



IOOS
Integrated Ocean
Observing System

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2026 IOOS MODELING COMMUNITY OF PRACTICE WORKSHOP REPORT

September
2026

[Workshop Webpage](#)

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Executive Summary

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The 2026 IOOS Modeling Community of Practice Workshop convened the coastal and ocean modeling community to assess current capabilities, strengthen partnerships, and identify practical pathways to advance modeling capabilities. Across three days, participants enthusiastically discussed current activities, challenges, and actionable next steps in the following areas: operational model modernization, Research-to-Operations-to-Research (R2O2R) pathways, stakeholder engagement, cloud and data infrastructure, integrated modeling, artificial intelligence and machine learning (AI/ML), data assimilation, and workforce development.

A consistent message emerged: progress depends on treating the modeling enterprise as a connected community rather than a set of isolated programs. Partners across NOAA/NOS, IOOS Regional Associations (RAs), academia, industry, other federal and local government agencies, and non-profits must work closely to share knowledge and lessons learned, and work together towards shared goals. Model developers, IT professionals, engagement specialists, and end users each bring distinct expertise that must be incorporated into the entire modeling value chain in order to create accurate, timely, accessible, and useful model products and tools. The strongest pathways combine these roles through sustained collaboration, shared infrastructure, transparent planning and communication, and continuous feedback between all stakeholders.

The workshop outcomes include:

- 1 [Ten community priorities](#) to guide community activities
- 2 A [terms & definitions document](#) to inform effective communication and information sharing
- 3 A [proposed Community of Practice structure](#) organized around cross-cutting strategic planning, community engagement and capacity building, operational transitions and infrastructure, and data management and emerging technologies

Executive Summary

Overarching Takeaways

The community emphasized that coordinated processes, common standards, interoperable infrastructure, and clear roles are more important than convergence on a single modeling framework, allowing fit-for-purpose regional and national capabilities to evolve together.

- Users and applications should drive operational definitions and modeling priorities, evaluation metrics, and product design.
- R2O2R is a continual process. Operational deployment is not the end of research and development, and regular update cycles and operations-to-research feedback are essential to incorporate user feedback to routinely reshape the research and operational products.
- Regional and national modeling efforts are complementary. RAs provide local expertise, trusted stakeholder relationships, and pathways for user-driven regional modeling, innovation, and service delivery, while NOS provides sustained operational modeling capabilities and national coordination.
- Operational requirements should be fit-for-purpose, depending on the operational home for the system (at RAs, NOS, etc.). Regional applications may not need to meet the same requirements as federal operational systems (i.e providing forecasts 24/7), as defined in the [Terms & Definitions document](#), and instead should reflect the application's specific needs and user requirements.
- Cloud computing, shared development environments, open software practices, and standardized workflows can reduce duplication, lower barriers, and promote and facilitate collaboration, but sustained technical support and stable access remain necessary.
- Physics-based models provide mechanistic understanding and prediction, while observations and data assimilation can constrain model states and improve forecasts. AI/ML can complement these forecasts, expand ensembles, improve access, and support hybrid systems, but requires rigorous validation, FAIR data, and sustained ownership. The community should work together to adapt emerging technologies in a coordinated manner.
- Workforce and funding challenges greatly affect the community's capabilities. Recruitment, retention, mentoring, training, competitive career pathways, and funding for long-term maintenance and operational systems are essential. Coordination between NOAA and the community, through RAs and Cooperative Institutes (CIs), is necessary to build sustained workforce development and funding mechanisms for the modeling community.
- Making ocean modeling and its benefits more visible, engaging, and accessible through creative outreach, social media, and professional storytelling will build investment, advocacy, and interest among students and the broader community, strengthening the future workforce.

Workshop Overview

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Purpose and intended outcomes

The workshop built on the 2021 Community Modeling Workshop, the July 2026 pre-workshop webinar, and broader NOAA discussions on unified forecasting capabilities, including the Unifying Innovations in Forecasting Capabilities Workshop (UFCW). Its purpose was to showcase community advancements, identify shared challenges, align community and NOAA priorities, and define actionable next steps for the IOOS Modeling Community of Practice. Specific goals of the workshop included:

- Showcase modeling systems, products, innovations, and stakeholder engagement strategies.
- Explore technological innovation, workforce development, and integrated modeling.
- Advance strategies for R2O2R and sustained operational support.
- Identify shared community priorities and opportunities to align with NOAA priorities.
- Strengthen collaboration across federal, academic, industry, and regional partners.
- Identify actionable next steps to support long-term community success.



Workshop Approach

The agenda combined presentations, community showcases, panels, facilitated discussions, breakout groups, chat input, and Slido polling. The planning team tracked recurring recommendations throughout the workshop and consolidated them into a draft priority list for community review and implementation planning.

Operational Modeling and R2O2R

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State of the modeling community

Opening presentations demonstrated both the breadth of regional modeling capabilities and the need for stronger integration with national systems. An overview of the IOOS modeling ecosystem was provided, along with deep dives into specific modeling applications from community experts. Examples across the RAs included physical, biogeochemical, ecological, and meteorological model applications and products, while community experts focused on harmful algal bloom forecasts such as the California-Harmful Algae Risk Mapping (C-HARM) system, data assimilative ROMS systems including the West Coast Operational Forecast System (WCOFS) and East Coast Community Ocean Forecast System (ECCOFS), and biogeochemical and ecological forecasting systems such as the Chesapeake Bay Environmental Forecast System (CBEFS). Presentations emphasized regional community systems as filling critical local needs, maintaining close connections with users, and providing fit-for-purpose operational services, while NOAA/NOS systems provide national operational continuity, service delivery, and a pathway toward Unified Forecast System (UFS) aligned architecture.

A key takeaway from the session was that **successful systems continually evolve**. Stakeholders never stop shaping regional products, operational models require regular refresh cycles, and research and operations depend on one another. Therefore, model development and operations need structured feedback among users, researchers, developers, and operators rather than a one-time handoff.

NOS model modernization and community feedback

NOS presented its vision for modernizing the operational modeling suite to improve the delivery of actionable information supporting marine navigation, public health, and coastal resilience. The proposed evaluation process aims to standardize and modernize physical oceanographic modeling systems, reduce resource fragmentation through cloud, high performance computing, and AI/ML capabilities, and develop a unified national system integrated with NOAA's UFS. NOS described a phased approach beginning with an open Request for Information (RFI) and other community engagement activities, followed by objective evaluations of model capabilities against NOS requirements, with the goal of developing recommendations for core model codes, infrastructure investments, and a phased transition plan. NOS emphasized that the process is intended to be collaborative and informed by partners, academia, industry, and the broader modeling community.

Operational Modeling and R2O2R

Participants emphasized that RAs, academia, industry, and other external partners should have meaningful opportunities to help define requirements, contribute capabilities, and inform modernization planning throughout the process. Specific recommendations for the modernization effort include:

- Begin with applications and user decisions, then work backward to determine the appropriate model, resolution, variables, and delivery format.
- Define usefulness through reliability, accessibility, timeliness, decision relevance, and impact—not solely parameter-level accuracy.
- Provide a configurable application framework to ensure model applications are fit-for-purpose where mission needs differ; one model application cannot serve every navigation, flooding, water-quality, ecosystem, and emergency-response scenario.
- Maintain observations, data assimilation, visualization, and data access as essential components of an operational modeling enterprise.

R2O2R pathways and barriers

Breakout groups agreed that "operational" at the regional level should be defined by application and user requirements rather than only by 24/7/365 uptime, as defined by NOS operational standards. ***Navigation, public safety, and emergency response need strict federal operational requirements, while region-specific products, such as ecological and biogeochemical forecasts, may meet user needs under different, application-appropriate service-level requirements that can be sustained through RAs or other institutions.*** Resources to maintain operational systems at academic institutions are often scarce or difficult to access, making governance, partnerships, and an appropriate operational home central to transition decisions. Key takeaways from the session include:

- Sustained funding across development, transition, operations, maintenance, and system updates is the most persistent barrier to R2O2R.
- Formal transition plans, operational readiness criteria, documentation, reproducibility, performance metrics, and technical readiness standards are needed to improve R2O2R.

Operational Modeling and R2O2R

- Common sandboxes, shared cloud environments, continual integration and delivery workflows (CI/CD), version control, and portable software practices can shorten transitions, streamline advancements, and reduce duplication.
- Lower readiness levels need room to experiment and fail, while later stages require clear ownership and sustained support.
- O2R feedback is underdeveloped and should be built into the R2O2R lifecycle.
- Stakeholder engagement is an essential component of the R2O2R lifecycle to inform requirements and help continually shape research priorities and operational products.



Stakeholder Engagement, Cloud Infrastructure, and Integrated Modeling

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Stakeholder engagement and co-development

The stakeholder engagement showcase highlighted that *effective engagement is a sustained relationship, not a single consultation*. Presenters described the need to show up consistently, listen, deliver clear communications, respond to criticism, and attend user-specific events. Iterative product development directly with users improves relevance, usability, trust, adoption, and the likelihood that model outputs support real operational decisions.

Stakeholder engagement also need not precede all model development: a research-driven modeling capability can evolve into a sustained decision-support system as users interact with prototypes, articulate the decisions they need to make, and continually reshape both the products and research priorities. For example, CBEFS evolved from an initially research-focused modeling system into a much broader environmental forecasting service as engagement with different user groups generated demand for additional variables, decision-support products, alerts, and simpler, more accessible ways to view multiple forecasts in one place. Additionally, C-HARM began as a NASA-funded research project that expanded into the robust system it is today based on the societal need for Harmful Algal Bloom forecasts.

Key takeaways from the showcase and discussion include:

- Service delivery is essential: Identify stakeholders and user decisions, translate needs into requirements, improve models and products, validate with users, and repeat the cycle.
- Use simple user stories and decision-focused questions to translate between technical teams and communities.
- Prioritize engagement with key user communities when capacity is limited, while maintaining mechanisms for broader input. Attend user events and tailor engagement sessions to specific user groups for efficiency.
- Use testimonials, usage analytics, operational examples, and societal or economic benefits to communicate impact and sustain investment in model applications and products.
- Recognize that model/product developers and engagement specialists have complementary expertise and should work together to optimize service delivery.

Stakeholder Engagement, Cloud Infrastructure, and Integrated Modeling

Participants called for closer coordination of engagement across NOS and the RAs. RAs have built relationships with local stakeholders through consistent engagement and have extensive knowledge of user needs. A coordinated approach to service delivery across NOS and the RAs would reduce stakeholder fatigue, improve requirements management, and help NOS incorporate regional expertise into planning, funding, and product evaluation. Participants also noted the need to include NOAA's Office for Coastal Management, consulting, and private-sector perspectives more consistently.

Cloud infrastructure and data access

A panel focused on modeling infrastructure and data access highlighted the ongoing transition toward cloud-based operations, shared sandboxes, NOAA data mesh concepts, the NOAA Open Data Dissemination (NODD) Program, virtualization, and tools for working with structured and unstructured grids. Utilizing cloud-based infrastructure can improve access, collaboration, scalability, and reproducibility, but it does not eliminate data-management challenges. Data gravity, cross-cloud interoperability, onboarding and workflow transitions, high costs, technical support, inconsistent formats, and ensuring consistent variable names remain significant barriers. Specific recommendations from the session include:

- Using hybrid approaches and choosing infrastructure based on the problem rather than treating cloud migration as an end in itself.

- Providing curated, harmonized views that make model outputs easier to compare and use without repeatedly reprocessing source data.

- Expanding educational resources, examples, notebooks, sandboxes, hackathons, and technical support so students and external partners can adopt tools.

- Using multi-tenancy, federation, cataloging, and virtualization to reduce duplicated infrastructure and data movement.

Stakeholder Engagement, Cloud Infrastructure, and Integrated Modeling

Integrated modeling

The integrated modeling panel demonstrated that integration is both a technical and organizational challenge. UFS-Coastal offers a community framework for coupling hydrodynamic, atmospheric, wave, and hydrologic systems, but progress requires common interfaces, standardized workflows, continuous integration and testing, and sustained support for community contributions. Panelists also highlighted common needs for long term observational datasets, authoritative topography and bathymetry, meteorological forcing, data standards, coupling approaches, and cross-system validation.

Examples from compound flooding, water quality, habitat, fisheries, and coupled land-ocean systems demonstrated that no single institution can provide every component. ***Successful integration depends on complementary expertise, shared priorities, and trust among federal programs, Regional Associations, academic researchers, industry partners, observing networks, and users.***



Emerging Technologies, Workforce, and Implementation

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Emerging technologies: AI, Data Assimilation, Cloud Computing

The technology roundtable examined hybrid physics-AI systems, data assimilation approaches, cloud-based infrastructure, graphics processing unit (GPU) accelerated modeling, model emulators, large language models, and operational flood forecasting. Speakers consistently emphasized that these technologies are complementary rather than competing approaches, and should be implemented in a coordinated manner across the community. Physics-based models provide mechanistic understanding and prediction, while observations and data assimilation can constrain model states and improve forecasts. AI/ML techniques can accelerate forecasts, expand ensemble capacity, improve access, and support hybrid systems, but require rigorous validation, Findable, Accessible, Interoperable, Reusable (FAIR) data, and sustained ownership. Specific recommendations from the session include:

- Investing in better forcing, observation density, validation, data ingestion, product generation, and sustained maintenance, not only larger or more complex models.
- Using portable frameworks, common interfaces, benchmarks, test environments, and reference workflows rather than assuming one model is interoperable across all contexts.
- Designing regional pilots and research prototypes for operational evaluation, sustained ownership, UFS compatibility, and user support.
- Developing model-ready and AI/ML-ready datasets with consistent quality control, metadata, access, and long-term archives.
- Using models and AI to help optimize observing systems while ensuring that high-quality observations continue to constrain models.

Participants emphasized the operational costs that are often overlooked in research proposals: data ingestion, validation, product generation, archives, and maintenance. One speaker summarized this as the need to "fund the plumbing." The group also discussed developing a standard reference dataset for machine-learning training and evaluation, similar to reference standards used in laboratory science.

Emerging Technologies, Workforce, and Implementation

Workforce and collaboration

Workforce development discussions focused on recruiting and retaining modelers, connecting students and early-career researchers with operational modeling efforts, updating academic curricula, creating embedded, skill-building experiences and training opportunities, and making career pathways more visible. CIs, fellowships, internships, joint appointments, summer programs, and short-term placements within RAs or NOS offices were identified as promising mechanisms for building technical skills and relationships across institutions. Key recommendations from the discussion include:

- Training the next generation across ocean physics, data assimilation, AI/ML, software engineering, cloud computing, and communication.
- Creating hands-on pathways for students and researchers to work with NOAA operational models, sandboxes, and computing resources.
- Pairing technical training with mentoring, networking, and clear career pathways.
- Addressing recruitment and retention barriers, including compensation, funding stability, citizenship restrictions, and limited advancement opportunities.
- Establishing mechanisms to share code, scripts, workflows, and lessons learned so new staff do not repeatedly rebuild the same capabilities.

Community Priorities and Proposed Community of Practice Structure

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The workshop concluded by identifying ten draft community priorities based on workshop discussions intended to guide future CoP activities and create a coordinated, actionable path forward toward shared goals. During the final session, participants reviewed and refined the draft priorities and were invited to volunteer to help lead or participate in priority-specific Working Groups (WGs). The proposed CoP structure below reflects the initial WG organization and participation identified during the workshop and is intended to support implementation of the community priorities. Recognizing that many priorities span multiple focus areas, the WGs are expected to collaborate closely, with a cross-cutting strategic planning team providing coordination across the portfolio and ensuring close alignment between NOS and the community.

Community Priorities

- 1 Strengthen collaboration across NOAA/NOS, IOOS Regional Associations, academia, industry, and other partners to support co-development, shared priorities, continuous feedback, and problem-driven collaboration.**

Ensure NOAA/NOS recognizes the RAs as integral non-federal partners in the U.S. IOOS enterprise, with roles that are distinct from but complementary to those of NOAA/NOS. Foster collaboration through Cooperative Institutes, shared projects, workshops, code sprints, and other flexible mechanisms. Leverage IOOS RAs as strategic partners for stakeholder engagement, regional expertise, user requirements, and product evaluation.

- 2 Build user-driven modeling systems by institutionalizing stakeholder engagement and co-development throughout the modeling lifecycle, designing models and products around decision-making needs, and translating model outputs into decision-ready products through user-centered design.**

Provide mechanisms for academia, RAs, and other partners to inform NOS priorities, ensuring user needs and community expertise are incorporated into planning and funding decisions.

Convene a Community of Practice stakeholder engagement workshop to develop a coordinated engagement strategy, mechanisms for shared user engagement strategies and requirements management, and approaches for communicating societal and economic value to improve coordination, reduce stakeholder fatigue, and better inform operational priorities at NOS.

- 3 Improve Research-to-Operations-to-Research (R2O2R) pathways through formal transition planning, regular operations-to-research feedback, continuous model improvement, and identification of an appropriate operational home. For capabilities intended for NOS operations, establish clear readiness criteria and pathways for integration with UFS and cloud architecture.**

Community Priorities and Proposed Community of Practice Structure

NOS and the RAs must establish clear, consistent pathways for transitioning models into operations, including operational readiness criteria, transition plans, evaluation processes, and regular update cycles. Support sustained funding for operational transitions and long-term model maintenance, recognizing that successful R2O2R requires ongoing investment beyond initial development.

4 **Develop community standards**

for technical readiness for R2O workflows, documentation, reproducibility, skill assessment, technical readiness, data management, and model evaluation.

5 **Promote shared infrastructure and modern software practices to increase efficiency and reduce barriers to collaboration,**

including improved code-sharing practices, openly shared workflows and scripts, cloud-native workflows, interoperable frameworks, and collaborative development environments. NOS and the RAs must invest in shared operational infrastructure, including cloud computing resources, sandbox environments for model co-development, and technical support that lowers barriers for community participation.

6 **Create a coordinated data ecosystem that includes data assimilation- and AI/ML-ready datasets that are well managed and easily accessible for model use.**

Ensure FAIR (Findable, Accessible, Interoperable, Reusable) and consistent datasets across all data access points through standardized formats, metadata, and protocols so users encounter the same data regardless of entry point.

7 **Advance emerging technologies together as a community by coordinating the integration of AI/ML, cloud computing, data assimilation, and other new computational approaches into strong physics-based modeling foundations.**

Utilize lessons learned from one another, while preserving and strengthening physics-based modeling as the operational backbone of the ecosystem, with data assimilation incorporated where appropriate, ensuring emerging methods complement rather than replace this foundation. NOS and the RAs must modernize modeling systems, including leveraging cloud computing, AI/ML, GPU architectures, and common frameworks while ensuring interoperability, reproducibility, and scientific integrity.

8 **Invest in workforce development through training, technical support, knowledge sharing, and succession planning.**

Strengthen the workforce pipeline by deepening ties between academia, NOAA, and industry through embedded experiences, Cooperative Institutes, and improved recruitment and mentoring. NOS and the RAs must support the next generation of modelers through training opportunities, fellowships, and internships in partnership with the community that emphasize skill development, mentorship, and networking and utilize existing infrastructure such as sandboxes and emerging technologies.

Community Priorities and Proposed Community of Practice Structure

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Advocate for sustained, diversified funding

that supports the full model lifecycle, from research through long-term operations, maintenance, and continued improvements.

10

Improve communication and transparency

through consistent terminology, open planning, stronger community engagement, and sustained communication channels that coordinate priorities and reduce fragmentation across the modeling community. NOS must develop a transparent, community-informed strategy for operational model modernization, including regular opportunities for feedback and collaboration throughout the process.

Proposed Community of Practice Structure

Cross-Cutting Strategic Planning Team

Provide shared leadership, coordinate work across priorities, develop the CoP roadmap and strategy, and connect community recommendations to NOAA/NOS planning.

Community Engagement and Capacity Building Working Group

(joint effort with the Coastal Coupling CoP)

Priorities 1, 2, 8, 9, and 10: collaboration, stakeholder engagement, workforce, funding, communication, and transparency.

Operational Transitions and Infrastructure Working Group

Priorities 3, 4, and 5: R2O2R pathways, readiness standards, shared infrastructure, software practices, and operational modernization.

Data Management and Emerging Technologies Working Group

Priorities 6 and 7: FAIR and model-ready data, AI/ML, cloud computing, data assimilation, interoperability, and emerging technologies.

The Future of the IOOS Modeling Community of Practice

As the community works together to advance the outlined priorities and work towards shared goals, formalization of the IOOS Modeling Community of Practice is essential. Central to this CoP is its role in facilitating two-way communication between NOS and the broader modeling community through the U.S. IOOS Office and the Regional Associations, to drive R2O and O2R across the community. The path forward includes the following:

- Establishment of the Cross-Cutting Strategic Planning Team

- Development of a CoP charter and roadmap

- Establishment of working groups with clear near-term priorities and actionable milestones

- Continuous CoP engagement opportunities through virtual community events, future workshops, and leveraging existing meetings and conferences for community focused gatherings

- Coordination with [other NOAA CoPs](#), including the Coastal Inundation CoP, Coastal Coupling CoP, and Marsh Modeling CoP

This framework will provide the foundation for a collaborative, action-oriented modeling community that leverages collective expertise, capabilities, and assets across the IOOS modeling ecosystem to advance coastal and ocean modeling. By strengthening collaboration across the community, the CoP will ensure operational needs are communicated to inform research and that research advances translate into operational capabilities. Sustained engagement across stakeholders and partners will ensure meaningful outcomes and enable the community to evolve with changing user needs, emerging scientific priorities, and technological innovations.

Appendix A: Background Materials and Relevant Links

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Workshop Materials

[Public Agenda](#)

Pre-Workshop Materials

[Webinar Recording](#)

[Webinar Summary](#)

[Webinar Slides](#)

[IOOS Modeling Terms & Definitions](#)

[IOOS Community Models and Products](#)

Appendix B: Planning Team and Workshop Participants

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Workshop Planning Team

Breanna Vanderplow, *NOAA U.S. IOOS*

Clarissa Anderson, *SCCOOS*

John Wilkin, *Rutgers University*

Marjy Friedrichs, *William & Mary's VIMS*

Joanna Peth, *NOAA NOS HQ*

Patrick Burke, *NOAA CO-OPS*

Kruti Desai, *UCAR-COL*

Workshop Participants

Rachel Ackerman, *NOAA*

Nabi Allahdadi, *Florida Gulf Coast University*

Corey Allen, *NOAA*

Jose-Henrique Alves, *NOAA OAR*

Eric Anderson, *CIRES, University of Colorado Boulder*

Joshua Anderson, *University of Wisconsin-Madison*

Kathleen Bailey, *NOAA U.S. IOOS*

Becky Baltes, *NOAA U.S. IOOS*

Brandon Bethel, *University of The Bahamas*

Aaron Bever, *FlowWest*

Lucila Houttuijn Bloemendaal, *NOAA U.S. IOOS*

Roxanna Braganca, *UCSB*

Shelby Brunner, *GLOS*

Maja Bubalo, *Croatian Meteorological and Hydrological Service*

Nicole Cai, *Yale University*

David Cannon, *University of Michigan; CIGLR*

Gabrielle Canonico, *NOAA U.S. IOOS*

Roxanne Carini, *NANOOS*

Jamie Carter, *NOAA OCM*

Felicio Cassalho, *NOAA*

Patricia Chardon, *CARICOOS*

Changsheng Chen, *University of Massachusetts Dartmouth*

Yong Chen, *Sun Yat-sen University*

Daniel Codiga, *NOAA*

Brian Cosgrove, *NOAA NWS OWP*

Edward L. Cruz, *CARICOOS*

Edward Davis, *NOAA*

Rachael Dempsey, *NOAA NOS*

Kendra Dresback, *University of Oklahoma*

Jason Ducker, *Lynker*

Greg Dusek, *Dusek Coastal Science & Consulting*

Masha Edmondson, *UCAR-COL*

Falk Feddersen, *UCSD*

Leandro Fernandez, *Oregon State University*

Ayumi Fujisaki-Manome, *Cooperative Institute for Great Lakes Research, University of Michigan*

Cong Gao, *Princeton University*

Appendix B: Planning Team and Workshop Participants

Workshop Participants

Graton Gathright, *3Raccoons*

Luke Ghallahorne, *Columbia River Inter-Tribal Fish Commission*

Sarah Giddings, *Scripps Institution of Oceanography, UCSD*

Lonnie Gonsalves, *NOAA NCCOS*

Carl Gouldman, *C-Coast Group, LLC*

Aditya Gupta, *University of Georgia*

Akanksha Gupta, *SIO, UCSD*

Joanne Gutowsky, *NOAA*

Muhammad Hajj, *Stevens Institute of Technology*

Merrick Haller, *Oregon State University*

Ruoying He, *NC State University*

Parisa Heidary, *NOAA*

Vanessa Hernaman, *CSIRO*

Debra Hernandez, *SECOORA*

Kate Hewett, *University of Washington - APL*

Gabrielle Hillyer, *IOOS Association*

Minna Ho, *UCLA*

Jakir Hossen, *Earthwise Systems Solutions, LLC*

Rosa Hunter, *Northwest Indian College*

Melissa Iwamoto, *PacIOOS*

Mansur Jisan, *NOAA*

Dominique Johnson, *NOAA CO-OPS*

Max Jones, *Development Seed*

Analise Keeney, *NOAA CO-OPS*

Jamal Khan, *IRD*

Tarang Khangaonkar, *University of Washington*

Bahram Khazaei, *NOAA OCS*

Kelly Knee, *Tetra Tech*

Alexander Kurapov, *NOAA OCS*

Michael Lalime, *NOAA U.S. IOOS*

Katie Lehman, *Maryland Mesonet & Hydronet, University of Maryland*

Ning Li, *University of Hawaii at Manoa*

Siqi Li, *SMAST, UMass Dartmouth*

Xumin Li, *University of Maryland College Park*

Patrick Limber, *NOAA NOS*

Yonggang Liu, *University of South Florida*

Zhilong Liu, *University of South Alabama*

Lev Looney, *NOAA AOML*

Rick Luettich, *University of North Carolina at Chapel Hill*

Douglas Luther, *University of Hawaii*

Michael C. Maddox, *University of Maryland - Hydronet*

Soroosh Mani, *NOAA OCS*

Avichal Mehra, *NOAA NWS*

Madeleine Melocchi, *University of Michigan*

Fatima-Zahra Miahmi, *PacIOOS / University of Hawaii at Manoa*

Isaac Miranda-Alcántara, *Universidad Nacional Autónoma de México*

Saeed Moghimi, *NOAA NOS*

Edward Myers, *NOAA OCS*

Jan Newton, *NANOOS*

Erica Ombres, *NOAA OAP*

Philip Orton, *Stevens Institute of Technology*

Mark Osler, *NOAA NOS*

Leilane Passos, *Oregon State University*

Kate Pereira, *Colorado School of Mines / UCAR WINGS Fellow*

Appendix B: Planning Team and Workshop Participants

Workshop Participants

Louisa Pitney, <i>NOAA NOS</i>	Patrick Tripp, <i>Tetra Tech Inc.</i>
Brian Powell, <i>University of Hawaii</i>	Kelley Uhlig, <i>NOAA</i>
Katherine Moore Powell, <i>Lynker</i>	Cristina Urizar, <i>NOAA NOS</i>
Lakshitha (Laki) Premathilake, <i>Pacific Northwest National Laboratory and University of Washington</i>	Tiffany Vance, <i>NOAA U.S. IOOS</i>
Li Ren, <i>NOAA NOS</i>	Jennifer Vogt, <i>NOAA</i>
Ilya Rivin, <i>NOAA</i>	Xiaoyu Wang, <i>Dalian University of Technology</i>
Luis Fernando Pareja Roman, <i>Rutgers University</i>	Nimisha Wasankar, <i>Alabama Water Institute, University of Alabama</i>
Mojgan Rostaminia, <i>NOAA OCS</i>	Heather Welch, <i>UC Santa Cruz and NOAA NMFS</i>
Henry Ruhl, <i>CeNCOOS</i>	Micah Wengren, <i>NOAA U.S. IOOS</i>
Dina Sang, <i>University of Alabama</i>	Cisco Werner, <i>Smithsonian Institution (National Museum of Natural History)</i>
Samantha Lauren Halstead Santez, <i>UMD</i>	Joannes Westerink, <i>University of Notre Dame</i>
Ella Scott, <i>NOAA CO-OPS</i>	Wei Wu, <i>NOAA OCS</i>
Charles Seaton, <i>Columbia River Inter-Tribal Fish Commission</i>	Jiangtao Xu, <i>NOAA NOS</i>
Greg Seroka, <i>NOAA NOS</i>	Z. George Xue, <i>LSU</i>
Lei Shi, <i>NOAA NOS</i>	Yanda Ou, <i>Louisiana State University</i>
Tom Shyka, <i>NERACOOS</i>	Zizang Yang, <i>NOAA</i>
Samantha Siedlecki, <i>University of Connecticut</i>	Kristen Yarincik, <i>IOOS Association</i>
Anna Simpson, <i>NERACOOS</i>	Hyungju Yoo, <i>Virginia Institute of Marine Science</i>
Pauline Singer, <i>IOOS Association</i>	Madeleine Youngs, <i>University of Maryland, College Park</i>
Abby Smith, <i>UCAR</i>	Ed Zaron, <i>Oregon State University</i>
Stephan (Steve) Smith, <i>NOAA NOS</i>	Aijun Zhang, <i>NOAA</i>
Derrick Snowden, <i>Tetra Tech Ocean Sciences</i>	Joseph Zhang, <i>William & Mary's VIMS</i>
Harikrishnan Sreeshylam, <i>University of South Alabama</i>	Le Zhang, <i>University of Maryland Center for Environmental Science</i>
Pierre St-Laurent, <i>William & Mary's VIMS</i>	Xiaochen Zhao, <i>Louisiana State University</i>
Kari St. Laurent, <i>NOAA NCCOS</i>	Lianyuan Zheng, <i>NOAA CO-OPS</i>
Liujuan Tang, <i>NOAA OCS</i>	Yifan Zhu, <i>University of Connecticut</i>
Terry Thompson, <i>NOAA</i>	Haibo Zong, <i>Fathom Science Inc.</i>
Dan Titze, <i>NOAA GLERL</i>	



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