2.4 Knowledge Gaps Identification

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2.4.1 Process

As was previously noted, the plenary sessions of the workshop were designed to help participants move into the working groups with a common knowledge of the state of international science in the GOM. The goals of the working groups were:

- To identify the pressing research needs/questions for the SGOM within each thematic area
- To discuss how bi- and trinational research networks might be developed

The process for organizing and structuring the working groups was planned by HRI representatives, facilitators, and other representatives from BOEM, NOAA, and NASEM-GRP over the course of several months and numerous conference calls during the last quarter of 2016 and March 2017. Working groups were organized into separate rooms by the three BOEM thematic areas (i.e., baseline studies, environmental monitoring, and fates and effects) and each working group had a facilitator from NOAA or NASEM-GRP and representatives from HRI who worked with facilitators to keep the working groups on track. Within each working group, the eight focus areas from the ESID database that were the focus of the inventory (i.e., coral and hard bottom, demersal fish, geology, infauna/meiofauna, pelagic ecology, seagrass, water quality, physical and oceanographic processes; some were combined in one or more of the working groups) helped participants organize by expertise, which facilitated the identification of unmet research questions or needs within each thematic area–focus area combination (see Appendix B). Focus-area groups within the working groups were provided with computers loaded with the draft inventory, a paper copy of the inventory specific to the working group's thematic area and large format paper worksheets to record the results of their summary of research needs within each focus area. Focus-area subgroups proposed research questions, and provided information about the research needs associated with these questions:

- What new data are needed to answer this question?
- What agency or organization is likely to collect this data?
- What existing data from the inventory can be used to answer the question?

After each focus-area group had reviewed the draft inventory, they generated a list of questions and identified potential resources available related to the data needs to answer the question. Then, each focus-area group designated a "Table Lead" that would remain at the table while the members of the focus-area group and other working-group participants were briefly rotated through the other focus areas. During these rotations, Table Leads briefed those who came to the table about the work that had already been accomplished. After the briefing, the new group of participants was asked if they had ideas or information to contribute related to items missing from the inventory, questions the focus-area group had already identified, or if they had additional research questions to add that were relevant to the focus area.

Once all working group participants within a thematic area had a chance to provide feedback to each of the focus-area groups, the focus-area groups reconvened to choose the questions that they felt were the most important to bring to their working group as a whole. Facilitators asked focus-area groups to limit the number of questions chosen from their list to three or four. A spokesperson for each group relayed the choices to the facilitator and the rest of the working group, and a list was compiled and projected on a screen so that the entire working group could see the questions. Then the working group as a whole discussed the list of questions, ultimately arriving at three questions that were either identified as the most

critical within their thematic area or that could be merged into broader questions that addressed several questions that were common or similar among the focus groups within the thematic area. These questions were then presented at the closing plenary and represented the distillation of the work by each thematic-area working group.

At the end of the research question exercise, and prior to the final plenary, each working group had a brief discussion of how GOM research networks could be established and developed that would help foster collaboration among the scientists of Mexico, Cuba, and the United States.

2.4.2 Results

All of the questions, types of new data, existing data sources, and entities that might collect data generated by each of the thematic-area working groups and focus-area subgroup are available in Appendices 2.1-2.3. Each working group approached the prioritization of questions slightly differently, so the presentation of the questions by thematic area varies somewhat. The top-ranked questions that were presented to the final plenary tended to be syntheses of several questions from more than one, or sometimes all, of the focus areas. Thus, there is no direct correspondence (in most cases) between the top-ranked questions listed under each thematic area and the larger set of questions found in either the appendices or the initial list of priority questions generated by each working group.

2.4.2.1 Baseline Studies

The Baseline Studies working group identified 17 priority questions (Table 7) from the 85 questions submitted by the focus-area subgroups (Appendix B.1). Four questions/research needs were then identified from the list and were ranked:

1. What is the current distribution and variability of benthic habitats?
2. What is the Gulf-wide connectivity of species and communities across space and time?
3. Historical reconstruction of data from peer-and non-peer-reviewed sources across all languages.
4. Determing baseline of primary and secondary production at different temporal and spatial scales, and how it relates to trophic dynamics.

The participants in the working group noted two broad themes that ran through many questions. These themes suggested three broad priority research topics:

1. Spatial and temporal distribution and habitat mapping of all groups
2. Taxonomic and genetic inventory of all groups
3. Ecological and genetic connectivity in relation to circulation processes.

The 17 priority questions were subsumed under these broad priority research topics (Table 7). However, the participants were not satisfied with the very broad questions that they ended up with, because they were too broad to be informative. Thus, the group went back to the questions and synthesized some of them into more specific questions or research needs under two broad research categories, which included mapping studies and connectivity (Table 8).

Table 7. Identified priority questions, proposed by focus-area subgroups in the Baseline Studies working group organized by broad research themes.

1. Spatial and temporal distribution & habitat mapping of all groups
    a. What meiofauna/infauna species are present at a regional scale?
    b. Longitudinal comparative baseline studies involving commercially and recreationally important fish species for entire Gulf.
    c. What are the processes driving the Loop Current intrusion, eddy separation, energy transfer from surface to the deep Gulf?
    d. What is the current distribution and variability of benthic habitats?
    e. What is the current distribution and connectivity of pelagic species?
    f. What are the local and regional impacts of sea-level changes in the GOM?
2. Taxonomic and genetic inventory of all groups
    a. What is the present land use and land cover and how has it changed over time?
    b. Can we increase the genomic database?
    c. Historical reconstruction of data from peer- and non-peer-reviewed sources across all languages in the Gulf
        i. Understand recreational fishing trends
    d. What are the baseline conditions of habitats in shallow and deep water and how have they changed over time?
    e. Connectivity studies of migratory and endangered species.
    f. Can we get access to existing bathymetric data and produce high-resolution maps of substrate types in the deep Gulf?
3. Ecological and genetic connectivity in relation to circulation processes
    a. What indicators and/or representative sites should be selected for targeted research monitoring to serve as proxies for the region? (seagrass and water quality)
    b. What is the temporal and spatial variability at different scales for community structure and species diversity? (Infauna)
    c. What is the connectivity of species and communities Gulf wide across space and time?
        i. What are the transfer rates of egg/larvae, ontogenetic migration of fish, and adult movement?
    d. What is the inventory of benthic habitat dependent species including genetics?
    e. Determining the baseline of primary and secondary production at different temporal and spatial scales and how it relates to trophic dynamics.

Table 8. Baseline Studies working group question "merge" representing the research priorities under two broad research categories—mapping studies and connectivity.

1. Mapping Studies
    a. Improved mapping of benthic resources, habitat and fish abundance, on fine spatial scales
        i. Define nursery habitat/true ecoregions based on abiotic factors
    b. What is the current distribution and interannual variability of seagrass cover; what drives variability?
    c. Where are sensitive, natural, and artificial biologic benthic habitats (corals and hard bottoms)?
    d. What is the current distribution and variability of benthic habitats?
    e. What is the current distribution and variability of pelagic species?
2. Connectivity
    a. Connectivity studies of migratory and endangered species
    b. Connectivity of species and communities throughout the Gulf in space and in time
        i. What are the transfer rates of fish eggs/larvae?
        ii. How does ontogenetic migration of fish and adult movements connect habitats in space and in time?
    c. How do circulation processes drive ecological and genetic connectivity at varying scales?

2.4.2.2 Environmental Monitoring Studies

The focus-area subgroups submitted a total of 65 questions (Appendix B.2). In the discussion of the entire workgroup to choose the priority questions, there was a great deal of overlap in the broad themes of questions if not the specifics. Ultimately, 22 questions or research needs in four categories were identified by the working group (Table 9). The four categories of research needs were submitted to the final plenary, with the following broad questions:

1. What are the priority needs [in each category] for monitoring?
2. What are the most important variables [in each category] that determine changes in the Gulf?

Table 9. Priority questions proposed by focus-area subgroups in the Environmental Monitoring working group organized by broad research themes that were identified by the working group as a whole.

1. Spatial and temporal distribution
    a. Predictive distribution modeling of infaunal/meiofaunal species habitat in the SGOM
    b. Locations, seasonality, and status of demersal fish spawning aggregations
    c. Distribution, role, and balance of lower trophic levels in SGOM (bacteria, plankton; carbon dynamics, primary production, microbial loops, HABs)
    d. Hypoxia
    e. Sufficient sediment distribution maps
    f. Benthic habitat types
    g. Effects of sea-level rise
    h. Recreational and commercial fish landings
    i. Nutrient inputs
2. Socioeconomic Considerations
    a. Assessment of coral resources
    b. Current conditions vs loss of ecosystem health: effects on fisheries, tourism and potential losses of income
    c. Conflicts and limitations between ecosystem health and economic development
    d. Water quality→ecosystem health→ecosystem services
3. Connectivity/Interchange
    a. Currents (esp. Loop Current) and distribution/connectivity of habitats, biota
    b. Intertidal→shallow water→deepwater: biota,
    c. Larval hotspots and the rest of the GOM
    d. Benthic boundary layer processes and water column, nutrients etc.
    e. Small scale and large-scale processes
4. Status
    a. Stony corals in SGOM; what are their restoration efforts and are they successful?
    b. Lionfish and other invasive species; impacts on the status of other species.
    c. Pelagic fish stocks
    d. Marine mammals, turtles, birds

2.4.2.3 Fates and Effects Studies

A total of 18 questions were identified by the working group as potential priority questions (Table 10) after discussing the more than 90 questions submitted by focus-area subgroups (Appendix B.3). This working group determined the priority questions by asking members to choose their top question. The four questions that received the most votes as the top priority were:

1. How do biota (individuals, communities, ecosystems) respond to environmental and anthropogenic impacts in space and time?
2. How are populations in the GOM connected via physical factors, chemical factors, and life stages?
3. How can environmental impacts be assessed without baseline data?
4. How do stressors, such as invasive species, ecosystem health, and sustainability, impact biodiversity?

Table 10. Priority questions proposed by focus-area subgroups in the Fates and Effects working group organized by overall ranking.
Questions in bold were those that were submitted to the final plenary.

1. **What are the environmental and anthropogenic impacts and response on biota? Multiscale (individuals, communities, ecosystems) over space and time?**
2. **How are populations connected across the GOM ecosystem: physical, chemical, and life stages?**
3. **How can environmental impacts be assessed without a baseline?**
4. **What are the impacts of stressors on biodiversity, including invasive species, ecosystem health, and sustainability?**
5. What are the main sources of stressors on water quality in the SGOM and northern Caribbean Sea?
6. What are the vulnerable areas of coral, hard-bottom, and seagrass and how can they be quantified, understood, protected, and restored?
7. How do we evaluate the effects of environmental variables vs the effects of pollutants?
8. How could we develop national standards based on international best practices that involve calibration of different methodologies from different research focuses?
9. How do we manage cross-national fisheries (pelagic): population structure and the impact of pollutant mixtures?
10. What are the relationships between human activity and coral, hard bottom, and seagrass ecosystems?
11. What is the pelagic community structure and function across different Gulf habitats?
12. How can we use current observing capabilities to determine the eddy variability in the SGOM water column?
13. What are the impacts of fracking technology on water quality?
14. What are the seafood safety issues and associated human health impacts across regions?
15. Are demersal fish populations resilient to disturbance and how can it be tested?
16. What is the cross-shelf and along-shelf transport variability in the SGOM?
17. What are the atmospheric heat momentum and mass fluxes in the SGOM?
18. Does the Benthic Index for the Campeche Sound (BIC) work in the northern Gulf?

2.4.2.4 Network development

Each of the working groups discussed the following questions and compiled a list of recommendations:

1. How should Mexico, Cuba, and the United States work together [on issues related to the GOM] in the future?
2. How can a network of professionals and scientists be formed?
3. How can program planning activities and logistics be facilitated?

The answers provided by all three working groups are presented in Table 11, Table 12, and Table 13. Several themes emerged. First, the need for student and research exchange among countries was recommended as an answer to all three questions. One respondent noted that exchanges of graduate

students are particularly important because they will begin building their networks with potential collaborators in the other countries early in their careers. Another theme was the need to develop bi- and trinational working groups, communities of practice, and data sharing mechanisms. This theme speaks to the heart of the mechanisms by which working relationships and trust can be built. Finally, the issue of funding was also pervasive. The success of efforts to develop bi- and trinational research infrastructures hinges on the availability of adequate funding and joint funding opportunities.

Table 11. Compilation of answers to question Question 1 concerning the development of research networks among Mexico, Cuba, and the United States to facilitate cooperation and collaboration on GOM research.

Question 1—How should Mexico, Cuba, and the United States work together [on issues related to the GOM] in the future?

1. Identify specific sites/habitats/areas to be studied and invite interdisciplinary participation by researchers from throughout the Gulf of Mexico
2. Create international panel/intergovernmental panel/interagency panel/on Gulf of Mexico sustainability
3. Provide travel support and funding for bi- and trinational partnerships
4. Support joint funding calls (e.g., NSF/CONACYT, BOEM/Fondo Hydrocarbon) or other requests for proposals that require US-Mexico or US-Cuban collaborations
5. Collaborate on proposals
6. Promote peer-review publications with large, multinational collaboratives of Gulf of Mexico researchers
7. Identify funding sources, share funding resources, and publish papers together
8. Convene workshops where experts from all three nations would work together to produce white papers on the current status of a given problem
9. Establish an informal “International Commission of the Gulf of Mexico”
10. Hold in-country data workshops so that data could be presented and then added to a data repository, perhaps GRIID-C
11. Convene a working group to combine data from all sources to improve habitat classification and mapping throughout the Gulf of Mexico
12. Carry out joint stock assessments for shared stocks and comanage fisheries
13. Include SGOM in the NOAA Ecosystem Status Report
14. Organize exchange programs for scientists and students

Table 12. Compilation of answers to Question 2 concerning the development of research networks among Mexico, Cuba, and the United States to facilitate cooperation and collaboration on GOM research.

Question 2—How can a network of professionals and scientists [working on issues related to the GOM] be formed?

1. Networking by general topics or research interests
2. Be efficient and use existing networks – for example, Facebook, ResearchGate
3. Create topical workshops to provide a venue for experts to meet and collaborate and for nonexperts to learn
4. Create a structure similar to the CloTOP program which operates worldwide—it has no dedicated funding but has been very successful
5. Invite more scientists to submit a profile to GulfBase so that people can contact potential collaborators more easily
6. Have GulfBase in both English and Spanish
7. Turn GoMOSES conference into the Gulf of Mexico International Science Conference
8. Student and researcher exchanges
9. Standardize Gulfwide monitoring methods and protocols
10. Form an association of marine laboratories in the Gulf of Mexico similar to the National Association of Marine Labs (NAML) in the United States
11. Build communities of practice around subject matter expertise
12. Create a trinational version of Texas OneGulf

Table 13. Compilation of answers to Question 3 concerning the development of research networks among Mexico, Cuba, and the United States to facilitate cooperation and collaboration on GOM research.

Question 3— How can program planning activities and logistics be facilitated?

1. Develop trinational working groups for specific issues
2. Funding opportunities that will allow scientists from all three countries to meet
3. Hold an annual conference (or side meeting at an existing meeting) that rotates between the United States, Cuba, and Mexico, e.g., ONEGULF Summit.
4. Offer field trips at meetings to foster collegiality and so that scientists can learn more about the other areas of the Gulf of Mexico.
5. Carry out joint research cruises to maximize ship time, facilitate collaborations, etc. and include multiple projects on a cruise, if possible
6. Student and researcher exchange programs
7. Strategy exchange with partners that addresses management, science, education, hydrocarbon development, and MPA issues
8. Agree that if autonomous scientific equipment roams into waters of the other Gulf of Mexico countries that it will be allowed to swim home
9. Allow cross-border transport of scientific specimens and research equipment
10. Bi- and trinational data sharing, especially stock assessments of shared fisheries stocks

2.4.2.5 Final Plenary

The entire workshop reconvened in a final plenary session so that facilitators could give a brief presentation of their working group's research priorities. Though not unexpected, all three working groups submitted research priorities that addressed overarching themes of biotic and abiotic connectivity, status and distribution of biotic and abiotic components, and effects of stressors. Perhaps the best description of the priority research needs in the GOM was the final question posed by the baseline studies working group: "What's where and how does the Gulf of Mexico work?"