U.S. UNDERWATER GLIDER WORKSHOP REPORT

January 18-19, 2017

INFINITY Science Center, MS

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APPENDICES (ONLINE):

The U.S. Underwater Glider Workshop was publicly announced on the Interagency Ocean Observation Committee's website (www.iooc.us). This public workshop proceeded according to the meeting agenda. A summary of the meeting follows.

OVERVIEW

Autonomous underwater gliders provide an advanced and cost-effective mechanism for collecting essential oceanographic data at spatial and temporal scales that help the United States achieve critical research and operational objectives. In 1989, Henry Stommel and Doug Webb proposed the first Slocum Glider with a buoyancy engine powered by a heat exchanger, which has led to the development of new underwater glider vehicles (e.g. SeaExplorer, Seaglider, Slocum, Spray) and sophisticated data software products. The broad technical and geographic expansion of underwater gliders presents a unique opportunity for greater coordination among the ocean observing community for organizing decision-makers, glider operators, and data users to enhance science, marine services, and maximize societal benefits.

Presented with this opportunity, the Interagency Ocean Observing Committee (IOOC), whose mission is to enhance the efficiency of and motivation for ocean observing networks, commissioned a Glider Task Team comprised of regional and national glider experts and federal resource managers. The Glider Task Team first conducted a survey of the glider community to obtain more information about observing data gaps that could be met with gliders, priority areas for science coordination, and resource sharing opportunities for the glider community. Survey results from 17 agencies and science organizations indicated a need for community-wide scientific collaboration and a desire for resource and information sharing. The opinions of those surveyed reflects the importance of gliders to meet scientific requirements and suggests that most missions are research-based. The survey also indicated that the lack of capacity to respond to events and constrained funding are among the limitations identified by some members of the glider community. To overcome these challenges:

- 92 percent of surveyed agencies and institutions are open to facilitating joint glider missions, including data sharing, deployment/recovery resources, and platform sharing
- 86 percent of the survey takers would use a community forum.

Following the survey, the Task Team convened a U.S. Underwater Glider Workshop attended by 90 national and international glider experts from government agencies, universities, nonprofits, and industry. The workshop provided a platform for:

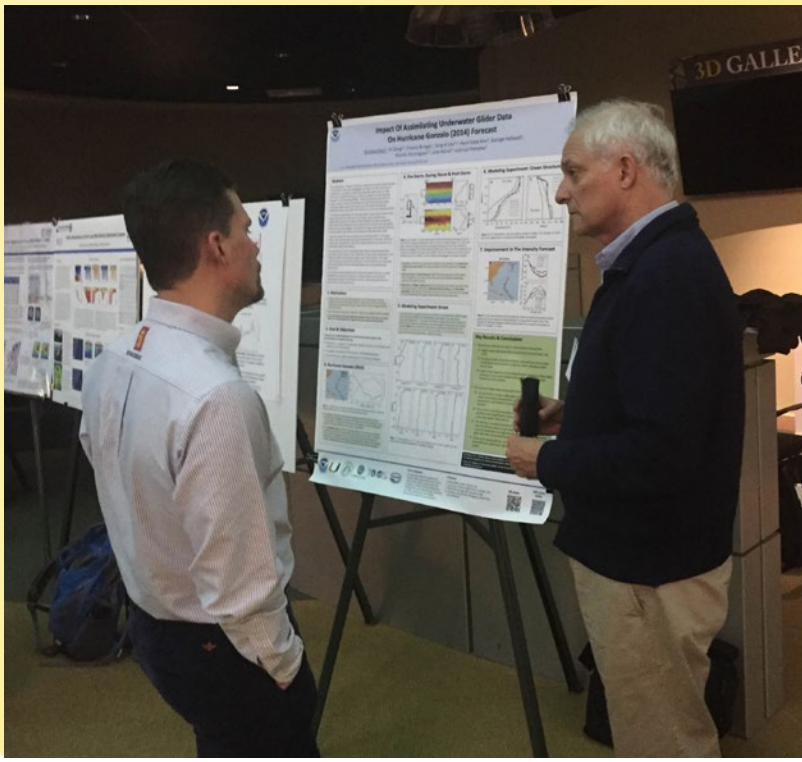
- Exchanging information on advances in glider capabilities, operations, and data processing;
- Exploring how gliders enable new scientific breakthroughs;
- Identifying gaps and coordination opportunities for planning, operations, and resources;
- Assessing best practices for observations, operations, and data management; and
- Designing the scope and aims for a coordination mechanism.

Attendees participated in a high-level plenary by federal agencies, scientific poster presentations, and guided discussion in breakout sessions on Sustained and Event Ocean Monitoring, Harmonizing Glider Efforts, and Developing a Glider User Group. The workshop resulted in diverse ideas broadly presented as:

- Initiate a US Underwater Glider User Group;
- Increase glider data assembly center robustness;
- Explore and encourage asset and platform sharing;
- Improve data and information services; and
- Engage international underwater glider groups.

GLIDERS FOR OCEAN MONITORING

The workshop divided ocean monitoring gliders into two categories: (i) event monitoring, used to target or to respond to specific events and (ii) sustained monitoring, used to establish baseline conditions and to identify trends.



EVENT MONITORING

Operational and scientific glider missions targeting specific features or events covered a wide range of scientific and geographic areas. Example features or events span various disciplines: physical (fronts and plumes, storms, deep water formation, meso- to submesoscale variability, internal waves, the marginal sea ice zone), biological (marine mammal and fish tracking, harmful algal blooms (HAB) and phytoplankton blooms), chemical (eutrophication, hypoxia, acidification), geological (sediment plumes, hydrocarbon seeps). Some events are specifically related to human activity (oil spills, marine pollutants, search and rescue, geopolitical). Event monitoring may begin with low-level detection, progress to more frequent environmental assessments with extensive sensor suites during the event, and continue after its conclusion for persistent impact assessment.

Many workshop delegates identified methods to enhance coordination, addressing science, technical, and data gaps. More effective use of existing glider assets can be improved through:

- Shared data from existing missions via national networks i.e. Integrated Ocean Observing System Glider Data Assembly Center (IOOS Glider DAC);
- Coordinated water space management of glider deployments, flights, recoveries and rescues by multiple groups;
- Shared use of spare glider inventory and sensors, mission planning and analysis software, and technical and regional expertise;
- Dedicated training through glider schools; and
- Enhanced federal and state government coordination and funding with academic, government, and industry glider operators.

Existing gaps in glider capabilities could be improved through:

- Longer duration glider deployments in an even broader range of operating environments
- Development of new low-powered, autonomous sensors;
- Development of rapid all-weather deployment capabilities;
- Development of on-board decision making and improved onshore path planning to reduce human piloting involvement;
- Simplification of glider repairs, refurbishment, and sensor calibrations; and
- Improvement of shared data through standardization, improved quality assurance and control procedures, and assimilation of a wider range of variables into models.

SUSTAINED MONITORING

Sustained glider monitoring missions have been used to collect regional data, to couple with or replace other observational platforms, and provide information to ocean circulation and biogeochemical models. Gliders are most effective at spatial and temporal scales associated with regional processes, which may include the physical circulation of the ocean's boundary currents, marine mammal monitoring and fisheries stock assessment, and ecosystem health (hypoxia, HABs). Many regions already implement sustained glider monitoring in select regions throughout the U.S. and Canada. Sustained glider missions in remote areas are logistically challenging, however implementation is happening at the Ocean Observatories Initiative (OOI) remote Global sites.

In general, workshop delegates provided technical information suggesting that effective sustained monitoring depends on increased collaboration between glider operators and continuous funding pathways. A synopsis of the specific collaboration opportunities includes:

- Facilitation of public/private partnerships;
- Formation of instrument/sensor pools or glider centers with partnering agreements;
- Operator collaboration and resource sharing (glider preparation, deployments, piloting, recoveries);
- Implementation of a user forum to share experiences; and
- Facilitation of data flow through data handling guidelines, data quality assurance and control, and shared pathways to modelers and other customers for the same data.

There are many regions that would benefit from the expansion of sustained glider monitoring (e.g. Gulf of Mexico, high latitudes, multiple Exclusive Economic Zones of the Caribbean/Pacific Islands) with the appreciation of resource limitations and the utility of gliders in certain environments. To address future monitoring activities, some workshop delegates suggested:

- Prioritizing any glider network expansions (in consultation with University-National Oceanographic Laboratory System (UNOLS), National Oceanic and Atmospheric Administration (NOAA), US Integrated Ocean Observing System (IOOS), and academic fleets);
- Determining how to maintain the critical mass of personnel required for sustained operations in more locations; and
- Identifying the best practices for coupling sustained monitoring with event response capabilities.

Cost savings could significantly improve sustained monitoring activities; this could benefit from extending glider deployment durations through energy source enhancement, improving deployment and recovery techniques, minimizing glider loss or the financial implications through insurance, and standardizing additional and/or new sensor integration.

HARMONIZING GLIDER EFFORTS

OPERATIONAL RELIABILITY

The key to glider mission success is often less about the hardware and more about the human interfacing with the hardware. Although some mistakes or errors always happen, many of them are likely preventable. Several key actions for glider operators were suggested that will minimize such errors and improve success:

- A dedicated glider team to develop required expertise and skill sets in operating and piloting gliders- this is not something people can 'jump in and jump out' of. If interns or students are used, clear mentoring and supervision needs to occur.
- A tiered-approach to piloting, used in larger glider operations, where a less-experienced pilot has an experienced pilot to call for assistance and/or advice.
- Knowledgeable glider teams that understand the waters of the area they are flying in. Issues such as currents and shipping lanes may be more obvious than fresh water plumes from rivers, fishing 'hot spots' attracting numerous vessels, and shallow bathymetry, to name a few (see complete list in addendum).

Workshop delegates presented many ideas and opportunities to improve operational reliability. These included:

- Encouraging deployment teams to avoid mistakes by not rushing glider deployments.
- Establishing talent and resource pools, i.e., documenting contacts and local expertise that can be made available when a group is flying in a new area.
- Improving communications with glider producers to provide feedback for strengthening reliability and development of products.

The greatest challenge to achieving these opportunities is a sustained funding source to allow for dedicated personnel and routine missions. Better communication within the glider community, specifically more effective ways to share knowledge, will improve operational reliability. Near-term steps over the next one to three years should include formalizing testing procedures and creating working groups.

DATA MANAGEMENT

Many opportunities were cited regarding glider data management with the need for shared formatting and data integration common themes (see Appendices). Near-term priorities should include standardization across glider operators and a glider data management working group. It was suggested that a glider data management group initially convene in 2017.

INTERAGENCY COLLABORATION

Workshop discussions focused on opportunities to better message the value of collaboration to federal agencies and to encourage them to share mission requirements for gliders. Challenges primarily focused on how to improve communication. Suggestions for moving interagency collaboration forward started with the formation of a Glider User Group. Existing interagency agreements should be reviewed and revised as needed.

INTERNATIONAL COLLABORATION

Sharing best practices will yield significant benefits to international glider operators and users. Moreover, establishing a common set of standards to exchange data would be beneficial to all. There are a number of areas where international planning and coordination of glider missions and linked research would rapidly advance knowledge and glider capabilities. The specific discussion topics should be widely distributed to the international glider community and communicated through the U.S. participants engaged with groups such as OceanGliders, posted on relevant webpages, and included in Glider User Group resources. Several other action items (see appendix) address access to foreign exclusive economic zones (EEZs), and review of existing IOOS and NOAA international agreements to incorporate gliders and glider operations.

UNDERWATER GLIDER USER GROUP (UG)^2

The overarching goal of an Underwater Glider User Group is to establish a community that facilitates sharing and cooperation in the following areas:

- Share experiences related to glider and sensor technology;
- Communicate the most recent scientific and operational accomplishments;
- Share approaches to logistical and operational challenges;
- Compare approaches to handling data collected by gliders, including quality control, formats, and distribution; and
- Disseminate news about opportunities and needs for gliders.

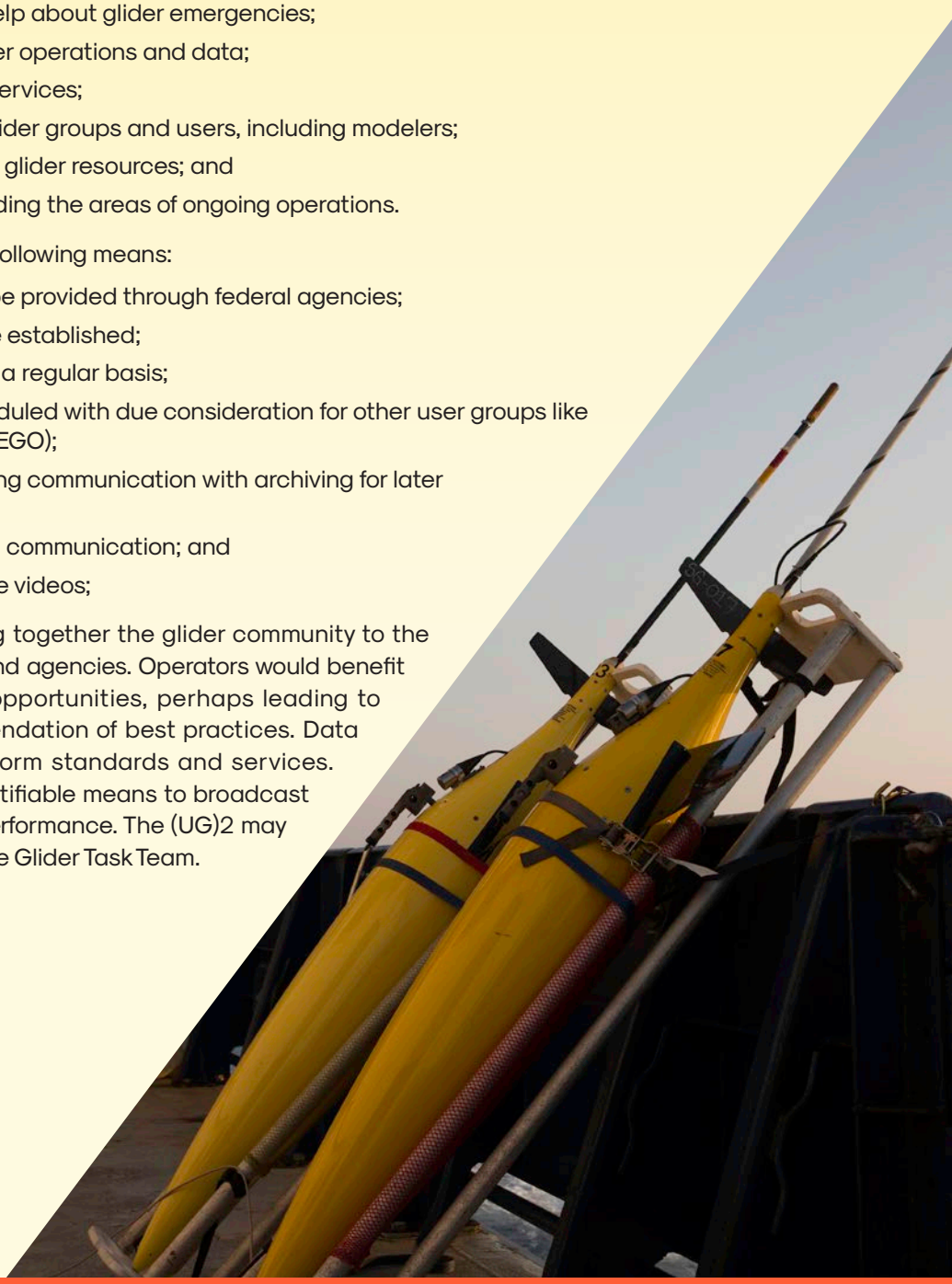
In the context of the mission areas above, (UG)2 might sponsor the following activities:

- Establish a forum for question and answers about gliders;
- Create a "hotline" to contact for help about glider emergencies;
- Host a software exchange for glider operations and data;
- Be a nexus for standards in data services;
- Foster communication between glider groups and users, including modelers;
- Set up a mechanism for sharing of glider resources; and
- Create a site for glider news, including the areas of ongoing operations.

The (UG)^2 would function through the following means:

- Sponsorship and funding should be provided through federal agencies;
- A national steering team would be established;
- Virtual meetings would be held on a regular basis;
- In person meetings could be scheduled with due consideration for other user groups like Everyone's Gliding Observatories (EGO);
- An online forum would allow ongoing communication with archiving for later reference;
- An email list would facilitate broad communication; and
- Training and tutorials could include videos;

If fully successful, (UG)^2 would bring together the glider community to the benefit of operators, data users, and agencies. Operators would benefit from sharing experiences and opportunities, perhaps leading to the development and recommendation of best practices. Data users would realize more uniform standards and services. Agencies would have an identifiable means to broadcast opportunities and assess performance. The (UG)2 may prove to be the legacy of the Glider Task Team.



WORKSHOP OUTCOMES

Many workshop delegates expressed a strong interest in finding opportunities for collaboration and coordination of resources to enable glider missions and subsurface data collection. Discussions also showed broad agreement for connecting the glider community between managers, operators, and data users. The following overarching suggestions below represent a framework for how to meet these goals and begin tackling specific challenges identified by the glider community.

INITIATE THE UNDERWATER GLIDER USER GROUP (UG)2

Initiating the Underwater Glider User Group (UG)2 is the top priority to provide the centralized platform needed to springboard many of the recommended actions. A steering team comprised of national representatives will drive the agenda and activities for (UG)2, maintaining international connections.

IMPROVE DATA AND INFORMATION SERVICES

Improved glider data management results in optimized utility for ocean stakeholders. Sending open glider data through the IOOS Glider Data Assembly Center (DAC) is a method to build on an established platform integrating glider data in the same formats and making the data accessible to all users. There is also a need for a glider data management working group to drive standardization across glider programs and address other data issues, which could serve as a sub-group of (UG)2 and boost Glider DAC activities. These efforts will likely require staff support and additional logistics to facilitate glider data standard development.

EXPLORE AND ENCOURAGE ASSET AND PLATFORM SHARING

Many workshop attendees are eager to leverage resources to expand the reach of the gliders and the data collected. Platform sharing business models, such as the University-National Oceanographic Laboratory System (UNOLS) fleet, Uber/Lyft ride-sharing services, or even a rental car organization, are the types of innovative mechanisms needed to get gliders that are on shelves into the water collecting valuable subsurface data. All of these models would require significant discussions and agreements to ensure fairness and safety to all parties. At a minimum, a forum could be established for operators to share plans and needs. Those with resources could post planned missions to which they are willing to add sensors, while those seeking glider support in the form of deployment and recovery, piloting, and maintenance could solicit help in a shared space.

ENGAGE INTERNATIONAL UNDERWATER GLIDER COMMUNITIES

Many of the international participants in the workshop were interested in working with U.S. operators and data users to expand their glider capacity and networks. Conversely, U.S. glider program managers are eager to learn from established glider operations abroad. The glider community should expand coordination on international forums such as Everyone's Glider Observatories (EGO), Integrated Marine Observing System (IMOS), Ocean Networks Canada, Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) International Steering Team, and potentially others. Beyond strategic planning and information sharing, the U.S. community can seek out specific opportunities to collaborate directly with international glider operators and on shared interest projects.