2016 NOAA Emerging Technologies Workshop

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Self Contained Ocean Observing Payload (SCOOP)

Lex LeBlanc (NWS/NDBC)

The National Data Buoy Center (NDBC) is deploying a sophisticated new Self-Contained Ocean Observing Payload (SCOOP) in its operational buoy network as a technology refresh initiative. The legacy payloads are labor intensive to build and difficult to deploy successfully. SCOOP is a smaller, lower cost, more reliable, modular payload that is easier to build, deploy and reduces the life cycle cost of maintaining the buoy array. SCOOP also increases observational capabilities, reduces reporting latency, extends the range of some measurements, and improves the accuracy of others. Details of these enhanced capabilities will be provided in the presentation.

Early successes: NDBC has extensively tested SCOOP including bench testing, shock and vibration testing, and field testing of three prototypes in the Gulf of Mexico over a one-year period. In 2015, NDBC deployed six SCOOP payloads in the Atlantic, Caribbean and Gulf of Mexico near existing moorings. Based on the quality of the SCOOP payload data compared to adjacent mooring, NDBC proceeded to deploy seven SCOOP payloads as operational stations. NDBC expects to replace all legacy weather buoys with SCOOP over the next five years.

Anticipated Impacts: NDBC's current 3m buoy platform's sensor suite and power system is a complex and labor intensive assembly costly to integrated into the buoy hulls and test. The design is hull specific and not modular in nature, must be disassembled to ship to the field, and retested prior to deployment. The platform is difficult to reliably perform at-sea maintenance due to exposure risks of exposure of the electronics and batteries to sea air when the buoy compartments are opened. The fleet of 3M discus and 6M boat-shaped buoys are large and require large vessels with heavy-lift capability per day cost approximate $30K/day. With the shrinking federal budgets and expanding homeland security mission, NDBC allocations USCG ship time are also decreasing. SCOOP Concept was to: Build a new, modular meteorological and oceanographic observing system of lower cost than 3m buoy Easy to assemble in the field Mount to rather than be integrated into a buoy hull Use modern meteorological, oceanographic and directional waves sensor packages Expand measurement capabilities, and decrease latency Add Real-time reporting cameras and AIS Design a subsurface ocean temperature profile capability to measure ocean heat content. Small enough to decrease logistic costs and require less costly vessels to maintain. SCOOP can be installed on a variety of moored and fixed platforms, including a new smaller moored buoy

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U.S. IOOS National Underwater Gliders

Derrick Snowden (NOS/IOOS)

Underwater profiling gliders are a versatile subsurface observing platform that provide broad spatial coverage and the ability to host a variety of sensors to fill various NOAA observing requirements and gaps in a cost effective manner. Gliders can provide sustained monitoring or conduct episodic response to field studies and events. The collection of IOOS partner operators has experience in both types of sampling protocols and has worked together to share data in a uniform way through the IOOS Glider Data Assembly Center (DAC) In typical use gliders profile from the surface to depth (up to 1000m) repeatedly at horizontal speeds of 0.7 to 1 km/h. Deployments of up to 6 months are routine, during which time the gliders survey track can extend well over 2000 km. During a few minutes on the surface, gliders obtain location by GPS and communicate through the Iridium satellite phone system. Sensors on gliders measure such physical variables as pressure, noise (background, ambient, ships, marine mammal calls, etc.), temperature, salinity, current, biological variables relevant to the abundance of phytoplankton and zooplankton, and ecologically important chemical variables such as dissolved oxygen and nitrate. As pH sensors continue to mature, gliders will provide excellent platforms for monitoring ocean acidification. Gliders may be deployed and recovered from a wide range of platforms, including small boats and chartered fishing vessels. And in the past decade their use has steadily increased as the systems have become more versatile and reliable, to the point now that much of the work they do can be called routine.

Early successes: Underwater profiling gliders have been tested for many years now and are being used in routine monitoring, as well as for event response. A recent example of using gliders for coordinated event response was during Deepwater Horizon. IOOS had developed strong partnerships with several federal agencies and it enabled them to respond quickly and efficiently to collect observations during the crisis. IOOS members in the Mid-Atlantic, Gulf Coast, Southern California, and Southeast regions deployed a fleet of seven gliders equipped with sensors to help indicate the presence of oil in the water column. Though scientists still used water sampling to confirm oil presence and source, gliders narrowed the search zone for subsurface oil, and helped answer key questions about potential movement of oil. Gliders also measured additional variables to inform ocean models used by emergency response teams. Glider technology is unique in that it collects data throughout the water column at low cost and at no risk to human life. Deepwater Horizon was the first U.S. oil spill response to apply this technology. More recently gliders have completed numerous types of missions including: ecosystem dynamics monitoring, climate monitoring, speed testing through the Gulf Stream, testing performance of acoustic receivers, listening to tagged fish, fish stock mapping, HAB mapping, ocean acidification mapping, hydrographic mapping, and sustained and targeted ocean observations for improving cyclone intensity and hurricane seasonal forecasts. In 2015, of surveyed regional glider operators, at least 5,546 glider days were completed. A glider day is defined as one glider in the water for one day. Since IOOS has started tracking this metric going back to 2008, over 43,100 glider days have been completed. These days represent gliders operating both within and outside the EEZ and glider missions receiving funds from U.S. IOOS, NOAA, ONR, NSF, EPA, various universities, state agencies and industries.

Anticipated Impacts: As mentioned in the questions 8 and 9, gliders have the capability to fill service gaps, improve coverage and realize efficiencies in meeting subsurface observing requirements. An additional impact beyond the individual glider profile is what the U.S. IOOS program coordination and partnership provide to enhance individual glider capacity. IOOS has an existing cooperative relationship with all of its regional associations distributed around the coastal U.S. as well as well maintained relationships with various other federal agencies collecting observations with gliders. These partnerships enable IOOS to be responsive to short notice events such as Deep Water Horizon and to combine resources and glider platforms to respond to events. IOOS glider capacity has proven it can provide sustained monitoring as well through the work of NOAA's Climate Program Office and the CalCOFI monitoring conducted by SCCOOS operator Dan Rudnick. This glider support to ship transects has enabled sustained monitoring year round and improved coverage from the limitations of ship transects. Additionally, glider data has begun to be assimilated or incorporated in ocean models improving forecast products and model analysis. Lastly, the IOOS Program Office has developed a glider Data Assembly Center (http://gliders.ioos.us/) to provide an overall architecture and capacity for data sharing. The Glider DAC provides glider operators with a simple process for submitting glider data sets to a centralized location, enabling the data to be visualized, analyzed, widely distributed via existing web services and the Global Telecommunications System (GTS) and archived at the National Centers for Environmental Information (NCEI). The next activity planned for the DAC is the implementation of some near real time QA/QC procedures following the guidance of the recently published Manual for Quality Control of Temperature and Salinity Data Observations from Gliders in May 2016.

3G ESP/LRAUV Mobile 'Omics Platform

Kelly Goodwin (OAR/AOML)

Transition Genomic Observatories to Unmanned Maritime Systems Unmanned maritime systems are a critical need to solve dependence on expensive ship-based observing systems. Autonomous technologies provide an opportunity to increase spatio-temporal data coverage while reducing ship costs; however, AUV technology typically does not enable wet sampling, which is required for the majority of biological information utilized to meet NOAA mandates. The Monterey Bay Aquarium Research Institute (MBARI) is developing an instrument to provide adaptive biological sampling via a mobile platform. The 3GESP/LAUV is achieved by engineering a 3rd Generation Environmental Sample Processor (3GESP) to fit into the payload section of a Long Range Autonomous Underwater Vehicle (LRAUV). The ESP is an in-situ molecular biology lab. Sampling occurs in cartridges, each outfitted with the necessary reagents for sample preservation or analysis of genomic information. Each vehicle holds 60 cartridges and can remain at sea for up to several weeks. Sampling is adaptive, triggered by temperature, chlorophyll, or oxygen signals. Such episodic events are the main drivers of ocean productivity in upwelling regimes. The 3GESP/LAUV is a attractive emerging technology, combining AUV sampling with cutting-edge ‘omic research.

Early successes: First flights occurred in July 2015. Success with adaptive sampling, microbial community analysis, and eDNA analysis for fish was achieved. Additional flights occur summer 2016 with delivery of the first set of instruments slated for December 2016.

Anticipated Impacts: Deployment into current observing systems could augment current efforts by providing a cost-effective means to increase spatio-temporal coverage. This technology could provide decreased dependence on expensive ship-based operations used to collect data via Niskin and tow samples. Unlike ship operations, these systems are easily adaptive – sampling is triggered by a set of signals for episodic events. Such events are the main drivers of ocean productivity in upwelling regimes; therefore these systems offer both financial and scientific advantages.

Unmanned Systems for Hydrographic Surveys

Rob Downs (NOS/OCS)

Since 2004, NOAA’s Office of Coast Survey has been evaluating unmanned systems in support of its navigational safety and nautical charting seafloor mapping requirements. Over that time, Coast Survey has collaborated with organizations within and outside NOAA, had significant operational experience with a variety of unmanned systems in a wide range of environments, transitioned small Autonomous Underwater Vehicles (AUVs) into operation, and learned valuable lessons concerning the benefits, limitations, and risks associated with owning and operating unmanned systems. The systems transitioned or evaluated include: Small AUVs which can be rapidly deployed to detect underwater hazards to navigation following severe weather or marine incidents. Large AUVs equipped with multibeam bathymetric data which can provide high resolution seafloor mapping data in depths greater than possible with shipboard systems. Unmanned Surface Vehicles (USV) that complement or possible extend the capabilities and effectiveness of NOAA's hydrographic survey fleet.

Early successes: Coast Survey has operated small AUVs in partnership with organizations within and outside NOAA in support of a wide variety of seafloor mapping requirements, including remediation of unexploded ordnance, detection of illegal fishing traps within Marine Sanctuaries, evaluation of legacy environmental threats, post-hurricane port surveys, and sea turtle assessment. Coast Survey has tested the capabilities of large AUVs aboard a hydrographic survey vessel (NOAA Ship Ferdinand R. Hassler) and has documented shipboard and manpower requirements, determined the most effective concept of operations, and evaluated expected efficiency gains provided by the AUV.

Anticipated Impacts: Small AUVs have increased the capabilities, flexibility, and responsiveness of Coast Survey to post-storm port surveys, navigation safety surveys, and special projects. The small systems can be quickly deployed to the survey area and operated by a small team (2-3) people from a wide range of platforms, including shore, small boat, or ship. Large AUVs with multibeam bathymetric sonars are not well suited to coastal seafloor mapping required for Coast Survey's nautical charting requirements, but can provide great benefit to NOAA resource managers by providing high-resolution seafloor mapping data in water depths greater than possible with shipboard sonars. Unmanned Surface Vehicles (USVs) can extend NOAA's seafloor mapping capabilities in very shallow water where it is either unsafe or ineffective to survey with manned resources. Additionally, larger USVs have an operational endurance that greatly exceeds small USVs or any unmanned underwater system, which gives them the potential to improve the survey efficiency of NOAA's hydrographic survey fleet.

DART-4G: Near and far field tsunami monitoring and reporting

Chris Meinig (OAR/PMEL)

The Deep-ocean Assessment and Reporting of Tsunamis (DART) 4G (4th generation) detection and measurement system represents a significant advancement in the measurement of tsunami waves in the deep ocean. Long recognized as the worldwide standard in the deep-ocean measurement of tsunami waves, this new generation of the DART technology addresses near-field tsunami detection, component obsolescence and offers improved system robustness and reliability, reduced fail points, reduced maintenance cycles and costs, and ease of deployment over the now operationally deployed predecessor DART II systems. Consistent with predecessor systems, the DART-4G provides two-way communication between the point of measurement at the Bottom Pressure Recorder (BPR) anchored on the seafloor and land stations. The BPR and surface buoy can be combined into one compact package that is both easy to deploy and cost effective. Successful deployment of the DART-4G is easily accomplished using small vessels, minimally trained staff, and less than 30 seconds on station or the units can be separated and deployed in the traditional manner using existing DART infrastructure.
The DART-4G incorporates a higher sampling rate version of the measurement technology used in the DART II and also has updated software and mathematical algorithms to take advantage of the higher sampling rate. Specifically, a new pressure transducer capable of Hz and sub-Hz sampling provides new detection capabilities that reduce the time between tsunami generation and detection so that nearby

coastal populations could receive warning faster than ever before, possibly as an earthquake is still rupturing. The overall result is lower latency and higher resolution data.

Early successes: On September 7 and 8, 2013, two DART-4G systems were deployed approximately 120 miles offshore Newport, Oregon. On 9 March 2014, one of these DART-4G systems detected a Magnitude 6.7 earthquake that occurred off the coast of California. Evaluation of the tsunami wave measurements from this system showed that the DART-4G technology filtered out local earthquake signals as designed. Although no tsunami was produced this event did not provide a test for removing separating an earthquake signal from that of a tsunami, both deployed systems passed engineering functionality tests. At the time of evaluation, data return rates for each system exceeded 95%. Two additional DART-4G prototype systems were deployed in partnership with SHOA just off of the Chilean coastline in Fall 2015 for further testing and for comparison with DART II systems that occupy more conventional offshore deployment sites. The two DART-4G systems were in operation at 01:54 UTC when the Magnitude 6.9 Illapel, Chile earthquake occurred on 11 November 2015 at 29.43°S latitude, 72.10°W longitude. The relatively small earthquake generated a tsunami that was captured by local tide gauges, the DART II, and the DART-4G systems. Consistent with performance during the September 2013 events, the DART-4G technology filtered out the signature earthquake signal as designed. Both DART-4G systems were automatically triggered into rapid report mode by the earthquake and both cycled through the expected tsunami report mode, reporting 15-second data until normal report mode resumed. Although no tsunami waves were evident, the filter again appeared to function as designed. Comparison of pre-run tsunami models with DART-4G data at all locations offshore Chile provided additional confidence that the DART-4G systems had performed as designed. In addition to the DART-4G systems deployed offshore Oregon and central Chile for testing, the technology is being transferred to commercial partner SAIC through an existing SAIC/PMEL licensing agreement and is also under evaluation by the National Weather Service (National Data Buoy Center) for refresh of the DART II operational array technology.

Anticipated Impacts: DART-4G technology is anticipated to have a significant impact on tsunami detection and forecasting. Currently, siting of the DART II operational system is governed by the need to separate in distance the source of a tsunami (earthquake epicenter) from the point at which measurements of the waves are made. This is because the DART II sampling scheme is insufficient to separate the tsunami waveform from that of the generating earthquake when superimposed on one another. With a major advance in pressure transducer technology, the distance limitation imposed on DART placement in the oceans since the earliest development by PMEL in the mid 1990's has been eliminated. Incorporation of these new advanced pressure sensors, capable of Hz and sub Hz sampling, into the DART-4G coupled with updated software and power management, detect and precisely measures tsunamis more accurately than ever before. The greatly increased number of measurements now allows for earthquake signals to be separated from tsunami waveforms so that the DART-4G can be sited closer to an earthquake epicenter than any predecessor DART at reduced cost and improved reliability. Closer proximity to an earthquake epicenter offers populations nearby a tsunami source, the potential of receiving early warning and forecasts, now typically afforded those only far afield. Modeling scenarios using a network of DART-4G systems along the Cascadia subduction zone show that nearby coastal populations could receive warning faster than ever before, possibly as an earthquake is still rupturing.

Saildrone

Jessica Cross (OAR/CPO)

The Saildrone is a solar and wind powered ocean unmanned surface vessel (USV) developed by Saildrone, Inc. in partnership with the NOAA Pacific Marine Environmental Laboratory (PMEL). This platform is approximately twice as fast as similar USVs, carries a large payload capacity (~200 lbs), and is equipped with four high-throughput solar panels. The speed, size, and power capacity of the Saildrones extend the operational potential of USVs to cover large areas, safely access remote regions, and operate over long periods of time. Endurance USV deployments are a critical new NOAA mission capability. Saildrones can be launched and recovered dockside and are remotely controlled from shore, requiring no ship time and limited advance scheduling. This enables adaptive deployments that can adjust to seasonal conditions and target anomalies as they arise. Data are also transmitted in real time through a user-friendly interface, enabling researchers to responsively target important features as they are observed or as scientific priorities evolve. This dramatically reduces operational risk and enhances the efficiency of environmental intelligence gathering. The adaptability of the Saildrone platform is a game-changing benefit for cross-Line Office and multidisciplinary collaboration. Onboard sensor suites can be adjusted to meet mission-specific needs across a broad range of applications, and given the size and power capacity of the Saildrone, multiple USV missions can now be combined. For example, physical oceanographic and meteorological sensors used by OAR researchers to assess climate and environmental conditions were deployed alongside specially developed echosounders used by NMFS for fish stock assessments, and modified acoustic hydrophones used by NMML to characterize whale populations. Combining these missions provides a much more comprehensive, cost effective, and collaborative approach to sustainable fisheries management and climate adaptation.

Early successes: The Saildrone-PMEL partnership started in 2014 with a CRADA to develop USV technology for high quality ocean and atmosphere sampling. PMEL provided engineering expertise on sensors and sampling schemes and Saildrone provided USV hardware and software expertise. The inaugural NOAA science field mission for the Saildrone was conducted in summer of 2015 with the Innovative Technology for Arctic Exploration (ITAE) testbed program. This highly successful deployment used two Saildrones to demonstrate platform endurance in challenging conditions. Over 97 days, each Saildrone traveled more than 7600 km. Despite notoriously cloudy conditions in the Bering Sea, solar-generated battery power never fell below 60%. The vehicles averaged a speed of ~2 kts, but reached peak speeds up to 7 kts in ideal wind conditions. The Saildrones weathered several intense storms without capsizing or major malfunction, including strong winds up to 46 kts. The Saildrones also filled an operational gap by successfully navigating the shallows near the Yukon River Delta, an area hazardous or inaccessible to ship-based operations. The Saildrone also aptly navigated high maritime traffic conditions in the Gulf of Mexico during a second field mission by PMEL and the University of Mississippi, where one vehicle completed 8,840 km in 115 days. The scientific goal of these missions was to assess the performance of a basic sensor suite for physical and meteorological parameters. The Saildrone data exceeded critical accuracy and precision benchmarks. Biofouling was held well below the necessary minimum. High data quality was achieved at multiple scales and in high variability areas. The Saildrone successfully mapped oceanographic fronts (large / synoptic scale), ice melt and river plumes (moderate / mesoscale), and phytoplankton bloom patches (fine / microscale). The platform easily transitioned between these priorities, demonstrating value across a broad spectrum of potential scientific uses.

Anticipated Impacts: Given the proven endurance, navigability, and basic measurement capabilities of the Saildrone, plans to fill service gaps, improve operational efficiency, and reduce operational risk are well underway. During 2016, OAR researchers at PMEL and Saildrone, Inc. have partnered with NMFS and NMML to utilize the Saildrone as a joint reconnaissance tool for fisheries and ecological population surveys. Using the Saildrone to track populations of pollock, fur seals, and critically endangered whales will direct shipboard surveys to key areas to improve survey efficiency and enhance accuracy and coverage of stock assessments. This will aid sustainable fisheries management and conservation efforts in an area already undergoing significant environmental change. The Saildrone platform can also enhance collection of environmental intelligence when networked with other targeted tools. During 2016, the Saildrones will follow positions provided by satellite GPS tags on the declining population of Northern Fur Seals to provide an oceanographic and acoustic assessment of fur seal prey quality. During 2017, the Saildrones will work with ship-based operations and sub-surface autonomous technologies to map the impacts of sea ice melt on physics, chemistry, and ecosystem in the Pacific Arctic. Lastly, the Saildrones can be used to expand and modernize sustained observing and environmental monitoring, such as the Tropical Pacific Observing System. During 2017 and 2018, the sensing suite on the Saildrone will be expanded to include high precision CO2 flux measurements via a modified PMEL MAPCO2 system and physical capabilities (radiative heat fluxes, air-sea buoyancy flux, wind stress, and upper ocean current profiles) to make the Saildrone the ideal and economical platform of choice for the study of air-sea interaction processes. By networking with the TAO buoy array, these enhancements will critically improve and expand climate monitoring and long-term weather forecasting.

Imaging FlowCytoBot (IFCB)

Marc Suddleson (NOS/NCCOS)

Woods Hole Oceanographic Institute (WHOI) invented and developed the Imaging FlowCytobot (IFCB). McLane Research Laboratories, Inc. is licensed by WHOI to manufacture, sell and service the IFCB instruments, components, and related items. Several federal agencies (NOAA, NASA, NSF), academic laboratories, and private companies have invested in IFCB Technology to date. NOAA Ocean Service (NCCOS and IOOS), OAR (Sea Grant) are supporting IFCB development, demonstration and deployment in the United States coastal regions. 5. Ownership will likely remain distributed across federal and NGO partners, and potentially extend to IOOS regional associations. The Imaging FlowCytobot (IFCB) is an in-situ automated submersible imaging flow cytometer that generates images of particles in-flow taken from the aquatic environment. Developed by Woods Hole Oceanographic Institute (WHOI), the IFCB uses a combination of flow cytometric and video technology to capture high resolution (1 µm) images of suspended particles, and machine learning technology to identify potentially toxic species from the images. Laser- induced fluorescence and light scattering from individual particles are measured and used to trigger targeted image acquisition; the optical and image data are then transmitted to shore in real time. IFCB generates high resolution (~3.4 pixels/micron) images of suspended particles in the size range <10 to 150 µm (such as diatoms and dinoflagellates). The instrument continuously samples at a rate of 15ml of seawater per hour. Depending on the target population, the IFCB can generate on the order of 30,000 high resolution images per hour. Collected images during continuous monitoring can be processed externally with automated image classification software. Images can be classified to the genus or even species level with demonstrated accuracy comparable to that of human experts. The IFCB is a proven, now commercially available, technology for Harmful Algal Bloom (HAB) detection. Its design incorporates antifouling procedures and periodic standard analysis to monitor instrument performance so that unattended deployments of 6-month duration are routine (Olson and Sosik 2007; Sosik et al. 2010). Time series observations with IFCB have provided important insights into outstanding questions in plankton ecology, ranging from the characterization of novel species to processes regulating bloom dynamics. For example, recent use of an IFCB has shown that the phytoplankton community structure changes rapidly, often by the hour, after the passage of tropical cyclones (Anglès et. al. 2015, doi:10.1002/lno.10117). The technology has also proven effective for applied and basic problems in HAB research.

Early successes: Since 2003, the IFCB has been measuring and counting the smallest phytoplankton (cells <10 micrometers), recording optical signals from individual cells as they pass through a focused laser beam, at the Martha's Vineyard Coastal Observatory(MVCO). A live time-series stream of millions of images from an IFCB deployed in-situ at the Martha's Vineyard Coastal Observatory from 2006 to present can be seen at the IFCB Dashboard (http://ifcb-data.whoi.edu/mvco/). NCCOS and partners have supported the long term continuous plankton imaging by an IFCB deployed at Port Aransas, TX has provided 6 early warnings of HAB events at this site and shipboard IFCB analyses have provided information about the origins of blooms in this region. The information provided by the IFCB have proven to be extremely valuable, both as a research tool and in providing early warning for Texas Parks and Wildlife Department and Texas Department of State Health Services personnel (Campbell et al. 2013, doi 10.1007/s11356-012-1437-4). A new NCCOS Prevention Control and Mitigation of HABs (PCMHAB) project is expanding access to IFCBs with another two instruments being deployed along the Texas coast. It is also guiding future production of more robust instruments for fixed deployments, and improving automated image classification of HAB taxa. The project also supports the development of a vision for a network of IFCBs in the Gulf of Mexico. Expansion of the IFCB concept is also being supported by the Integrated Ocean Observing System's (IOOS) Ocean Technology Transition (OTT) Project. Two IFCBs are planned to be integrated into a San Francisco water quality monitoring program starting in 2016. One of the IFCBs will be integrated into the existing R/V Polaris cruises. This IFCB currently being tested in the lab with samples from both the Santa Cruz Wharf and Pinto Lake, including comparing preserved samples (Lugol's preservative) using the IFCB and either Sedgewick-Rafter or Utermohl microscopy. Statistically there is no difference in counts of Pseudo-nitzschia using the IFCB versus microscopy. The second IFCB will be integrated into the mooring program at Dumbarton Bridge and South Bay. The Woods Hole Oceanographic Institution (WHOI), with support from IOOS' OTT Project, is expanding the IFCB's potential operational use by adapting it for deployment it on autonomous vehicles in the Gulf of Maine (2016) and in the Gulf of Mexico (2017). Initially conceived as an instrument that would be deployed at fixed locations, the IFCB-AV project has been designed so that the strengths of the current IFCB design are best translated to a mobile deployment platform. Using autonomous vehicles will enable high resolution plankton studies with both long duration and spatial coverage. The project also leverages an extensive effort to transition the suite of IFCB image analysis tools to a web services design, minimizing the investment necessary for new users to take advantage of these.

Anticipated Impacts: The IFCB is the premier, commercially available in-situ phytoplankton imaging instrument and is uniquely capable of generating near real-time biological and community data on a wide range of target species. The capacity to remotely measure presence and abundance of various organisms has numerous applications of relevance to NOAA's mission. In the context of harmful algal blooms, for which NOAA serves as the lead Federal agency under the Harmful Algal Bloom and Hypoxia Research and Control Act legislation, timely observations and measurements of harmful algae are important not only to improve operational and transition forecasts (e.g., data assimilated into models for 'on-the-fly' course correction), but have considerable intrinsic value in filling critical gaps related to early warning of toxic bloom events, helping to identify potential drivers of HAB growth and validating airborne/satellite observations and models. Deployment of sensors like the IFCB fills a critical need identified within HAB forecasting implementation plans being formulating under the auspices of the NOAA Ecological Forecasting Roadmap. A broad spectrum of user groups place a high value on access to the type of actionable information provided by the IFCB, either via direct use of these data to guide rapid decision making and resource allocation for seafood monitoring, safeguarding public health (e.g., drinking water treatment), and regulating recreational activities or through enhanced resolution and accuracy of forecasts made possible by ingestion and assimilation of near real-time, in-situ data streams.

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