missions needed for successful ocean exploration.
- With today's tight budgets but expanding mission requirements, we need to establish new ways of conducting the same work for significantly lower cost. This will require a paradigm change in what we produce for ocean exploration. For example, most ocean exploration technologies currently require significant infrastructure for operation. For example, advanced remotely operated vehicles (ROV) or autonomous underwater vehicles (AUV) require a surface ship for launch, operation, and recovery. The cost of the surface or support ship typically dwarfs the cost of the ROV or AUV. To break the cost curve, new technologies and modes of operation are required that eliminate the need for a surface or support ship. This defines a set of technologies that can operate mainly autonomously for weeks or months at time, with the ability to collect vast amounts of data and carry a wide variety of sensors.
- Another way to break the cost curve is investment in low-cost, lightweight systems that reduce required infrastructure while maintaining or improving data collection results.

#### *CITIZEN EXPLORATION*

David Lang  
Co-Founder, OpenROV

- One of the most interesting trends in science is happening *outside* of science. The rapidly changing technology landscape is driving a new generation of tools that can be made more affordable and more connected. This explosion of new devices and sensors is driving involvement from a new genre of participant: the citizen scientists.
- It isn't necessarily a new idea. Disciplines like astronomy and ornithology have been incorporating the research and perspective of non-professional scientists for decades. The concept is novel for ocean exploration because of the high costs associated with fieldwork and the relatively small amount of funding that supports the work. At *OE 2020*, we talked about the

potential of this developing trend and how best to harness it. In the subsequent years, the discussion has continued with enthusiasm and the technology developed extensively.

- The high cost of traditional ocean exploration infrastructure—ships, submersibles, remotely operated vehicles, and so on—and the limited federal investment in this expensive and often aging infrastructure, means that conventional ocean exploration assets are likely to remain limited. The dropping costs and rapid improvements in instrument capability of flexible, small platforms is creating an opportunity to expand the pace and scope of exploration in the near future. The challenge now is to move beyond dialogue and towards meaningful, systemic engagement.

#### *DATA SHARING*

Vicki Ferrini

Research Scientist

Lamont-Doherty Earth Observatory

#### *Community progress toward data sharing since 2013:*

- Over the past several years, there has been considerable progress with respect to making basic metadata and *field data* (unprocessed) acquired by ships openly accessible in a more timely fashion. This is in part due to the development and adoption of the “Rolling Deck-to-Repository” (R2R Program), which transformed the data submission paradigm and streamlined the transfer of data/metadata to the NOAA’s National Centers for Environmental Information (NCEI) by working directly with vessel operators rather than individual scientists. While R2R was developed for the U.S. Academic Research Fleet, the model is highly efficient and NOAA has adopted many of its principles. Responsibilities for processing shipboard data vary by operator. In cases where data are processed by vessel operators, processed data are propagated fairly routinely to NCEI, but in cases where data processing lies with members of the science party the data are less routinely made available.
- Multiple efforts have been developed over the past several years that focus on ensuring that high quality data are consistently acquired across the research fleet and that technical resources and best practice documentation are publicly available. These efforts typically provide expert oversight of the operation of a particular instrument suite, and include but are not limited to, the Multibeam Advisory Committee (MAC), Joint Archive for Shipboard ADCP (JASADCP), and Shipboard Automated Meteorological and Oceanographic System (SAMOS). Knowledge from these efforts is broadly shared across the Ocean Exploration Community. While this is proving to be a productive model, it has not yet been adopted for all data types.
- Community input on metadata needs and data formats over the past several years is helping to improve the consistency and utility of data made available at NOAA’s NCEI.
- Collaborative efforts for developing standards for publishing and sharing metadata are helping with interoperability and discovery of related and complementary data in distributed systems. There is still work to be done to lower barriers to adoption of tools and interfaces for the science community and the public.

- Over the past few years, more effort has been put into leveraging social media to disseminate highlight data (video, images, maps) with the public. This is an important and worthwhile aspect of public outreach and engagement that can significantly benefit our community.

*Challenges & Opportunities in this area over the next five years*

- Final data products and interpretations generated by scientists are still falling through the cracks. We've made considerable progress with underway data and the culture is clearly changing, but documenting data and contributing final data products to appropriate repositories is still time-consuming for individual investigators and is not adequately rewarded. There are many opportunities for addressing this challenge including, but not limited to, software development/deployment, workflow development, and training.
- It is still extremely challenging to comprehensively discover what data exist and how to access those data. We've done an excellent job with some data types, and have made little to no progress with others.
- Video data management remains a growing challenge for our community, and includes topics such as video formats, data volumes, long-term storage, and access/accessibility. A small workshop will be held in 2016 that will include members of the Ocean Exploration Community and industry specialists to begin to develop community consensus on a way forward, but significant effort and cost will be associated with developing a robust solution for large volumes of video content (sourced from both submersibles and airborne drones).
- The cost of managing scientific data is non-trivial and the mechanisms for supporting those costs remain unclear at best.

*What can federal agencies, particularly NOAA, do to help?*

- Foster partnerships among various data management efforts that are closely integrated with subsets of the Ocean Exploration Community to ensure that efforts augment one another, lessons learned are shared, and that distributed content can be accessed through common standards.
- Ensure that data policies are consistently implemented across agencies and across data types (e.g. underway (raw) vs. processed data products; policies regarding open access to underwater photos/video acquired with federal research money is *extremely* variable at present).
- Help to identify funding mechanisms/opportunities and possibly collaborations with the tech industry for developing/integrating the kinds of tools/techniques that will lessen the "burden of data management" on individual scientists and facilitate the flow of data/information. Tools that can be incorporated into the daily workflows of scientists are sorely needed.
- Continue to help shift the culture among the science community with respect to data sharing and data citation. Part of this entails clearly defining data sharing obligations/expectations and following up to ensure compliance. Software tools can and should be part of the solution along with professional credit for data contributions.

## PUBLIC ENGAGEMENT

Louisa Koch

NOAA Director of Education

- Since *Ocean Exploration 2020*, the telepresence-enabled exploration model in place aboard the E/V *Nautilus* and the NOAA Ship *Okeanos Explorer* has been deployed on the Schmidt Ocean Institute's *Falkor*, and on some UNOLS research vessels. Anyone can now participate in ocean exploration via a standard Internet connection. The maturation of telepresence technology and its broader deployment have created important new opportunities to engage the public in ocean exploration
- Other efforts to engage citizen scientists in ocean exploration have made strides through projects such as the NOAA Phytoplankton Monitoring Network and the Marine Debris Tracker program. National and international initiatives like Ocean Sampling Day help build awareness of ocean issues and create context for public engagement in ocean exploration. These efforts should be expanded. As technology improves and is more widely available, the ability of citizen explorers to contribute to the national program increases.
- Increased coordination and leveraging of new developments in tools and methods among the three U.S. ships of exploration, the *Falkor*, *Nautilus*, and *Okeanos Explorer* could make it easier for education partners to connect with a broad array of ocean exploration expeditions. More coordination between the ships of exploration and formal and informal educational institutions could help educators use ocean exploration results in new and powerful ways to reach students, their parents, and the general public.
- Closer working relationships between the ocean exploration programs (both government and non-government) and zoos and aquaria could help bring ocean exploration to a broader segment of the public.
- While telepresence has proven to be an effective way of engaging the science community and providing access to the public, live expeditions can have greater educational impact with interpretation. The *Nautilus* has built an effective education program by having trained communicators aboard the ship. The Schmidt Ocean Institute's *Falkor* has also used this model.
- Limited berth space might prevent the *Okeanos Explorer* from having on-board educators or communicators, but the ship could partner with a shore-based education institution that could provide the contextual interpretation of the live feeds as they're happening. NOAA could develop this model for interpretation with partners to help expand public engagement in any expedition.
- The Next Generation Science Standards present new opportunities to incorporate ocean exploration themes. Ocean exploration through telepresence can bring authentic discovery right into the classroom.



### **Internal Response to *Ocean Exploration 2020* and *National Forum 2014* Recommendations**

Since *OE 2020*, NOAA established the Ocean Exploration Advisory Board (OEAB), arguably the most important step the agency could take toward coordinating a national ocean exploration program. *National Forum 2014* established the link between ocean exploration and NOAA mission priorities, a critical step toward stabilizing OER within NOAA. Ensuring that OER is identified as part of the agency's environmental intelligence mission is required if NOAA is to serve as a national coordinator.

More specifically, OER has incorporated *OE 2020* and *National Forum 2014* recommendations across its investment areas. Examples—organized by *OE 2020* theme area for convenience—follow.

#### **PRIORITIES**

- Since the summer of 2013, OER has supported one or more expeditions or research projects in twelve of the thirteen priority geographic areas, ocean features, and oceanic processes and phenomena *OE 2020* and *National Forum 2014* participants identified as important. (Only in the Antarctic has OER not supported an expedition recently). OER made substantial efforts to address *OE 2020's* highest geographic priority, the Arctic, and the highest ocean feature priority, the water column.
- The FY 2015 Federal Funding Opportunity focused on the high Arctic to capitalize on data and information collected through Arctic U.S. Extended Continental Shelf (ECS) mapping efforts. Other recent OER-funded Arctic activities include supporting sea trials of the *Nereid Under Ice* vehicle during its first under-ice field expedition; autonomous platform (i.e., sail drone, wave glider, autonomous profiling buoys) tests and operational deployments from the USCGC *Healy*; Arctic microbial work; and a marine archaeology project focused on the lost whaling fleet. OER expects that these activities, particularly its support for testing technologies appropriate for exploration in the Arctic, will set the stage for additional exploration in the region by others.
- In addition to Arctic water column work, OER is partnering with the Smithsonian Museum of Natural History and the National Marine Fisheries Service (NMFS) to conduct routine water column transects during a subset of all remotely operated vehicle (ROV) dives from NOAA Ship *Okeanos Explorer*. In the fall of 2015, NOAA is installing five new EK60 frequencies and an ADCP on *Okeanos Explorer*. These new instruments will greatly expand OER's ability to characterize the water column.

#### **PARTNERSHIPS**

Partnerships have been fundamental to OER's operations—and its successes—since the office was formed in 2001. In addition to maintaining and strengthening our historically effective partnerships with sister federal agencies and academic institutions since *OE 2020*, we are actively pursuing new partnerships internally and externally. Examples include:

- Soon after *OE 2020*, OER completed the latest instalment of its multiyear partnership with the Bureau of Ocean Energy Management (BOEM) and the U. S. Geological Survey. The Department of Interior awarded the Atlantic Deepwater Canyons: Pathways to the Abyss series of expeditions a *Partners in Conservation Award*. The three interagency partners are in the initial planning phase of a follow-on multiyear effort that could begin as early as 2017.

- OER's partnership with the Ocean Exploration Trust continues to help NOAA meet agency and national priorities through E/V *Nautilus* telepresence-based expeditions. After working in the Caribbean and Gulf of Mexico in 2013, 2014, and much of 2015, E/V *Nautilus* is now conducting exploratory work in the eastern Pacific.
- OER has made tremendous strides with internal NOAA partnerships. A recent decision by the Mid-Atlantic Fishery Management Council to recommend protections for many of the deepwater Atlantic Canyons clearly demonstrates the success and value of OER's 'campaign' approach to partnership activities involving multiple vessels including NOAA Ship *Okeanos Explorer*. The office leveraged that success into its latest campaign focused in the Central and Western Pacific monuments and sanctuaries. These internal partnerships also respond to *National Forum 2014* recommendations that ocean exploration expeditions map directly to NOAA mission priorities.
- OER recently initiated two new, but very promising partnerships. A new partnership with NASA focused on advancing telepresence methodologies and technology is beginning to take shape. In September 2015, OER and the Global Foundation for Ocean Exploration formally entered into a multiyear cooperative agreement focused on increasing the capabilities of the *Okeanos Explorer*.

#### PLATFORMS

The *Okeanos Explorer* has been an effective platform for OER to date. But like much of the rest of the exploration and research fleet, she is ageing, and there are no current plans to replace her. OER has invested its limited resources in some improvements in ship instrumentation, but is looking toward the future with other investments:

- OER has made preliminary investments to scope development of a robust flyaway capability to support telepresence-enabled exploration on multiple platforms. New flyaway systems could be an important contribution to a national ocean exploration program and would allow OER and NOAA to maximize the use of the existing research vessel fleet for exploration.
- OER supported the first under-ice deployment of the *Nereid Under Ice* vehicle. The office also invested in several projects that tested new tools and sensors on existing submersibles including *Hercules* and *Deep Discoverer*. The multiyear Marine Biodiversity Observing Network (Marine BON) NOPP award is partially funded by OER. Marine BON is a new observing system that could have important implications for our ability to characterize ocean environments.
- This summer, OER operationalized a voucher sample collection program using the *Deep Discoverer* ROV on *Okeanos Explorer*. Though OER's long-term objective is to focus on collection of digital data and information, a discrete physical sampling capability is a near-term step toward that goal.

#### TECHNOLOGY

Given OER's existing and projected budget, the office will continue to rely on private sector and other partners to lead the development of new technology, consistent with Decadal Review and *OE 2020* recommendations. Advancing the application of new and novel uses of existing technologies, however, is an important consideration across all OER investments and operations.

- Since *OE 2020*, OER has invested in a number of projects that aim to increase the pace, scope and efficiency of exploration. Examples include Boeing AUV demonstrations; *Nereid Under Ice* and other autonomous vehicle deployments in the Arctic; a NOAA Pacific Marine Environmental Laboratory (PMEL) partnership to deploy first full ocean depth hydrophone; and ROV *Deep Discoverer* sampling capabilities and video system advancements.

#### *CITIZEN SCIENCE*

OER has not prioritized robust participation by citizen explorers in *Okeanos Explorer* expeditions or other activities. But OER is investigating the possibility of adding a robust citizen science capability to our education repertoire. The office is developing a pilot video data interpretation and data display project that would engage citizen scientists and meet program needs for data interpretation and attribution. Such a project, if successful, could have broad implications for a national program. OER intends to make a decision about implementation in early 2016.

#### *DATA SHARING*

Even before *OE 2020*, OER's partnership with the NOAA National Environmental Satellite, Data, and Information Service (NESDIS) and active engagement in the federal data management community put the office at the forefront of federal innovation for ocean data management procedures. OER and NESDIS designed data management systems for the *Okeanos Explorer* as a model for ocean exploration data management, meeting needs for both immediate public access and long-term data preservation. The office collaborated with NSF, OET, and others to share elements of NOAA's approach, and to develop community best practices.

- Since *OE 2020*, OER and NESDIS have collaborated on the Video Data Management Modernization Initiative, designed to improve online discovery and access to the scientific data collected on video media. First prototyped in the Amazon Cloud, the current implementation allows users to preview low-resolution video data and to submit online requests to obtain the high resolution data archived in the NOAA Comprehensive Large Array-data Stewardship System (CLASS). The procedures under development within OER to manage the large volumes of data on video media provide a test-bed for video data management needs for all of NOAA as well as a national ocean exploration program.
- OSTP has approved NOAA's plan to respond to the OSTP February 2013 policy memorandum *Increasing Access to the Results of Federally Funded Scientific Research* (PARR). NOAA's policy sets out requirements for intramural and extramural data management and access to both data and publications. The OSTP requirement and NOAA's implementation policy are important steps toward meeting the *OE 2020* recommendations for data. OER is in compliance with the policy and will require grantees to meet PARR and NOAA requirements.

## PUBLIC ENGAGEMENT

OER's website continues to be the primary means for the public to learn about NOAA's ocean exploration activities. But the office's use of social media tools continues to expand, and "traditional" social media outlets like YouTube (OER's channel is the most popular NOAA YouTube account), Facebook, and Twitter continue to grow significantly over time.

- OER experiments with Google Hangouts, Reddit, and the upcoming release of its own app that will allow mobile device users to participate in expeditions are promising as new ways to engage the public. OER education programs remain an important way the office reaches teacher with new ocean exploration material and approaches.
- OER success with social media presents opportunities (and challenges) for consolidating and organizing disparate sources of input to support OER and other expeditions. Models like Zooniverse and OpenExplorer could help guide OER and other ocean exploration institutions toward a common approach to tapping public enthusiasm for ocean exploration and in turn, reinforcing public engagement.