National Artificial Reef Workshop




Alexandria, Virginia
June 9 – 10, 2016

NOAA FISHERIES

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Presentations and Materials
All presentations and workshop materials are available online at:
http://www.nmfs.noaa.gov/sfa/management/recreational/artificial-reef-workshop.html

I. Workshop Recap

NOAA Fisheries and the Atlantic States Marine Fisheries Commission (ASMFC) convened a national artificial reef workshop June 9–10, 2016, in Alexandria, Virginia. Nearly 80 participants from around the nation—including state artificial reef program managers, scientists, recreational fishermen, and non-governmental organizations, among others—shared lessons learned in artificial reef application, discussed opportunities and challenges, and considered the potential future direction of artificial reefs in U.S. waters.

A steering committee of artificial reef experts coordinated closely with NOAA Fisheries and ASMFC staff to develop the following objectives for this workshop:

- Provide an overview of current science and applied experience (lessons learned) regarding the application of artificial reefs as a tool to support or enhance sustainable fisheries.
- Identify and examine key considerations associated with artificial reefs as a potential management tool to support and/or enhance sustainable fisheries.
- Identify management challenges and associated research needs, knowledge gaps and limitations, and strategies for monitoring, using, and managing artificial reefs.
- Discuss the potential roles of federal, state, and private sector partnerships in resolving artificial reef challenges and achieving objectives.

A series of opening presentations set the stage for collaborative discussion that took place throughout the course of the workshop. The facilitator presented a summary of pre-workshop survey findings that helped shape the agenda. Key experts then provided artificial reef history, introduced a frame of reference for considering artificial reefs as a potential fishery management tool, and created common understanding of the regulatory framework for all present. NOAA Fisheries staff also introduced the NOAA Ecosystem Based Fishery Management Policy (EBFM). Presentations/presenters included:

- *A Brief History of Marine Artificial Reef Development in U.S. Waters*
  Dr. Bill Gordon (on behalf of Richard Christian), University of Rhode Island
- *Artificial Reefs in Fisheries Management: Has the Time Come?*
  Dr. Steve Bortone, Gulf of Mexico Fishery Management Council (retired)
- *NOAA Ecosystem Based Fisheries Management Policy*
  Kirsten Larsen, NOAA Fisheries
- *Overview of the Regulatory Framework*
  Keith Mille, Florida Fish and Wildlife Commission

Six managers/practitioners from around the nation built upon early framing conversations by presenting on the artificial reef experience from their respective regions, and then participating in a panel discussion. The panel helped create awareness of various state artificial reef program

objectives, strategies, and applied experiences from around the nation. Interested readers are encouraged to view all presentations on the project webpage. Presenters/panelists included:

- *North and Mid-Atlantic:* Mark Rousseau, Massachusetts Department of Fish and Game
- *South Atlantic:* Bob Martore, South Carolina Department of Natural Resources
- *Gulf of Mexico:* Dale Shively, Texas Parks and Wildlife Department
- *Washington:* Theresa Tsou, Washington Department of Fish and Wildlife
- *California:* Eric Wilkins, California Department of Fish and Wildlife
- *Hawai'i:* Paul Murakawa, Hawai'i Department of Land and Natural Resources

Following the panel discussion all workshop participants gathered in small groups of 8 to 10 participants to share experiences and lessons learned, and begin discussing solutions to common challenges. Report-backs to the full group highlighted challenges, methods for overcoming barriers, and future needs. (A comprehensive description of session outputs is included on page 9.)

Day 2 of the workshop began with a series of five presentations, followed by a panel discussion among experts that explored the current state and potential future direction of the science. Presentations/panelists included:

- *Ecological Functioning of Artificial Reefs with Fisheries Management Implications*
  Bill Lindberg, University of Florida
- *Planning Artificial Reefs in the U.S.: Recent Trends and Evolutionary Challenges*
  Bill Gordon, University of Rhode Island
- *Science Informing Artificial Reefing Practices: Key Findings, Knowledge Gaps, and Future Directions from the Northwestern Gulf of Mexico*
  Greg Stunz, Texas A&M University Corpus Christi
- *Artificial Reef Socioeconomics: Everything but the Kitchen Sink*
  Bill Huth, University of West Florida
- *Artificial Reefs: The Good, the Bad and the Ugly*
  Jim Bohnsack, NOAA Fisheries

Similar to day 1 collaborative discussions, participants again self-organized into several small groups following the science presentations. The facilitation team organized tables by topics explored during the presentations. Participants then chose a topic of interest and rotated to other topics as desired. Each group explored science gaps, partnerships, and priorities. (A comprehensive description of the science session outputs is included on page 14.)

The final small group breakout session tasked all workshop participants to build a bridge toward future activities based on new knowledge gained and ideas shared among peers over the course of 2 days together. Specifically, small groups identified and discussed key workshop takeaways that will influence next steps (individual and collective), and improve communication and collaboration among artificial reef practitioners across the United States.

While not consensus-based, final report-backs to the full group identified numerous takeaways that may shape future actions across a broad range of categories, including:

- Management
- Science
- Funding
- Needs and potential future actions
- Identified concerns

At the culmination of the event, the conveners (NOAA Fisheries and ASMFC) thanked everyone for their collaborative engagement on an important national issue and noted that, moving forward, NOAA Fisheries will utilize workshop outputs to evaluate its future role in considering artificial reefs as a potential fisheries management tool. (Interested parties are encouraged to read the summary of workshop takeaways included on page 19.)

II. Welcome and Opening Remarks

NOAA Fisheries and ASMFC jointly convened a national artificial reef workshop June 9–10, 2016, at the Westin Alexandria in Alexandria, Virginia. Nearly 80 participants attended from around the nation, including state artificial reef program managers, scientists, recreational fishermen, and non-governmental organizations among others.

Russell Dunn, NOAA Fisheries National Policy Advisor for Recreational Fisheries, opened the workshop and welcomed participants. He acknowledged broad interest in artificial reefs, affirmed the need for a conversation about their potential role in fisheries management, and NOAA's need to better understand the science and management challenges, and benefits associated with artificial reefs.

Mr. Dunn thanked the steering committee for its guidance in shaping the workshop objectives and agenda. Patrick Campfield, Director of the Fisheries Science Program at ASMFC, also welcomed participants. He described ASMFC's and the Gulf States Marine Fisheries Commission's (GSMFC) 30-year history of coordinating information exchange and helping guide artificial reef development among the Atlantic and Gulf states.

The conveners thanked all participants for attending and expressed eagerness for new information sharing and discussion of a range of perspectives throughout the workshop. They noted that artificial reefs have been utilized and tested as restoration and mitigation tools in U.S. waters, but the potential as a fisheries management tool has not yet been explored to any meaningful extent.

Facilitator Rich Wilson of Seatone Consulting reviewed the workshop agenda, noting how presentations and panel discussions would frame a series of small group discussions during the course of the workshop. He drew attention to the Participant Workbook, where supplementary

text, an overview of all presentations, and additional materials were compiled as a resource for participants. (All presenter biographies can be found on pages 22–27 of the workbook.)

Workshop Objectives

- Provide an overview of current science and applied experience (lessons learned) regarding application of artificial reefs as a tool to support or enhance sustainable fisheries.
- Identify and examine key considerations associated with artificial reefs as a potential management tool to support and/or enhance sustainable fisheries.
- Identify management challenges and associated research needs, knowledge gaps and limitations, and strategies for monitoring, using, and managing artificial reefs.
- Discuss the potential roles of federal, state, and private sector partnerships in resolving artificial reef challenges and achieving objectives.

III. Summary of Pre-Workshop Findings and Themes

The facilitator presented a summary of key findings from a pre-workshop survey completed by nearly half of all invited participants. The survey captured perspectives and insights from prospective attendees on a range of artificial reef–related topics. Survey results revealed topics of interest, recent advances and important gaps in artificial reef science and management, potential for coordination and partnerships, and lessons learned from different regions around the nation. Most importantly, the results helped shape the workshop agenda and recruit guest presenters who framed key topics and issues that participants then discussed over 2 days.

IV. Background and History of Artificial Reefs

Scheduled presenter Richard Christian was unable to attend the workshop, so Dr. Bill Gordon, University of Rhode Island, presented *A Brief History of Marine Artificial Reef Development in U.S. Waters* on Mr. Christian's behalf.

The first documented marine artificial reef in U.S. waters was placed in 1850. That said, most artificial reef development occurred over the past five decades. Dr. Gordon described how construction has generally been driven by four factors:

1. An engaged constituency.
2. Availability of suitable materials.
3. Dedicated funds for construction, monitoring, and assessment.
4. Supporting artificial reef policies, state and local programs, and planning documents.

From the 1950s to 1980s, more than 80 percent of artificial reefs were constructed from materials that outlived their original purpose, or "materials of opportunity." Construction, Dr. Gordon noted, has generally out-paced scientific assessments of artificial reef effects on natural

habitat or as a potential fisheries management tool. Early artificial reef policies emerged in the 1970s, culminating in the landmark National Fishing Enhancement Act of 1984. The Act, however, did not provide spending authority for appropriations aimed at supporting artificial reef implementation.

Rigs-to-reefs programs also began developing in the early 1980s. As of 2015, 470 offshore oil and gas platforms have been converted to permanent artificial reefs in the Gulf region. The 1980s were also a popular time for designing reefs out of specific materials to suit a defined purpose. The Japanese government, Dr. Gordon noted, has designed structures for specific aquaculture and commercial fishing activities that may provide lessons learned for U.S. practitioners.

Today approximately half of coastal states have artificial reef program plans. These plans are unique to each state's habitat, geography, and resource use dynamics. The U.S. Federal Aid Sportfish Restoration Fund provides significant resources for state artificial reef programs. Increasingly, these programs will need to coordinate with other entities engaging in marine spatial planning so artificial reefs are appropriately sited and managed. Development of an information clearinghouse, containing a wide range of resources, would likely also benefit practitioners around the nation.

V. Artificial Reefs in a Fisheries Management Context

To help frame the issue of fisheries management, and the connection to artificial reefs as a potential management tool, Dr. Steve Bortone, retired Executive Director of the Gulf of Mexico Fishery Management Council, presented on the general topic, *Artificial Reefs in Fisheries Management: Has the Time Come?*

Dr. Bortone described how practitioners have deployed different artificial reef types for decades for various purposes (e.g., habitat mitigation, fish aggregation, trawling deterrents, water movement deterrents). He noted that, in defining fisheries management, the key phrase is "active manipulation based on quantitative choices" such that fisheries will be sustained or improved. The management process involves both resource manipulation and influencing human behavior.

Dr. Bortone suggested that artificial reef practitioners consider modifying Seaman and Jensen's 2000 definition of artificial reefs, to read: "One or more objects of natural or human origin deployed on the seafloor to influence physical, biological, and/or socioeconomic processes related to living aquatic resources." He further emphasized that this definition can be sensibly abridged to read "objects deployed to influence aquatic resources."

Currently, artificial reefs play virtually no role in the management of any fishery in U.S. waters, or for that matter, the world. That said, Dr. Bortone reviewed potential artificial reef applications in fisheries management:

- Increase habitat.
- Mitigate stressed or destroyed habitat.
- Enhance life stage survival of a species.
- Facilitate movement or colonization.
- Reduce pressure on natural fishing habitat.
- Redirect water movement.

Conversely, he noted obstacles to applying artificial reefs in fisheries management:

- Difficult to evaluate success in a fisheries management context because they have not been employed as fisheries management tools.
- Challenges with data compatibility and sampling methods.
- Lack of study replication.
- Unintended consequences.
- Studies often do not provide fishery managers the information needed for decision making.

While thousands of artificial reefs (or other objects that function as artificial reefs such as seawalls, docks, and pipelines) have been deployed throughout the world, Dr. Bortone estimated likely less than 0.001 percent of the continental shelf has been affected. To overcome obstacles, he noted, artificial reefs must allow reliable predictability of effects just as is required of other fisheries management options. Pressing needs to support implementation as a potential fisheries management tool include:

- Cooperation/organization.
- Nationwide information database.
- Estimate of artificial reef footprint and impacts.
- Energy budget.
- Meaningful management objectives.

Finally, notwithstanding ongoing scientific debates, Dr. Bortone suggested that future studies may want to focus on how artificial reefs generate both high attraction *and* production. Later workshop conversations, as well as past studies, pointed out a continuum from attraction to production. Resource managers, Dr. Bortone noted, may consider strategic implementation of artificial reefs as a tool directed at select species rather than entire species assemblages. He further stressed that managers need to better communicate to artificial reef researchers the management questions they need answered. (A summary of the question/answer session that followed Dr. Bortone's presentation is listed in Appendix I.)

Next, Kirsten Larsen, NOAA Fisheries Office of Science and Technology, provided an overview of NOAA's recently released *Ecosystem Based Fisheries Management Policy* (EBFM). The policy formalizes NOAA Fisheries' commitment to EBFM. While the policy is new, the concept itself is not. The policy is intended to capture the current state of EBFM within NOAA Fisheries and

provide both the agency and the Regional Fishery Management Councils guidance moving forward. Managing on an ecosystem level may provide more stability for fisheries. It also provides an opportunity to address trade-offs and different stakeholder priorities, balancing social and ecological needs.

NOAA Fisheries is a mandate-driven science agency whose work is needed to support management choices for 750+ taxa and over 5 percent of the world's ocean area. NOAA Fisheries adopted the EBFM policy to more efficiently and effectively fulfill its mandates. The forthcoming NOAA Fisheries EBFM Road Map, expected in summer 2016, builds upon the policy by providing a national implementation strategy. (A summary of the question/answer session that followed Ms. Larsen's presentation is listed in Appendix I.)

VI. Overview of the Regulatory Framework

In order to create common knowledge and understanding among workshop participants on artificial reef governance, permitting requirements, and associated regulatory issues, Keith Mille of the Florida Fish and Wildlife Conservation Commission provided an *Overview of the Artificial Reef Regulatory Framework*.

The majority of artificial reef activities, Mr. Mille noted at the outset, are overseen by the U.S. Army Corps of Engineers (ACOE). He provided an overview of relevant federal laws, ACOE regulations, and state regulatory jurisdictional issues that apply to artificial reef development in U.S. waters.

In Mr. Mille's home state of Florida, coastal governments (i.e., municipalities) hold artificial reef permits issued by the ACOE (required in both state and federal waters) and Florida Department of Environmental Protection (required in state waters). Regulatory constraints on artificial reef construction address issues such as spatial boundaries for navigation, channels, marine habitat resources, historic areas, sand borrow areas, existing structures and leases, etc.

Many states now implement materials limits for artificial reef structures. Some areas, Mr. Mille noted, face challenges with unpermitted material types and locations, especially for private deployments. Poor past artificial reef practices, many now prohibited, generated negative press from many vivid old photos and records and still contribute to misconceptions about modern artificial reef programs.

Mr. Mille stressed that opportunities do exist for improved coordination among parties working on permitting and regulatory issues. He encouraged pre-permit application consultations between applicants and regulatory agencies. He also noted that achieving permitting compliance does not necessarily mean that fisheries management objectives have been achieved.

Finally, Mr. Mille suggested that interested parties could further explore the topics presented in the opening session at a special artificial reef session planned for the annual meeting of the American Fisheries Society in Tampa, Florida, on April 20–24, 2017. (A summary of the question/answer session that followed Mr. Mille's presentation is provided in Appendix I.)

VII. Regional Experiences and Lessons Learned

a. Panel Discussion

Following the opening framing conversations, six managers/practitioners from around the nation shared brief presentations on the artificial reef experience from their respective region, and then participated in a panel discussion. The discussion helped create awareness of different state artificial reef program objectives, strategies, and applied experiences. (Interested parties are encouraged to view all regional presentations on the project webpage.)

Presentations/panelists included:

- *North and Mid-Atlantic:* Mark Rousseau, Massachusetts Department of Fish and Game
- *South Atlantic:* Bob Martore, South Carolina Department of Natural Resources
- *Gulf of Mexico:* Dale Shively, Texas Parks and Wildlife Department
- *Washington:* Theresa Tsou, Washington Department of Fish and Wildlife
- *California:* Eric Wilkins, California Department of Fish and Wildlife
- *Hawai'i:* Paul Murakawa, Hawai'i Department of Land and Natural Resources

Each presenter described specific examples, if available by region, of artificial reef fishery management and/or enhancement applications. All presenters addressed challenges, lessons learned, and needs moving forward. After the presentations the facilitator opened the panel discussion with an initial question, which was then followed by numerous questions, comments, and discussion between presenters and the full group. (A summary of the panel discussion that followed all presentations is listed in Appendix I.)

b. Small Group Breakouts

Utilizing a "World Café" style format, which encourages diversity of thought and ideas, all participants engaged in the first small group collaboration of the workshop. Groups of 8 to 10 participants shared experiences and lessons learned, and began discussing solutions to common and sometimes unique challenges. Each group considered three guiding questions:

1. What have been your biggest challenges regarding artificial reef application, and how have you overcome them?
2. What lessons have you learned, what has worked well, and what experiences can you share that may benefit others?

3. From your perspective (your constituency/interest group) what are your needs moving forward?

Discussion note: The facilitator acknowledged that funding challenges are no doubt paramount among many artificial reef practitioners. He requested participants also identify other important challenges and needs.

Report-Outs and Full Group Discussion
After breakout discussions, all participants reconvened and each small group shared highlights from their respective conversations. The following outputs reflect themes and associated responses presented during the report-outs and collected on note-taking sheets and poster paper provided to each group.

1. What have been your biggest challenges regarding artificial reef application, and how have you overcome them?

Science and Research

- Site selection and spatial habitat utilization by life stage and species life history (e.g., spawning, nursery).
- Addressing species bottleneck issues.
- Understanding if/how artificial reefs contribute to the existing mosaic of marine protected areas (MPAs).
- Unknown/unanticipated ecological impacts of artificial reefs (e.g., introduction of new predators or invasive species; converting one habitat to another; human impacts of favoring one fishery over another, etc.).
- Accounting for different concepts of scale.
- Understanding which species are habitat-limited.
- How to integrate artificial reef habitat into fisheries management stock assessment models.
- Science questions from managers are difficult to answer, especially with limited resources.
- Difficult to study and monitor productivity of artificial reefs with active fisheries.

Permitting and Regulations

- Permitting can be a "moving target" at both state and federal levels.
  - ⇒ The definition of an artificial reef in California is too specific.
  - ⇒ In Texas permits changed from each reef zone to each individual reef.
  - ⇒ Potential solution: Create a single entity (federal-state partnership) that can set permit standards for the nation so requirements do not change along with regional staffing changes.
- Delays associated with Endangered Species Act section 7 consultations.
  - ⇒ Potential solution: Create standardized protocols for data collection and possibly have a programmatic Environmental Impact Statement for an entire region.

- It is not always clear what matching funds are permissible for a project in permitting application materials.
- State permitting hurdles:
  - ⇒ Process can take several years and cost hundreds of thousands of dollars.
  - ⇒ Different review agencies require different levels of detail and different application methods.
  - ⇒ Potential solution: Need permitting consistency within each department and among designated permitting review staff.
- Federal plans may not fit regional needs.
- California lacks an artificial reef policy.
- Obtaining water quality certifications from issuing agency is difficult
- Lack of state policy and federal consistency.
- Liability

Monitoring

- Increased monitoring demands and difficulty obtaining accurate citizen science data.
- Lack of baseline data (for user group benefits, economics, recreational use, etc.).
- Limited ability to monitor artificial reefs due to inadequate resources.

Communication and Outreach

- Public perception and/or awareness of state artificial reef programs.
  - ⇒ Potential solution: Regular outreach and easily accessible information about public artificial reef sites (e.g., website and printed material for fishermen).
- Effective public education and outreach methods—cross-communication challenges among stakeholders with various interests, expertise, etc.
- Lack of awareness, and lack of public relations around artificial reefs.
- Overcoming the stigma of "ocean dumping."
- Identifying suitable sites for informal meetings with stakeholders.

Planning, Management, and Maintenance

- Recreational fishermen do not always acknowledge they are part of the problem.
- Capturing institutional knowledge within organizations.
- Defining a clear purpose(s) for new artificial reefs (e.g., socioeconomic, mitigation, etc.).
- Deployment challenges for large structures.
- Identifying potential user conflicts.
- Maintaining artificial reefs.
- Unclear goals and plans for proposed artificial reefs.
- User and interagency conflicts.
- Securing a reliable source of materials, transportation, and materials storage space.

2. What lessons have you learned, what has worked well, and what experiences can you share that may benefit others?

Science and Research

- Spatially explicit sampling of all habitat types is necessary.
- Research/report requirements could benefit by developing objectives and structure in order to standardize data collection and help put questions up-front.
- Success metrics should be clearly defined by the applicant and permitting agency in advance of project.
- Ensure metrics are concise, obtainable, and measurable.
- Specific artificial reef types can benefit one species more than others (e.g., gag grouper); design and implement artificial reefs according to specific management objectives.
- Citizen science does not always work well for monitoring artificial reef productivity.

Design, Siting, and Deployment

- Beneficial to aggregate materials into large clusters with satellite materials dispersed around the central cluster.
- Consult user groups and permitting agencies early in the process of artificial reef design, site selection, and project implementation in order to identify and address concerns.
- Develop a "Best Practices" document.
- Diversify materials to support different life stages of species.
- Recognize that concrete materials continue to cure/hydrate when underwater.

Permitting and Documentation

- Recognize benefits of streamlining the permitting process (e.g., regional permits, interagency review teams, programmatic consultations by NOAA and/or ACOE).
- Use innovative in-kind donations to help raise matching funds for artificial reef permitting costs (e.g., cost to build a structure, services training value of a decommissioned tank, logistics value for artificial reef deployment, etc.).
- Pay attention to funding source requirements. Build in funding for ongoing monitoring and maintenance.
- Recognize benefits of having a local partner who takes ownership of the artificial reef once installed, with a contract containing long-term management commitment.
- Maintain good artificial reef documentation with regular monitoring and data updates.
- Consider lessons learned from the Gulf region regarding how to streamline the permitting process among multiple agencies.

Outreach and Education

- Recognize the importance of doing outreach and education to all audiences (e.g., general public, fishing groups, environmental groups, NGOs, elected officials, etc.).
- Engage private sector/non-profit partnerships.
- Understand it is important to have a diversity of artificial reef materials that can provide suitable habitat for different life history stages of important species.

Other

- Recognize the benefits of securing buy-in across stakeholder groups.

- No "painless solution" exists. Balanced solutions require sacrifice from all stakeholders.
- Marine reserves and uncharted reefs help reef fish populations rebound. Advances in technology, however, make it easier for fishermen to locate uncharted reefs.
- Consider the "shifting baselines" phenomenon and how the concept applies to conservation perspectives and targets among different generations.
- Regional differences in the acceptance, or not, of artificial reefs as "the norm" affects the level of development.

3. From your perspective (your constituency/interest group) what are your needs moving forward?

Science, Research and Monitoring

- Better understanding of how research can inform science-based products for fisheries managers.
- Climate change planning—ecosystem effects, sea level rise, etc. affecting species composition.
  - ⇒ Understanding cumulative impacts of habitat alteration and/or habitat loss from wind farms.
  - ⇒ Working with renewable energy installations (e.g., wind farms) to achieve artificial reef effects.
- Scientifically defensible data to support artificial reef development, including greater understanding of the difference between designed and donated materials.
- Scientifically sound, standardized studies that cover large geographic areas.
- Reference points (e.g., artificial reefs where no fishing rules are enforced) are needed to implement monitoring for management effectiveness. Explore the possibility of using existing MPAs to install artificial reefs and create de facto reference sites.
- Habitat needs of species by life stages.
- Standardized coast-wide monitoring programs/protocols, including long-term monitoring. Use well-established, consistent monitoring metrics.
- Socioeconomic analyses by region (e.g., cost/benefit analyses).
- Piggyback/leverage data collection programs (e.g., Marine Recreational Information Program) of other agencies/researchers.
- Data on artificial reef catch rates and fishing efforts.
- Identify and address data gaps.
- More rigorous scientific data at the regional level.
- Synopsis of research completed since 1997.
- Science-based outreach to the public.

Relationship to Fisheries and Ecosystem Management

- More artificial reefs that enhance fishing and replace lost fishing opportunities from habitat loss, degradation, and fishing closures; reduce pressure on existing reefs.
- Artificial reefs to replace and/or recover lost reef habitats.
- Protection of existing commercial fishing opportunities.

- Management strategy evaluation trade-offs to develop adaptive management strategies.
- Reliable funding source for both baseline and continued monitoring.
- Measurable goals for artificial reef projects.

Permitting and Regulations

- Defined national priorities with regional flexibility.
- Streamlined, comprehensive permitting processes.
- Simplified regulations that help facilitate enforcement.
- Individualized/developed permits and regulations for each artificial reef (not permits "translated" from other federal/state environmental programs, such as wetlands).

Coordinated Planning

- National program (federal or federal/state partnership); coordination and consistency.
- National cross-dialogue, inclusive of diverse stakeholder types.
- Central clearing-house of artificial reef research and information.
- Non-regulatory national artificial reef coordination program.

Other

- Understanding needs for historical restoration and the role of artificial reefs.
- Staffing and training support for regulators.
- More diverse funding sources and private funding increases.
- Marketing campaigns directed at policy-makers.
- Receiving better materials from the Navy and Maritime Administration (MARAD).

VIII. Current State and Potential Future Direction of Science

a. Panel Discussion

A series of five presentations followed by a panel discussion with science experts explored the current state and potential future direction of the science. The session aimed to:

- Describe and facilitate discussion on the scientific basis that informs the application of artificial reefs as a potential management tool to enhance sustainable fisheries.
- Identify science gaps that need to be addressed to advance the potential for use of artificial reefs as a management tool.
- Illustrate key elements of partnerships and/or cooperative arrangements among federal, state, university, and other researchers.
- Identify short- and long-term priorities, then foster discussion on how future research might be better focused.

Presentations/panelists included:

- *Ecological Functioning of Artificial Reefs with Fisheries Management Implications*
  Bill Lindberg, University of Florida
- *Planning Artificial Reefs in the U.S.: Recent Trends and Evolutionary Challenges*
  Bill Gordon, University of Rhode Island
- *Science Informing Artificial Reefing Practices: Key Findings, Knowledge Gaps, and Future Directions from the Northwestern Gulf of Mexico*
  Greg Stunz, Texas A&M University Corpus Christi
- *Artificial Reef Socioeconomics: Everything but the Kitchen Sink*
  Bill Huth, University of West Florida
- *Artificial Reefs: The Good, the Bad and the Ugly*
  Jim Bohnsack, NOAA Fisheries

At the completion of all five presentations, the facilitator opened the panel discussion with an initial question and then welcomed questions and comments from the full group. He requested that both panelists and questioners keep comments relatively brief so as to allow for inclusive discussion on what may be various topics of interest during the panel discussion. Interested parties are encouraged to view all science presentations on the project webpage. (A summary of the panel discussion that followed all presentations is listed in Appendix I.)

b. Small Group Breakouts

Similar to the day 1 collaborative discussions, participants again self-organized into several small groups following the science presentations. The facilitation team organized tables by topics explored during the presentations. Participants then chose a topic of interest and rotated to other topics as desired. Each group explored science gaps, partnerships, and priorities.

1. From your/your agency's perspective, what are the primary **science gaps** related to this topic that need to be addressed to inform management and artificial reef application?
2. Related to this topic, can you describe key elements of successful **partnerships** and/or cooperative arrangements among federal, state, university and other researchers?
3. From your/your agency's perspective, what are the short- and long-term **science priorities** related to this topic, and how can future research be better focused?

Report-Outs and Full Group Discussion
After breakout discussions, the groups reconvened and shared highlights from their respective conversations. The following outputs capture responses presented during the report-outs and collected on note-taking sheets and poster paper provided to each group.

Discussion Topic: Fisheries Management/Reef Function

Primary Science Gaps

- Habitat use/needs by various life stages of species.

- Spatially explicit sampling of the different habitats and life stages (e.g., where is the bottleneck and how should reefs be designed)?
- How artificial reefs feed into the fisheries management process, and into science products for managers (e.g., stock assessments and fisheries allocations).
- Role of reefs—is it foraging space or a refuge? What species are actually benefitting from a particular artificial reef?
- Understanding how artificial reef habitat contributes to overall productivity.
- Understanding the type and amount of fishing effort occurring on artificial reefs.
- How natural habitats contribute to overall fisheries impact.

Key Elements of Successful Partnerships

- Identify leaders to initiate partnerships. Forged partnerships help leverage funding, streamline monitoring, etc.
- Recognize that personal relationships are the key to maintaining successful partnerships.
- Facilitate greater coordination and engagement with federal agencies in each step of the artificial reef permitting and development process.
- Ensure correct stakeholders are engaged when initiating a project (e.g., stock assessment scientists, ecologists, recreational fishing entities).
- Establish clear goals and outcomes at the outset of any partnership. Ensure accountability and engagement with all partners.

Science Priorities

- Integrate artificial reefs into ecosystem management and understand their potential role in fisheries management.
- Habitat use by various species and life stages.
- How/if artificial reefs can ameliorate climate change and species distribution shifts.
- Explore what site fidelity means for fish using artificial reefs.
- Duplicate peer-reviewed artificial reef science so management decisions are founded on robust science, and not one study.
- Establish clear goals and objectives up front so artificial reefs are designed to achieve defined outcomes. Identify who sets goals and tools used to achieve them.

Discussion Topic: Design, Siting and Deployment

Primary Science Gaps

- How to select appropriate materials to maximize ecological benefits (size, shape, concentration/density, etc.).
- Mapping the seafloor bottom to reduce potential for sinking/subsiding materials.
- Predictability and cost-benefits of using pre-designed materials versus materials of opportunity.
- Review and, when needed, refinement of stated artificial reef development goals.
- Artificial reef interaction with natural reef habitat.

- How to site reefs in shallow water without violating clearance regulations.

Key Elements of Successful Partnerships

- Demonstrate interdisciplinary capability and share resources (e.g., equipment, people, time, funds, etc.).
- Recognize partnerships are successful when:
  - ⇒ Fisheries management agencies take the lead.
  - ⇒ Partners provide information on artificial reef needs.
  - ⇒ Partners offer political leverage.
  - ⇒ The number of partners on one project is limited.
  - ⇒ Open information exchange occurs among all parties.

Science Priorities

- Design comparative studies.
- Understand the pros and cons of using different materials and site designs; keep information up to date as new technologies emerge.
- Explore how to improve access to artificial reefs and monitor how improved access affects reef ecology.
- Determine how to implement lessons learned by other countries.

Discussion Topic: Monitoring

Primary Science Gaps

- Regional-scale, scientifically sound, standardized studies (e.g., gear and methodologies that produce comparable data for stock assessments).
- More standardized, comparable studies on inshore reef sites and their ability to enhance nursery habitats.
- Baseline data on a site before artificial reef material is deployed in order to better assess environmental changes that result from the new reef.
- Standardized, baseline monitoring across regions to assess how artificial reefs are functioning over time and how they perform compared to natural reefs. Also need long-term consistent source of funding to support such monitoring.
- Assessment of changes in angling effort as a result of new deployments to reduce bias in long-term fishery-dependent surveys.
- Assessment of other user groups' activities on a proposed artificial reef site to help expedite the permit process.
- Comparable site versus system-related data.
- Clearly defined, realistic, and achievable goals for new artificial reef projects, and monitoring protocols that assess whether goals are being achieved.

Key Elements of Successful Partnerships

- Incorporate performance monitoring protocols into new artificial reef projects when applying for the permit. Helps expedite the permit process.
- Bring universities into state artificial reef programs to provide monitoring and scientific studies on artificial reef function.
- Get buy-in from other user groups on new artificial reef projects to bolster support for state programs and improve how they are perceived.
- Recognize that monitoring is an important aspect of collaboration.
- Be aware universities can assist state programs.
- Coordinate efforts through the ASMFC and GSMFC Artificial Reef Technical Committees; provides a venue for information sharing on what has worked and what has not, as well as information on new monitoring technologies.
- Consider coordination with Regional Fishery Management Councils.
- Use/share different gear types to help address monitoring visibility.
- Use volunteer divers and other citizen scientists where appropriate (surveys).
- Develop collective performance metrics.

Science Priorities

- Set clearly defined, realistic, and obtainable goals—and standardized monitoring protocols to assess those goals—for new artificial reef project permit applications.
- Outline standard monitoring procedures within permit paperwork. How is standardized monitoring determined? Via committee, use of templates, other?
- Conduct research on what material type(s) works for different species life cycles.
- Recognize monitoring and data collection feeds information to all other topics under discussion.
- Develop long-term, standardized studies that provide scientifically based answers to what is working best or demonstrate programs are meeting goals.

Discussion Topic: Socioeconomics

Primary Science Gaps

- Lack of data on user groups (fishermen, divers and other non-extractive users); inconsistency that results in lack of compatibility.
- Difficulty in setting up socioeconomic surveys and methodologies employed across regions; also poses difficulties in comparing studies.
- Use of aerial surveys.
- How to accurately consider extraneous costs, such as promoting diving and fishing at artificial reef sites.
- Ecosystem-wide socioeconomic evaluations; analysis of positive *and* negative artificial reef effects for all user groups; economic multiplier effects.

- How to measure dollar amounts by human use versus human effect on artificial reefs (e.g., scuba diving is more expensive than fishing, and brings in more revenue, but at many reefs more fishermen are present than divers).

Key Elements of Successful Partnerships

- Establish regional and national expert panels that conduct surveys.
- Learn lessons from academic partnerships. Partnerships are strong in some regions while not in others.
- Recognize up front stakeholder engagement is critical:
  - ⇒ Florida: Annual Sea Grant event organizes all regional stakeholders.
  - ⇒ Need active, frequent, and open communication.
- Integrate matching financial contributions for socioeconomic studies to instill partnerships that "go beyond words" to action.
- Capitalize on partnerships to think outside the box about development (e.g., using artificial reefs as living art).
- Share information to help create and maintain partnerships.

Looking Ahead

- Practitioners must consider existing regulated areas and sustainability of communities.
- Socioeconomics should be a primary consideration when discussing the potential of artificial reefs as fishery management tools.
- Socioeconomics is also critical to understand and implement human/user management on artificial reefs.
- How should practitioners determine what socioeconomic impacts are important for decision-making? Just because an artificial reef brings financial benefits to a single stakeholder group, does that mean it is the right thing to do?

Discussion Topic: The Good, the Bad and the Ugly

Primary Science Gaps and Priorities

- Artificial reefs as sources and/or sinks.
- Economic valuation of artificial reefs.
- Develop monitoring protocols at different scales—devise artificial reef plan based on population or local level?
  - ⇒ Establish control sites to understand impacts when artificial reef sites are fished/not fished.
  - ⇒ Conduct frequent sampling and replication.
  - ⇒ Design sampling for individual species and specific life stages.
- Recreational fish surveys: ask "did you catch fish on a reef or not?"
- Understand the role of artificial reefs in reducing natural mortality in order to relieve bottlenecks.
- California needs life history data to inform development of a future artificial reef plan (e.g., data on larval habitats).

- Design artificial reefs to target specific species.

Key Elements of Successful Partnerships

- Develop a "Best Practices" document to guide artificial reef practitioners:
  - ⇒ Perhaps update the National Artificial Reef Plan. Ensure any updates consider and incorporate regional differences.
  - ⇒ Create accessible, supplementary guidelines for small groups who do not want to utilize the full plan.
- Address issues where improvements are needed:
  - ⇒ Illegal reefs and not enough enforcement to address this problem.
  - ⇒ Ghost artificial reefs—no longer in human use but at times trap and kill turtles and other animals.
  - ⇒ Lack of expertise and training in artificial reef deployment.
- Partnerships should recognize regionally different priorities, including the purpose for applying artificial reefs (e.g., fishing, mitigation, etc.).
- Facilitate open and transparent planning processes, forge partnerships with the recreational fishing community and consider competing interests.
- Anticipate road blocks when developing partnerships (e.g., liability/insurance).

IX. Fostering Mutual Learning and Advancing the Discussion

During the last breakout, participants discussed how to build a bridge toward future artificial reef–related activities (individual and collective) based on new knowledge gained and ideas shared during the course of the workshop. Participants also discussed ways to improve communication, information sharing, and collaboration. Again in small groups, the facilitator suggested participants consider discussing the following topics, or any subject that came to mind as each group considered next steps:

- Enhancing communication and information sharing.
- Building partnerships and strengthening collaboration.
- Improving management, regulations, and policy.
- Advancing the natural and social science.
- Identifying and mobilizing resources (e.g., human, technological, financial).

The full group reconvened one final time and small groups shared workshop takeaways. The following themes and associated takeaways are not necessarily consensus-based. Rather, these outputs grew from 2 days of extensive information sharing and collaborative discussions about regional experiences, challenges, science, and lessons learned.

Management

- Incorporate artificial reefs into ecosystem-based management and marine spatial planning efforts.

- Consider arrays of artificial reef zones as potentially beneficial for drawing fishing pressure away from natural habitat zones.
- Science and management must recognize that humans are part of the ecosystem and their behaviors need to be factored into artificial reef planning.
- Artificial reefs may exacerbate problems in overfished stocks if not properly managed/enforced.
- Artificial reefs may play an important role for species success in the face of future climate change and warming ocean temperatures.
- On-the-water observations of recreational users are a valuable tool for monitoring and informing decision-making.
- Artificial reefs as a fisheries management tool needs formal recognition and regular discussion, even if society never gets to actually using them for this purpose.

Science

- Recognize "attraction/production" does not have to be an either/or question; it can be looked at as a continuum. Individual artificial reefs may produce both attributes.
- Standardize data collection/housing protocols so that information is easily accessible and usable for managers.
- Include artificial reefs in fisheries stock assessment analyses. The habitat component of stock assessment is too often (or nearly always) missing.
- Advance large-scale, scientifically based studies (e.g. monitoring, function, socioeconomics, etc.) to fill data gaps.
- Evolve state programs from opportunity-based to science-based. Target specific species and life history stages that benefit from increased suitable habitat.
- Do not let available artificial reef science go to waste because it is not perfect.
- Utilize targeted citizen science to benefit state programs.
- Recognize that now is the time to determine the role artificial reefs play in fisheries management models.

Funding

- Funds from the Deepwater Horizon catastrophe create an opportunity for the Gulf states to incorporate artificial reef research and development into applied science.
- Consider acquiring funds to integrate artificial reefs into new or revised coastal zone management plans and integrated seafloor planning efforts.

Needs and Potential Future Actions

- Create a national clearing house of information (i.e., database) where relevant, up-to-date information can be easily obtained; include information on artificial reefs, lessons learned from around the world, and video interviews with first generation practitioners.
- Be proactive with artificial reef design. For example, consider writing in pre-approved construction materials into permit applications (e.g., decommissioned bridge materials).
- Determine an effective grassroots mechanism to continue efforts from this workshop:
    - $\Rightarrow$ Several participants stated the need for more artificial reef workshops.

⇒ Several suggested using this workshop as a catalyst for continued collaboration.

- Foster consistent outreach about state programs to a variety of user groups.
- Consider using monitoring videos shared during the workshop as educational material for the general public. These videos present excellent visual demonstrations of activity occurring on artificial reefs.

Identified Concerns

- Most recreational fishermen believe artificial reefs have value, but not all resource managers are convinced. Recreational fishermen are connected to and can raise artificial reef issues in the fisheries management process. Federal agencies can and should play a role in coordinating some of these efforts.
- Conspicuous absence of commercial fishermen in this process (including this workshop).

X. Closing Comments

The facilitator thanked all note-takers, timekeepers, and those offering report-backs from collaborative discussions. Mr. Dunn thanked all participants and ASMFC, the workshop host. NOAA is pleased, he noted, to hear new ideas, connections, and possible future actions resulting from the workshop. Moving forward, NOAA will utilize the discussion outputs to evaluate its future role in considering artificial reefs as a potential fisheries management tool.

Appendix I: Presentation Q&A and Panel Discussions

A Q&A session followed most expert presentations, especially the Panel discussions. A summary of back-and-forth discussions between presenters and workshop participants, often helping to clarify key concepts or flag important issues, is included below. Readers should refer to sections above for a description of presentations that helped frame workshop discussions.

Presentation: *Artificial Reefs in Fisheries Management: Has the Time Come?*
Presenter: Dr. Steve Bortone, Gulf of Mexico Fishery Management Council (retired)

Summary of post-presentation comments, questions, and responses:

- Comment: Deploying artificial reefs in estuaries can play an important role in fisheries management. In Delaware, we have nine artificial reef sites in one bay, providing habitat for juvenile marine sea bass.
    - Response: This is an important point. Estuarine reefs are not highly touted, and more research and demonstration projects are needed in this area.
- Question: Regarding the "attraction/production" debate, is it recommended to look at whether artificial reefs are harmful or beneficial to production?
    - Response: This is a species-specific question. Both attraction and production can be studied to a degree for the species one is attempting to manage. Artificial reefs can also be multi-functional wherein the same artificial reef has different functions for several species. Some have argued it is a continuum from attraction to production. I would argue that there are at least two axes – attraction and production where you can have low and high attraction and low and high production that are not mutually exclusive characters.
    - Additional comment: The question about attraction versus production will almost always be impossible to answer unless the researcher is 100 percent sure of all activity of the reef the previous day or days (e.g., boating and fishing impacts), as this affects fish counts.
- Question: How might managers move beyond this long-debated issue?
    - Response: It is not possible to move beyond this debate, as it has embedded human elements. It is reasonable for an artificial reef to have high attraction and high production for some species; high attraction and low production for others; low attraction and high production for others; and low attraction and low production for others. Managers must decide what they want to manage for and be cognizant of the attributes of species they are interested in.

Presentation: *NOAA Ecosystem Based Fisheries Management Policy*
Presenter: Kirsten Larsen, NOAA Fisheries

Summary of post-presentation comments, questions, and responses:

- Question: Is NOAA Fisheries attempting to identify monitoring gaps as it considers how to conduct EBFM?
    - Response: Yes, data gaps will be addressed under item #2 in the EBFM Guiding Principles pyramid: "What is the foundational science we need?" NOAA Fisheries is exploring how to conduct and organize monitoring efforts and utilize data in new, innovative ways.
- Comment: Please consider the value of artificial reefs to recreational tourism. For example, artificial reefs make a significant contribution to the Florida economy.
    - Response: Indeed, there are human use benefits from artificial reefs beyond ecological considerations (e.g., recreational use/no commercial take).
- Question: Has NOAA considered the cumulative ecological impacts of introducing artificial reefs into large areas? For example, if one million acres of artificial reef habitat is introduced into a soft-sediment bottom will the entire species composition of that area change?
    - Response: NOAA scientists are currently researching this question.
- Comment: Japanese researchers have explored this topic and found it a matter of trade-offs. For example, artificial reefs in an area like this may attract octopus at the expense of reducing flounder because a large area of muddy bottom habitat was removed.
- Question: How will NOAA address monitoring and enforcement requirements, and funding needs associated with these activities, within its policy? These questions will come up when new permit requests or renewals are submitted to ACOE for review and approval.
    - Response: This is not yet known.
- Question: How will NOAA address scale in the context of ecosystems? Are humans considered as another dimensional scale in EBFM?
    - Response: Scale has been discussed at length within NOAA Fisheries. Most management decisions are made at the local or regional scale. Assessment design may initially be conducted at an individual stock level, and then scaled up to an ecosystem level as we continue to develop new models and collect needed data. Humans are an integral part of the ecosystem the way NOAA has defined "ecosystem."

Presentation: *Overview of the Regulatory Framework*
Presenter: Keith Mille, Florida Fish and Wildlife Commission

Summary of post-presentation comments, questions, and responses:

- Question: Is the second regulation listed under 33 CFR 322.5(b) "*Facilitate access and utilization by recreational and commercial fishermen*" in direct opposition to special management zone regulations that exclude use of specific fishing gear at a certain site?
    - Response: ACOE regulatory requirements provide guidance for artificial reef construction that could be used for both recreational and commercial fishing activities. In order to protect certain artificial reefs from being fished or limit

specific gear types, or to minimize conflicts between user groups, some are designated as special management zones (SMZs). For example, sometimes funding sources such as USFWS Sport Fish Restoration (SFR) require assurance that recreational fishing access at SFR funded artificial reefs will not be impeded by commercial activities, and establishment of a SMZ might be necessary to comply with those funding requirements. While 33 CFR 322.5(b) could possibly be interpreted to mean that federal agencies cannot prohibit commercial fishing, regardless of whether the fishing occurs on a natural or artificial reef, restrictions on access may be a stipulation of the funding source which is not prohibited by ACOE permits. Additionally, for areas in state waters, the respective state permit may contain proprietary authorization which may similarly mandate use limitations as part of the sovereign submerged lands authorization. It is important to make the distinction between regulatory, funding and proprietary requirements. Comment: This is should be considered during the breakout groups or at a subsequent workshop/meeting.

- Question: How much information exchange occurs between Florida and the federal fishery management council system regarding decision-making on artificial reefs?
    - Response: Very little to none. Typically, the only time the fishery management councils have been directly involved in artificial reef permitting is during establishment of SMZs, which is rare.
- Question: If all of the man-made substrates were removed from the Gulf of Mexico would fish be able to survive on remaining natural habitat?
    - Response: Human contribution to seafloor structure is very small, especially in regions where there exist large expanses of existing natural reef structure. Historical records pre-dating artificial reef development demonstrate that fish would survive on natural habitat. The question then becomes will people be able to catch fish at the same rate in the absence of artificial reefs? The species, location and the quality of the artificial reef habitat are variables for consideration too. This question is also linked to the prior discussion on species-specific management (i.e. overfishing, habitat degradation).

Panel Discussion: Regional Experiences and Lessons Learned
Presentations/panelists included:

- *North and Mid-Atlantic:* Mark Rousseau, Massachusetts Department of Fish and Game
- *South Atlantic:* Bob Martore, South Carolina Department of Natural Resources
- *Gulf of Mexico:* Dale Shively, Texas Parks and Wildlife Department
- *Washington:* Theresa Tsou, Washington Department of Fish and Wildlife
- *California:* Eric Wilkins, California Department of Fish and Wildlife
- *Hawai'i:* Paul Murakawa, Hawai'i Department of Land and Natural Resources

Summary of comments, questions, and responses during the Panel discussion:

- Question: A number of panelists cite SMZs and MPAs as tools that help managers implement, monitor, and better understand artificial reefs. What are the drivers behind designating such zones? Are they designed proactively or in response to high fishing pressure? And do any scientific studies exist that demonstrate a spillover effect from regulated artificial reefs?
    - Response: In most cases, special designations are put in place to protect artificial reefs from fishing pressure. For example, a permit application can state that an artificial reef is intended as a SMZ. It is a long, complicated process to achieve such designations. Regarding spillover effects, some small-scale studies have been conducted though nothing published to date. Additional response: Planning zones in the Gulf are linked to the rigs-to-reefs programs and are intended to assist with accurate seafloor planning. If an artificial reef was proposed outside a particular zone, or was up for renewal, it was previously possible to bypass the general permit process until regulations changed about 1 month ago. Currently, a new permit must be filed for new artificial reefs, or if new material is to be added to an existing site.
- Question: From the perspective of a recreational angler, it appears the Atlantic and Gulf coasts have well established artificial reef programs, and the west coast states have a very limited number of artificial reefs. California recently set aside a percentage of its marine habitat as MPAs, where recreational fishing is limited or prohibited in certain areas. Is there an opportunity for artificial reefs to support recreational fishing in this state?
    - Response: There is a possibility for establishing artificial reefs in California, however a state plan is needed first that provides structure and appropriate regulations. It is critical for state agencies and their federal agency partners to be aligned on these issues. Additional response: Several California Department of Fish and Wildlife staff have visited Texas and Louisiana to learn from our artificial reef programs. This kind of workshop helps improve collaboration and learning among states and federal agencies, as states primarily operate independently.
- Question: Several years ago, a research effort revealed that sport and party boat owners were deploying their own materials in undisclosed locations, often illegally, to meet client demands. Is this an issue the states are concerned about and, if so, are there any suggestions on how to address it?
    - Response: Some regions struggle with this issue more than others. There is little that can be done to prevent these activities beyond increasing law enforcement, which is very costly. Additional response: In the Gulf, particularly in Alabama, members of the public can deploy their own materials as long as they are approved. Some have recently requested fish aggregation devices (FADs), though these tools may have limited to no habitat value.
- Question: What is your source of non-public funds for unpublished artificial reef sites that serve as MPAs in South Carolina waters?
    - Response: Funding has come from a variety of sources. For example, the South Atlantic Fishery Management Council provided its own project funding.

- Question: How does liability apply for permitting unpublished reefs? Is it navigation departments, habitat preservation departments, other?
    - Response: In the south liability lies with the permit holder. Additional comment: ACOE reviews whether or not applicants are insured. Insurance is difficult for private citizens to obtain, therefore states typically become applicants.
- Question: Are efforts underway to quantify economic activity generated by artificial reefs on the west coast?
    - Response: No such studies are currently underway in California or Washington. Additional comment: One past study demonstrated that the Yukon, a sunken ship in southern California, has generated $4.5 million in revenue for the state. Similar studies have been done for rigs-to-reefs projects.
- Question: Do protocols exist for monitoring sediments for toxins that leach from materials of opportunity?
    - Response: Such protocols are established on a case-by-case basis. Occasionally the U.S. Environmental Protection Agency (EPA) will establish regulations for monitoring the leaching of toxins.

Panel Discussion: The Current State and Potential Future Direction of Science
Presentations/panelists included:

- *Ecological Functioning of Artificial Reefs with Fisheries Management Implications*
  Bill Lindberg, University of Florida
- *Planning Artificial Reefs in the U.S.: Recent Trends and Evolutionary Challenges*
  Bill Gordon, University of Rhode Island
- *Science Informing Artificial Reefing Practices: Key Findings, Knowledge Gaps, and Future Directions from the Northwestern Gulf of Mexico*
  Greg Stunz, Texas A&M University Corpus Christi
- *Artificial Reef Socioeconomics: Everything but the Kitchen Sink*
  Bill Huth, University of West Florida
- *Artificial Reefs: The Good, the Bad and the Ugly*
  Jim Bohnsack, NOAA Fisheries

Summary of comments, questions, and responses during the Panel discussion:

- Question: From a scientific perspective, what are the enabling conditions that will allow resource managers to move in the direction of using artificial reefs for fisheries management, and what does that mean for the future direction of the science?
    - Response: As fish, crustaceans, mollusks, etc. grow, they rely on cavity space scaled to their body size for habitat. Sometimes animals outgrow this space. If a species demonstrates a bottleneck related to habitat structure in their life history, installation of artificial reef structures may help alleviate this bottleneck. However, this only occurs if a very strong year class is moving through the system, and it applies only to certain species. Spatial and temporal components

must be considered in population dynamics modeling. Fisheries performance can be one indicator of artificial reef performance.

- Question: If all artificial reefs and other man-made structures were removed from the coast of Maryland, would the resident reef fish populations (e.g., black sea bass, tautog) survive on remaining natural reef? Same question for red snapper off Texas?
    - Response: Some evidence exists showing that in muddy bottom portions of the western Gulf region of Texas, artificial reefs support colonization and rapid recovery of certain species. However, there is also a high abundance of different species on natural reefs, indicating that perhaps artificial reefs have enhanced populations in this area.
- Question: What does science tell us about production potential of red snapper and gag on artificial reef pyramids, and how this potential may change relative to the proximity of artificial reefs to natural reefs?
    - Response: One paper, currently under peer review, estimates a 2 percent or less production rate of artificial reefs located in close proximity to natural reefs. Fish are being caught young, before they are able to reproduce and contribute to reef productivity. Shrimp trawls are one big source of species mortality. Others are the large size and bag limits of the fishery. If artificial reefs were installed, and fishing limited or prohibited, these structures certainly show potential to contribute to production regardless of proximity to natural reefs.
- Question: Can the panelists speak on the topic of artificial reef habitat valuation?
    - Response: A growing number of scientists are engaged in this emerging area of ecosystem service valuation. Generally, valuation is conducted from the human perspective, and the collective science community is just beginning to explore this topic. It is an area that needs more attention, and could be included in more requests for proposal processes nation-wide.
- Question: Many studies have been conducted on the role artificial reefs play relative to recreationally important species, but have any studies been conducted on how artificial reefs may support bait fish that are the food source for recreational species?
    - Response: Some researchers are interested in studying this issue. Broadly speaking, the forage base issue is an important one in fisheries management, but has not been tightly linked with artificial reefs yet. In the Gulf, some initial characterizations of food source/forage species, and associated utilization of artificial reefs, are being conducted. Not much work has been conducted looking at how cryptic species use artificial reefs.
    - Response: One must consider if humans are competing with other fish species—and by extension affecting the goals for artificial reef functionality—by fishing at the base of the food web. This also gets to the point of catching fish before they reach reproductive age. In red snapper, one big, old female fish has the same reproductive capacity as 210 smaller females.
- Question: In your view, what is needed from fisheries managers to help strengthen artificial reef science, habitat science, etc. to inform decision-makers?
    - Response: Formal program evaluation is the key. Programs should be reviewed in a formative and summative way (possibly state by state). This formal review

method is not actively practiced in artificial reef resource management. Goals and parameters for success must be articulated at the outset of any program. Resource managers and scientists must have a solid understanding of *why* artificial reef programs are successful in order to articulate that success to decision-makers. An analogy can be made to the "Sesame Street" television program, where at the end of each episode viewers are informed of the math, communication, etc. skills the children have gained. This allowed the show to obtain a large amount of broadcast funding.

- Question: Do you see any future role for the Interstate Marine Fisheries Commissions relative to artificial reef management?
    - Response: Yes, there is a role, which is already happening in the Gulf. Moving forward, the Gulf region, as well as other states, could develop consistent sampling/monitoring methods and programs to compare and analyze artificial reefs from the management perspective. NOAA has not been actively engaged in any coordination or management of artificial reefs recently. That said, the Commissions could potentially act as liaison between NOAA and scientists.
    - Response: Coordination of research is highly important. Each state agency could partner with researchers and begin replicating studies on regional or even broader scales.

Appendix II: Workshop Participants

* Workshop Steering Committee Member

Name	*Affiliation*
Alisha Gray	Florida Fish & Wildlife Conservation Commission
Amy Comer	North Carolina Department of Environment and Natural Resources
Bill Gordon	University of Rhode Island
Bill Huth	University of West Florida
Bill Lindberg*	University of Florida
Bob Martore	South Carolina Department of Natural Resources
Bob Williams*	NOAA Fisheries
Brian Nunes-Vais	Ann E. Clarke Foundation
Chris Deacutis	Rhode Island Department of Environmental Management
Chris Laporta	New York Department of Environmental Management
Chris Meaney*	NOAA Fisheries Office of Habitat Conservation
Chris Wojcik	Artificial Reef Sculptor
Clay Tam	Western Pacific Fishery Management Council
Craig Newton	Alabama Department of Conservation and Natural Resources
Dale Shively	Texas Parks and Wildlife Department
Dan Reed	University of California Santa Barbara
Dave Witting	NOAA Fisheries Office of Habitat Conservation
David Bacon	Fish Reef Project
David Fries	Institute for Human Machine Cognition
David Molnar	Connecticut Department of Energy and Environmental Protection
Dawn Hayes	NOAA Office of National Marine Sanctuaries
Dean Rewerts	California Ships to Reefs
Dean Sensui	Western Pacific Fishery Management Council
Ed Bonner	Philadelphia Army Corp of Engineers
Ed Parnell	Scripps Institution of Oceanography
Eleanore Rewerts	California Ships to Reefs
Eric Wilkins	California Department of Fish and Wildlife
Fred Baddour	Artificial Reefs International
George Frankel	Eternal Reefs Sarasota
George Sedberry	NOAA Office of National Marine Sanctuaries
Greg Stunz	Texas A&M University-Corpus Christi
Heather Coll	NOAA Fisheries Office of Protected Resources
Heather Sagar	NOAA Fisheries Office of Policy
James Ballard*	Gulf States Marine Fisheries Commission
January Murray	Georgia Department of Natural Resources
Jason Peters	Georgia Department of Natural Resources
Jeff Stephens	Water Gremlin Company
Jeff Tinsman	Delaware Department of Natural Resources and Environmental Control

Jessica Coakley	Mid-Atlantic Fishery Management Council
Jim Bohnsack	NOAA Fisheries Southeast Fishery Science Center
Jimmy Sanders	Mississippi Department of Marine Resources
Joe Weatherby	Artificial Reefs International
John Froeschke	Gulf of Mexico Fishery Management Council
Kate Spidalieri	NOAA Office of National Marine Sanctuaries
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Mark Rousseau*	Massachusetts Department of Fish and Game
Meghan Lapp	Seafreeze, Ltd.
Michael Malpezzi	Maryland Department of Natural Resources
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Monty Hawkins	Recreational Fisherman (Maryland)
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Paul Murakawa	Hawai‘i Department of Land and Natural Resources
Pete Clarke	New Jersey Division of Fish and Wildlife
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Rob Workman	Artificial Reefs International
Ron Dean	NOAA Fisheries Office of Protected Resources
Roy Miller	Atlantic States Fishery Management Council
Russell Dunn*	NOAA Fisheries
Sean Meehan	NOAA Fisheries Southeast Regional Office
Stephanie Hunt	NOAA Fisheries Office of Sustainable Fisheries
Steve Bortone	Gulf of Mexico Fishery Management Council
Steve Donohue	Environmental Protection Agency
Steve Schroeter	University of California Santa Barbara
Terra Lederhouse	NOAA Fisheries Office of Habitat Conservation
Theresa Tsou	Washington Department of Fish and Wildlife
Tim Mullane	Coleen Marine Inc.
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