The Chairman's Report opening comment has to be that overall the Panel was extremely positively impressed with the quality of the ecosystem science being done in the NOAA SE Regional Fisheries Laboratories. The projects are well chosen, linked well to client needs; their ecosystem content is rich and well conducted. Possibly more important for a healthy ecosystem science endeavour, the scientists and their diverse partners are excellent – enthusiastic, articulate, and have a vision for their work. Those qualities would not characterise the science projects and people that do them without supportive and committed leadership. In any review, it is necessary for the Panel to focus on opportunities for improvements and expansion. The comments that follow will be of that nature, but should not be taken as proposals to bring the ecosystem work up to scratch. They are ideas of how to make work that is good and often excellent better and more secure.

Theme 1 – General Context

In various ways all the review team found that although the individual projects and groups of projects we saw here excellent, there was no *overall* Strategic Plan for where ecosystem science in the Region should be heading, and how it was going to get there. None of the Panel members thought a tight and binding strategic Plan was needed. In fact, some observed such a Plan would be a drawback because creative flexibility would be lost, and all Panel members who expressed views on creation of an organization such as an Ecosystem Science Division separate from other organizational units thought the idea lacked merit. Everyone has a place in an ecosystem approach to marine and coastal science, and whatever their job they should be thinking in that framework.

Nevertheless, notwithstanding all that has been accomplished within individual projects – and in cases like the coral reef programs some considered the work on the global cutting edge – the progress has been to some extent opportunistic and may not be secure. For true ecosystem approaches to the types of complex science issues being investigated, there is too little secure funding, and too little technical foundation that would survive changes in funding priorities of current partners. There are a number of ideas for how to address these needs in the reviews of the Panel members. To keep the creativity we saw in the current programs, they need to stay bureaucracy-light and expert driven, like the coral program, the tuna and menhaden work, and the restoration work. But some overarching vision for how progress can be collective rather than project-by-project might facilitate both more ambitious planning (ambitious in the science, not solely in the anticipated funding) and better communication with clients and partners of what deliverables they could feel confident of receiving.

Theme 2 - DATA

All scientists feel their time series are too few and too short, but in general the Panel was positively impressed with many aspects of the data. This is particularly the case for data on habitats and some of the pressures on them, and for many aspects of the upper trophic levels in these systems, particularly the coral reef systems. There were greater concerns about data on lower trophic levels, early life history stages, and oceanographic properties, and a variety of suggestions are made in the reviews for improving these data streams. Many involve greater access to and use of high tech advances now available to the ocean research community (but some require additional technical support). In various contexts several of the reviews also highlight the need for more regional approaches to data management and ensuring data availability. Particular concern was expressed that there seems to be large amounts of Deep-Water Horizon- related data that have never been analyses beyond at the most descriptive levels (if at all). Unused data do eventually become unusable, and in other cases data series that were analysed by different experts for different reasons now may exist in multiple copies with undocumented differences among them. Both situations degrade the value of one of science's most fundamental assets.

Several reviews also noted that the data and information shortfalls in the social and economic sciences are even greater than the overall shortfalls in data and information in the physical, chemical and biological sciences. This is hardly a novel observation, and is recognized by NOAA leadership. There has been some hiring of expertise in the social sciences, but it will take far for capacity than is currently available to meet the needs for social and economic information in the many ecosystem projects underway or contemplated in the SE. There were a few suggestions for progress in this area, including more attention to drawing information from local and indigenous knowledge systems.

The review Panel members also took note of the concerns expressed during discussion panels and the poster sessions that many data are known to exist but are very difficult to access. Acknowledging the special legal circumstances associated with some data from the Deep water Horizon work, and confidentiality issues associated with commercial data at the level of individuals, otherwise full and ready access to data should be routine. Where this is not the case, coordinated action from NOAA leadership is required.

Theme 3 – Models

Several concerns arose in the reviews with regard to modelling. The quality is generally excellent and some, such as the tuna work, again world-leading. But project teams seem to work largely independently, and there is a need for much more support in many areas, such as the Gulf of Mexico and to support the restoration work. Moreover, potential synergies with

strong oceanographic modelling experts in other nearby institutions, particularly AOML, and in other regions are underutilized (and possible not used at all). This is inefficient.

Downscaling of regional and global climate models and their products was a particular concern. Downscaling is complex scientifically and hard to validate effectively. Also downscaling initiatives seem to be being done independently in multiple projects, sometimes even overlapping with each other geographically. This is both inefficient and possibly scientifically suboptimal.

It was also noted by several of the Review Panel members that the more serious modeling projects envisioned here would require significant enhancements of access to high power computers. This will particularly be the case if the strengths of ensemble modelling, which some Panel members felt was being under-utilized, were to be tapped into. Serious efforts to build appropriate partnerships or otherwise get access to this power is needed.

Theme 4 – Inclusion in Management Advice

All Review Panel members comment ed positively on the apparently strong linkages between the ecosystem science projects and the potential clients in management and policy agencies. The fact that the linkages were strong, however, does not ensure either the scientists know what ecosystem information to provide to the management bodies, nor the managers know how best to make use of the ecosystem information they receive. Focused work on the science-policy interface was highlighted as a need in most of the reviews, again with a variety of ideas for how this interface should be strengthened. Several involved more use of Management Strategy Evaluations, but that is neither the only path forward, nor is it a single pathway but rather a way for framing the interface that makes it particularly tractable to some model-based approaches.

Some of the reviews also highlighted that if both science and management wait for ecosystem-based science advice with reduced overall uncertainties and even lower risk of any possible imperfections in management decisions, these will be just research projects forever. At some point before perfection, the leap to using the ecosystem-enhanced advice in informing management decisions will have to be taken.

It was also observed in several of the reviews that, planned or not, the region seems to backing into place-based management approaches perhaps faster than some of the other NOAA Regions. This reflects several factors - the great importance of habitat quantity and quality in ecosystem dynamics in the Region, the many pressures from both natural and anthropogenic factors on those habitats, and the strengths of habitat expertise in both the science and

management communities here. The Review Panel members consistently viewed these as strengths in the region, but also as opportunities for much greater integration of habitat considerations into management advice, in fisheries and in other areas.

It was also noted that the basis for prioritization of efforts to address different management concern were unclear. For example, because of the total biomass taken by menhaden fisheries, even fairly small bycatch rates (as a percent of the menhaden catches) may actually be a much greater pressure on some of the bycatch species than is posed by some of the ecosystem processes being studied systematically. Clearly complete and readily accessible data on total catch composition (species and sizes) is necessary for all fisheries, to set a context for prioritizing other ecosystem pressures on commercial and protected species.

Theme 5 Communications

Overall the Panel members found the level of collegiality within team to be very high., and this is a great strength. However, the fragmentation among laboratories in the SE Region, and sometimes even among different projects at the same laboratory, is a real concern. Aside from the serious impediments to exchange of ideas and information arising from the restrictions on travel, no Panel members could isolate specific impediments to greater communication among projects and Centers, but neither do there seem to be real structural incentives to interact. With some many projects surviving on insecure funding sources, it might be that such “business models” inherently draw teams together tightly, but keep project members focused on their funders’ needs and not on opportunities to share expertise, or at least knowledge, with participants in other projects.

It was noted in various ways in several reviews that more interactions and communication outside the Region, with other NOAA research centers and with international communities, should be encouraged. Lots of possible ideas for increased communication were suggested, but all as “work a try” rather than “pretty sure it will succeed”.

Reviewer Report on Program Review of Ecosystem Science

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Background

The Southeast Fisheries Science Center (SEFSC) has excellent and committed staff – federal employees, CIMAS (Cooperative Institute Marine and Atmospheric Studies) employees, and other arrangements. The commitment to the mission was evident in all the presentations, both verbal and poster, and from the discussion panels and informal conversations. From this foundation, the future for ecosystem science, and science in general, at the SEFSC is bright. The whole team should be congratulated for an excellent job presenting the ecosystem programs at the SEFSC to the review panel.

Up front, I apologize for the superficial nature of my review. The amount of information was large and I recognize the ecosystem activities at the SEFSC are actually broader and deeper than presented. I could make a number of detailed comments and could discuss science, challenges, and potential solutions with each presenter and panel member. But I interpret the emphasis of the review to address over-arching issues and to identify strategic paths-forward rather than a detailed review of each program element presented. I am happy to talk further with SEFSC Directorate or staff on any of the specific elements. Because of my individual interest in climate change, I will provide separate comments on the Climate Regional Action Plan and share the Northeast version to the SEFSC when a draft is available.

General Observations and Recommendations

Ecosystem science - by its nature - requires integration and collaboration across multiple scientific disciplines and within and among institutions and organizations. Additionally, ecosystem science links across all NOAA Fisheries mandates: fisheries, protected species, habitat, and aquaculture, and allows the identification of trade-offs and interactions among these different mission elements. It is also my strong-held belief that tactical assessment and management cannot be accurately completed without a broader understanding of the ecosystem. Further, the continued pursuit of tactical management, without a strategic, ecosystem viewpoint, can actually decrease the ability of the agency to reach longer-term goals; three of the four key objectives of the Magnuson-Stevens Act are longer-term than providing annual catch limit advice: prevent overfishing (short-term), rebuild overfished stocks (medium term), increase long-term economic and social benefits (long-term), and ensure a safe and sustainable supply of seafood (long-term). Thus, in my view, the dichotomy between stock assessment and ecosystem science is false. NOAA Fisheries must do both to meet its fisheries mandates and must include ecosystem science in its other mandates.

From this perspective –recognizing the value of fisheries work and broader ecosystem work - there are five options for moving forward. 1) Maintain the current balance between fisheries and ecosystem work

(maybe an 85:15 split) – a status quo option. 2) Increase ecosystem work at the expense of single-species assessments (for example a 60:40 split), arguing that this will improve stock assessments in the long-run and better support other mandates (e.g., Endangered Species Act [ESA]). 3) Decrease ecosystem work in favor of stock assessments (for example a 95:5 split), thereby providing our primary customers with more tactical advice. 4) Argue for more resources to do both (95:25 split). 5) Look for efficiencies by doing both (a 70:20:10 with the 20% in parallel).

Most of the pressures on the SEFSC described during the review, would support the first or third alternative. The Fisheries Management Councils (FMCs), while supporting ecosystem work, were very clear that more assessments were a priority. This implies that for the SEFSC to make progress on the long-term goals of Magnuson-Stevens Act , the importance of ecosystem work must be continuously communicated to fisheries stakeholders and the inherent trade-off as a result of limited resources most be identified as one barrier, but not the only barrier, to improved stock assessments. Given the pressures from fisheries stakeholders, the third alternative is hard to justify. The fourth alternative is the preferred option, but unlikely given the current budget outlook. However, to increase the possibility of the third or fourth alternative, the SEFSC needs to expand its partnerships with stakeholders and groups interested in other NOAA Mission elements; demonstrating the excellent work that is being done, while also identifying the barriers to expanding these activities. If the SEFSC wants to expand ecosystem activities in the short-term, which will contribute to its assessment activities, the fifth alternative provides the only avenue forward. This will require greater integration and coordination across the SEFSC. This will also require a defined commitment to ecosystem activities from the SFESC Directorate. This is not to say that the SEFSC is not committed, but during the review, there was a degree of uncertainty in the future of ecosystem science at the SEFSC that was expressed by many of the presenters.

Based on the above analysis, the main issues are:

- Building collaboration and partnerships within the SEFSC, within the region, nationally, and internationally
- Communicating results and strategic vision internally and to external partners and stakeholders
- Defining, prioritizing, and implementing a vision for Ecosystem Programs at the SEFSC
- Continued efforts to receive internal and external funds for priority ecosystem science

There was a discussion about a potential change in organizational structure: an ecosystem division. In my opinion, structural changes in and of themselves do not address the core issue – how to conduct ecosystem science that is relevant to the NOAA Fisheries mission. Leadership (Directorate, Division Chiefs, and Branch Chiefs) must define common goals that are supported by staff and stakeholders. If consensus on a plan forward can be reached within the SEFSC, then the organizational structure is less important.

At times during the review, I felt as if I were sitting in Woods Hole or in Narragansett. Many of the challenges are similar and this suggests a national response rather than, or in addition to, a SEFSC response. I know that a national examination of program reviews is planned, but I have specifically identified issues that I feel are national issues, as well as SEFSC issues.

The last point is that the more planning, process, tracking, communicating and consolidating that is done, the less science is done. Thus, the value of any new initiative needs to be carefully weighed. For example, the SEFSC may want to develop a database of ecosystem activities to be able to track and report, but the value of this new administrative structure needs to be weighed against the cost of lost

science time, and maintaining the information. As another extreme example, staff could be asked to report daily on their ecosystem activities to keep everyone up-to-date, but no one would have time to read these daily reports and a daily report would take time from the true work of staff. This is obviously a ridiculous proposition, but the natural inclination is to develop new structures and processes within an organization, but these have costs that need to be carefully considered before they are implemented.

Key (Specific) Findings and Recommendations

Theme 1 – Management Context and Strategic Planning

Observations

- The SEFSC servers a number of organizations: 3 FMCs, 2 Marine Fisheries Commissions, 8 States, 2 Territories, 1 Protectorate, International Commission for the Conservation of Atlantic Tunas, Southeast Regional Office, to name some.
- There is clear tension in the resource allocation among NOAA Mission elements and more broadly ecosystem science.
- There are a number of issues confronting the SEFSC, but no clear prioritization beyond fisheries (ESA, invasive species, aquaculture expansion, bycatch, oil and gas development, water diversion).
- There is a different level of effort among the Gulf of Mexico, Southeast U.S. Shelf, Caribbean and Tropical Western Atlantic.
- The SEFSC needs to recognize that it is backing into place-based management (oil and gas activities, artificial reefs, National Marine Sanctuaries, National Estuarine Research Reserves, fishery closures, offshore aquaculture).
- There are communication issues within and among laboratories. I introduced staff working at the Miami Laboratory during the poster session who had been at the lab for >5 years, but not meet. Also, the comment was made during the review that interactions between Galveston and Miami were at the level of reading each-others papers. These are two specific examples and may not accurately reflect the issue of communication within the SEFSC, and the Directorate should make their own evaluation.

Recommendations to address issue

- The benefits of ecosystem science to stock assessment should be summarized and communicated to fisheries stakeholders regularly. As they ask for more ecosystem science, the argument for more support for ecosystem science becomes stronger. Also, as they see the value of ecosystem system, the demand for single-species assessment may reduce.
- Develop an “issue” prioritization for the SEFSC and then communicate to staff and partners. Explain prioritization is based on current financial resources.
- Develop a clear view of strategic partnerships for each of the SEFSC laboratories. These partnerships should be developed by laboratory leadership and an engagement strategy developed. These partnerships and strategies should then be accumulated by the SEFSC Directorate and when and where possible, time invested on strengthening these relationships. Several examples emerged during the review including The Nature Conservancy and Miami Water Keeper. This does not need to be a time-consuming and comprehensive effort. A couple hours of brainstorming and then a discussion among laboratories. Follow-ups with partners could be a conversation identifying areas of joint interest and possible collaboration.

- Develop greater interaction with the Northeast Fisheries Science Center and the Chesapeake Bay Office. There are a number of overlapping issues: movement of stocks from south to north, Highly Migratory Species, shallow-water habitat research, ecosystem modeling, vulnerability assessments, Integrated Ecosystem Assessments, stock assessments, aquaculture, protected species issues, etc. There is cooperation, but it is more ad hoc. Perhaps an initial discussion of overlaps and interest based on NOAA Mission Elements.
- Provide an opportunity for staff from like-minded programs to interact, for example the coastal habitat work in Florida and Texas/Louisiana. These opportunities can be direct, have people from Florida travel to Texas/Louisiana, or indirect, arrange for staff to attend the same third party meeting and request that they spend some time discussing their programs.
- Opportunities should be developed for out-of-the-box thinking, for example, approaches for coral conservation under the ESA or evaluating the effects of the Turkey Point outflow. These don't need to be restricted to the SEFSC and the SEFSC can be involved or can lead depending on the issue.
- Develop a list of potential funding opportunities and communicate to staff annually with a list of SEFSC priorities. The GMFMC Executive Director indicated that the Deepwater Horizon Oil Spill Restore funds and climate change funds will be large drivers for ecosystem science in region. The SEFSC is developing a Regional Action Plan. How much effort is there to be competitive for Restore Act funds, either directly or with partners? What other funding has been obtained by SEFSC historically – past 5 years.
- Don't limit the amount of non-base funds coming into the Center, work to channel the proposals going out of the SEFSC to high priority issues. There is a huge amount of work needed to support NMFS customers. We should leverage, partner, and collaborate, to the greatest extent possible; seeking non-base funds needs to be part of this strategy.
- Work with NOS on place-based mapping (http://marinecadastre.gov/data/). Ensure fisheries related marine zoning is included.
- Working with SERO, hold workshop on defining the science needed to support offshore aquaculture in the Gulf of Mexico. A perspectives paper could be developed and published and used to raise awareness regarding the issues and the lack of funding. The NEFSC has aquaculture expertise that could potentially be contributed.
- If SWAT teams or Working Groups are formed, to the extent possible include a range of expertise from data to analytics to social and economic scientists. This will be problem dependent, but SEFSC could consider moving forward on a problem that will require social and economic dimensions to encourage the interactions.

Theme 2 – Ecosystem Data

Observations

- There is a huge amount of data collected in the Gulf of Mexico by the SEFSC. There are also sampling programs in the Southeast U.S. Shelf, Caribbean and broader Tropical Western Atlantic. Further, the statement was made that NOAA Fisheries is the biggest collector of Ecosystem Data in the Gulf of Mexico. This seems to continually surprise much of the marine science community.
- There are opportunities to collect more data to support the NOAA mission at marginal cost.
- The GMFMC and SAFMC focused heavily on the importance of data but also emphasized the important of gaining a better understanding of the ecosystem and mechanisms affecting fishery population dynamics.

- The use of long-term data and experimental design in the Florida Key reef fish monitoring program and the coral program were excellent and serve as an example of the utility of formal hypothesis testing to management.
- The importance of maintaining taxonomic expertise was raised several times, as well as the value of using genetic techniques to contribute to species identification.
- The importance of litigation-quality data was stressed during the Deepwater Horizon (DWH) presentation.
- The integration of social science and economic data is happening. The degree is difficult to evaluate in part owing to the upcoming review of these programs next year.

Recommendations to address issue

- It is clear that data management is an issue. Examples came up during the DWH and the Ecosystem Status Report (ESR) presentations. This is not isolated to the SEFSC. Given the NOAA Fisheries is generally the largest collector of biological data in U.S. LMEs and that IOOS predominantly collects physical data, there is an opportunity to work together. However, I do not believe that the IOOS model of data standardization works for NOAA Fisheries biological datasets; a distributed system with software that integrates data from different database structures should be considered. Also, the SEFSC does not need to design something; there are options where SEFSC could be submitted and served (e.g., http://www.bco-dmo.org/). This is a national issue.
- The ESR, Integrated Ecosystem Assessment (IEA), and DWH efforts rely on substantial quantities of data; some of which are managed by the SEFSC and most of which are not. There are new computer science tools for handling distributed data and for handling data provenance (e.g., https://tw.rpi.edu/web/project/ECOOP). It might be worthwhile for NOAA Fisheries to review these tools and provide the review to each Fisheries Science Center. This is a national issue.
- The adequacy of SEFSC IT resources should be evaluated for supporting mission critical activities. As SEFSC moves into oceanographic modeling, more complex population models, ecosystem modeling, and climate modeling, computer needs (storage, processors, and bandwidth) are going to increase. Working with CIMAS to use UM computer services may be an option.
- Food habits seemed to be limiting the development of Atlantis in the Gulf of Mexico and the multispecies model for Atlantic Menhaden. The SEFSC should consider adding a Food Habits program to the SEAMAP trawl and/or trap surveys in the Gulf of Mexico and along the Southeast U.S. Shelf. These additions may be supported by the GMFMC and SAFMC.
- The SEFSC should identify positions that provide core-taxonomic skills and then ensure that those positions are continued. Similarly the SEFSC should identify core-ecosystem positions and ensure that transition plans are in place.
- The SEFSC should consider developing a research plan, not elaborate, but a document that describes important needs from a research perspective. Scientists could then base proposals on these needs to limit mission creep resulting from the dependence on external funds for many of the ecosystems programs.
- The value of habitat maps was clear from the reef fish work in the Florida Keys. The SEFSC should work with collaborators and partners to develop habitat mapping initiatives along the Southeast U.S., Caribbean, and Gulf of Mexico if they do not exist yet.
- Evaluate opportunities and barriers for citizen science. Example of working with REEF is excellent. Could scientists be brought in from Caribbean nations for participating and training

through TNC thereby increasing regional capacity and helping the SEFSC? Maybe some of the other partners could provide contract staff to support SEFSC science.

- Consider integrating SEAMAP CTD operations with NOAA OA data needs in collaboration with AOML (Rik Wanninkhof).
- Keep working to integrate social and economic data in ecosystem, fisheries, and endangered species, activities. This takes communication, integration, and understanding across disciplines.
- During debrief the discussion of fishermen knowledge, a workshop was described, which sounded very productive. There are ways to quantify this type of information if the SEFSC is interested (e.g., http://www.nsss.eu/).

Theme 3 – Ecosystem modeling and analysis

Observations

- The modeling and analysis work described during the review is excellent: the Gulf of Mexico IEA, the Gulf of Mexico Ecosystem Status Report, the analysis of the Deepwater Horizon Incident, the Gulf of Mexico climate forecasts, the development of a red tide index for use in stock assessment.
- One of the discussion questions reflected a general skepticism to the value of including environmental data in stock assessments. There were also excellent examples of the inclusion of ecosystem information in stock assessments: HAB index in the Gulf of Mexico and multi-species modeling for Atlantic Menhaden. There are many ways to use environmental information in stock assessments and tension between stock assessment and ecosystem science needs to be addressed.
- The SEFSC is developing an MSE capability in the Gulf of Mexico. This will be a valuable tool for the region.
- The whole Atlantic Menhaden approach is an excellent example of using an ecosystem approach in a single species context. It involves stakeholder engagement, partnerships, modeling, analysis, data, etc. It can serve as a case study for future efforts.

Recommendations to address issue

- The prioritization of issues in the Gulf of Mexico IEA presentation was excellent (Kelble). This might be a good approach for making one step in terms of defining science priorities in the other LMEs where the SEFSC has responsibility (Southeast U.S. Shelf, Caribbean, Tropical Western Atlantic).
- NOAA Fisheries could lead a discussion of the use of ecosystem information in stock assessments. The issues of hindcast, nowcast, and forecast should be included. As should multi-species and the use of general ecosystem considerations. This is a national issue as well.
- The idea developed during the review (probably developed before the review) for formal working groups to address specific issues. This is an excellent idea and supports the general matrix approach to ecosystem science. My recommendation would be to start with one issue and develop Terms of Reference for the group. Allow them to complete their work, evaluate the process, and iterate. Issues to consider are that participants get value, supervisors approve of time and effort, an end product is defined, and the end product is of value to ecosystem science at the SEFSC.
- Richard Merrick's idea – develop links with NOAA Ecological Forecasting initiative to predict hypersaline events (NOS/NWS) in Biscayne Bay

- Moving to model ensembles; so not only dealing with one model, but dealing with multiple models. This needs to be on the radar screen.
- Use OSSEs to optimize fisheries sampling. This idea is not well developed but could work with the OMOC center at RSMAS.
- Potentially take advantage of the ESRL summary of AR5 IPCC models (http://www.esrl.noaa.gov/psd/ipcc/ocn/). There is a high-res global climate model that was developed by GFDL (http://www.gfdl.noaa.gov/high-resolution-modeling). Also, USGS is developing watershed models for use in climate change studies (https://profile.usgs.gov/markstro).

Theme 4 – Incorporation into Management

Observations

- A number of excellent examples of ecosystem work supporting management decisions: Rozas shrimp habitat information to stock assessment, Bohnsack fish counts to stock assessment, Miller coral work to ESA support, and more.
- The statement was made that strategic advice is not asked for, which begs the questions, why would NMFS consider providing strategic advice. This may suggest a reluctance to provide strategic advice, but given many of the objectives of Magnuson-Stevens Act, Endangered Species Act, Marine Mammal Protection Act, etc are long-term, strategic advice is needed.
- All of the posters were excellent, but I found two particularly innovative. Mapping of threats in St. Croix by Social Science Research Group staff and involvement in the IGEL Program by Galveston Laboratory staff. These two could be scaled-up in support of broader ecosystem goals.

Recommendations to address issue

- GMFMC advocated for stepwise approach – build from successes. I concur with this approach and the SEFSC has been following this approach. So I think the SEFSC is on the right track. However, the comment was made that once you incorporate ecosystem advice, you will likely need to continue the provision of the advice and may need to apply to other situations. This is a double-edge sword: a success that than takes even more resources to maintain. The work in question was funded by FATE (the Harmful Algal Bloom [HAB] example). FATE funds development but not operationalization of new approaches and this is a major flaw in the FATE and other HQ funding programs. This argues for a redesign of this HQ funded programs; perhaps slowing down on development funding and providing some operational funds to the Fisheries Science Centers for successes.
- Might consider PSA for Caribbean fisheries as a way to provide some information for a lot of species (http://fishbull.noaa.gov/1083/patrick.pdf)
- The examples of management successes could be written-up as a review for publication to show the progress made in the Southeast. This supports Theme 5.
- Could evaluate the Texas/Louisiana approach for informing the shrimp assessment for use in Florida
- Could increase cooperation with Flower Gardens and Grays Reef National Marine Sanctuary and expand approached developed in the Florida Keys.

Theme 5 – Communication and Peer Review

Observations

- Individuals at the Miami Laboratory view themselves as the Southeast Fisheries Science Center and individuals at the other laboratories feel a degree of isolation from the Southeast Fisheries Science Center and from the other laboratories. This is an issue in any Fisheries Science Center with multiple laboratories and contributes to a lack of integration and collaboration.
- The SEFSC-AOML Workshop sounds very rewarding; but represented the Miami Laboratory and AOML (http://www.aoml.noaa.gov/phod/meetings/load.php?pFullStory=20140529_20140529_aoml_sefsc.htm).
- The publication record of many of the programs was excellent. However it was difficult to evaluate the evenness of publications across SEFSC staff and across the ecosystem programs. Most were peer-review publications.
- The ability to travel is limited and the SEFSC covers a large expanse and stakeholders cover an even larger expanse.

Recommendations to address issue

- Consider "alternative" methods for communication particularly for among laboratories. NOAA has approved Google Hangouts, which allows video links between individuals. New types of communication could be experimented with and then pros, cons and lessons learned shared with all staff.
- Consider opportunities for staff to strengthen professional relationships. Joint projects, even small things, between laboratories can help people get to know each other. Could also set up formal rotational assignments between laboratories or between stock assessment groups and ecosystem groups. These could target a priority topic within a given year.
- Could spread future reviews around the SEFSC to engage Center staff – this would likely cost more (travel) but might be worth it in terms of within SEFSC communication and integration.
- Could fund one inter-laboratory seminar speaker per lab, per year.

Other

Observations

- The review was very well run. Combination of presentations, panel discussions, and poster was excellent.
- Tenuous nature of a lot of the programs described – activities supported by multiple sources over time. Many seemingly important activities have 1 or a handful of FTEs.

Recommendations to address issue

- Because the "whole program" was not presented, a conceptual diagram or roadmap to show "where we were" in the ecosystem programs.
- Evaluate the activities that the SEFSC wants to continue, wants to build, and wants to end. This is hard, but necessary.

Conclusions

The state of ecosystem science in the SEFSC is strong. Most of the programs are directly related to the NMFS Mission and producing useful products. The down side is that pretty much all of the programs reported funding limitations. Many excellent programs are supported by a handful of FTEs, with the remainder soft money CIMAS staff. There is also a high degree of uncertainty. Do the stock assessment programs and marine mammal programs express the same degree of uncertainty? If the answer is no,

then communicating the importance of ecosystem science and the level of ecosystem science that will be supported is critical. Also, providing a small amount of support to help these PIs compete for funds will be important; you want to avoid mission creep, but if the goals of ecosystem science at the SEFSC are clearly stated, PIs should be trusted to pursue opportunities that are in line with these goals.

I very much appreciate being involved in the review and thank you wholeheartedly for the invitation to participate.

Review Panel Member 2

Before the specific observations and recommendations on each Theme, I wanted to stress that overall the quality and relevance of the ecosystem working being done by the SE Fisheries Science Center and its many partners is excellent.

It is the nature of reviews such as this, that commentary focuses more on opportunities for improvement or expansion of efforts. Such a focus within this report should not be taken as an overall critical view of the Region's ecosystem science. Very much the opposite. All the presentations, panel discussions and the posters were impressive. But we all also know that we face a long road ahead, as we grapple with many complex science challenges. I hope some of these thoughts and ideas are helpful as that the Regions and its partners face those challenges.

Panel Member's Major Recurrent Observations and Recommendations

Theme 1 – Management Context and Strategic Planning

- Observations

1.1. Overarching Scope of Planning
The opening morning highlighted and many presentations reiterated that in all three ecosystem, but particularly Gulf and SE US there are many anthropogenic pressures on these marine and coastal systems. Also the coastal communities and industries have many values attached in various ways to the marine ecosystems and their resources. Some of these values are based on commerce, but also some important ones are cultural and aesthetic. Even if this review is about SE Regional *Fisheries* enter science, for only a few components of the ecosystem (and often only some of their life history stages) is fishing the dominant anthropogenic pressure (and this is far more than just the Deep water Horizon event and its ecological legacy in the northern Gulf)

The Science leadership clearly appreciates this reality. Nevertheless, against this overarching backdrop that fisheries is only one of many pressures, there were a number of occasions when the science leadership (and "leadership" defined inclusively, no intent to make this solely a local issue) retreated behind "mandate". This was done to justify approaching the planning of science to be done more narrowly than the scope of the challenges that need to be addressed, and particularly the application of science results in contexts too narrow for success. Pressures outside the mandate of NOAA, and NOAA Fisheries, may well be externalities for budgeting, and actions at the project implementation level. But they are NOT externalities at the scale of the ecosystem dynamics being studied and which need to be taken effectively into account in development of management options for the anthropogenic pressures that are within the NOAA and NOAA Fisheries mandates.

1.2 Overall Greater Emphasis on Habitat

Several of the individual sessions were largely focused on marine and particularly coastal habitats - both their properties and dynamics and the pressures on them. In addition, even in the sessions with other central foci, habitat issues were often present in the presentations and discussions to an extent that I have not seen in other ecosystem reviews in which I have participated. First of all, I want to stress that I took this as a strength of the SE Region. Based on what I saw and heard during the week, and the background material that I had read, in the SE Region, both coastal/estuarine and reef habitats *are* the major ecosystem concern. Certainly physical oceanographic processes in the offshore and water column, trophodynamic relationships among species, etc., are all important in the Ecosystem Approach. All these factors have a role. However, habitat quality and availability are a dominant factor not just to the reef communities but also to key life history stages of many of the taxa in the Gulf and coastal systems. In addition the increasing density of human population in the SE, and the diverse anthropogenic pressures, both land-based and in the near-coastal and reef areas, seem to be dominant forces on the larger system dynamics. These anthropogenic pressures are only going to increase in the future, and sound science documenting the linkages of these forcers to marine and coastal system dynamics is going to be crucial if the living marine resources can be conserved, used sustainably, and protected. Even if this coastal work receives disproportionate support compared to other Regions, the support is fully justified.

Having made the point about the importance of this work, there are areas where it can be strengthened in at least focus, potentially even in a time of limited budgets.

Some of the potential for increased focus is a manifestation of the point in 1.1 – There are impressive linkages between the coastal habitat work and data sources and managers of *some* (far from all) the land-based pressures on these habitats. However, these need to be expanded even in the restoration projects, to be sure all the major pressures, land-based and water-based, are brought into consideration in science and management. In the Gulf and the Caribbean even more scope (and need) exists to get these pressures included in the studies of these system dynamics. Similarly there is more scope of work on ways that the habitat dynamics – changes in both quality and quantity of habitats – is used in assessments of marine and coastal populations (and, when managers are ready, communities). There is excellent work being done on increasing our understanding of what the linkages are – some in a fairly completely DPSIR framework. Now we need to see more attention to how to *use* the increasing knowledge in the science advice to decision-making about how these resources are used – whether in fisheries or other uses. I think we have more information than we are using about the extent of seasonal and interannual variation in quantity and quality of these estuarine, near-coastal and reef habitats, and at least some insights into what that variation means for populations, species and communities. We need to find more convincing ways to present this knowledge to fisheries and other managers, and that includes better ways to link the habitat dynamics to the decisions they have to make among options for management.

1.3 Getting "forgiveness" to do the ecosystem work

Throughout the week, it was clear that the motivation to expand the ecosystem context of all the research, assessments, and advice exists in the SE Region. It is shared by the science community, their full leadership cadre, many of their management clients, and a substantial part of civil society. Likewise there is lots of competence to do the work, and even some of the resources – never enough, but more than can be used right now – just as there are more ecosystem data available than are being analyzed, and more analytical results than are being used in advice and management. What is missing is *time* - time from routine single species assessment work for "feeding the insatiable mandate beast" to add more ecosystem content to all the work being done.

It has to be accepted at all levels of NOAA from Headquarters leaders to rank and file biologists that the hunger of the "mandate beast" will never be satisfied, even if there were more staff all working even more of their evenings and weekends as well as their day jobs. The ecosystem content *cannot* \ be thought as as something added on after the routine work is all done, to incrementally add value to the products of the routine work. The ecosystem products *themselves* have to serve some of the needs currently being served by these routine assessment products. It is not BOTH routine products and ecosystem content – it really is "either – or."

The forgiveness to make time to do the ecosystem work can only be won by showing the managers how they can do the jobs they are expected to do as well and ideally better, with advice based on more integrative ecosystem information than lots of piecemeal information, tailor-made to each specific stock and fishery.

This is actually a challenge for Science as well as management, but it goes to the heart of making the case for EBFM. The individual products *will* take longer to produce and require input from more experts. The payoff is that the more costly products have to be more valuable, and they can be. Done right, they do NOT need to be tailor-made anew for every stock and fishery. They are really ecosystem-based science and advice for ecosystem-based management decisions. The full suite of needs of the "mandate beast" are satisfied (or at least met as well or better than they are now; the beast will stay insatiable for ecosystem advice as well) by fewer, richer products of ecosystem approaches to the science.

This will not be an easy journey for science or for management to take, but it we take it together, it will be easier than either group going alone and hoping the other will catch up some day. Neither can it be a protracted journey, if we are to really move from business as usual to EBFM. We need a strategy to take it together

- Recommendations to address issue

1.1. Leaders need to encourage planning approaches which more completely reflect "full ecosystem thinking" in terms of the human dimension of the ecosystem, not just ecosystem thinking about the bio-physical dimensions. (noting that all the right things are being said about humans being part of Ecosystems). The fact that NOAA cannot control water

releases in the Everglades Canal or flows and quality of runoff from the Mississippi or Rio Grande, does not make it scientifically sound to treat these factors as constants in scenario development. This will be a huge challenge for leadership accountable for adhering to budgetary mandates. However if not overcome in imaginative ways, a lot of other excellent ecosystem work will bear little fruit (however low or high it hangs and ripe or green the fruit may be)

An actionable short term item might be to have the planners of ecosystem scale work in the South Florida restoration projects, and the coupled physical oceanographic – biological modelers in the Gulf charged to find plausible scenarios of management decisions likely to be made by the water managers in Florida, and by agriculture and water use agencies in the major drainages of the US Midwest and Texas/Northern Mexico respectively, and include these as forcers in scenario developments for their work. The outcome sought is whether the probability of success of alternative management options for the managers that are NOAA clients in the restoration and the fisheries work in those systems, is contingent to an important amount on decisions made by other managers that are not direct NOAA clients (at present), but get to make their decisions ahead of the decisions made by the managers to whom NOAA Fisheries is providing support.

1.2 Beyond the general recommendation to maintain and where possible expand the habitat science being done in the SE Region, particularly in estuarine, coastal, and reef habitats, there should be specific work targeted at a slightly different type of management strategy evaluation for fisheries decisions – and decisions made by managers of other pressures on these marine and coast systems. Rather than MSEs that explore sensitivity of advice to model and parameter uncertainty in the current assessment models, and to multiple hypotheses of what the fishing industry or nature may do in future, these MSEs would be exploring how the decision matrix presented to managers would look different, depending on how the quantified habitat information (changes in quality and/or quantity of estuarine and reef habitat, for example) might be used in decision-making. Combined with appropriate retrospective performance testing of the information in the decision matrices, insights might emerge about how best to use the habitat information in actual management. (These retrospective performance tests might be something like developing decision matrices as per standard MSE best practices, with two sets of decision tables – identical in assumptions about the decisions, but differing only in one table having the estimates of outcomes of the various decisions as predicted / forecast /estimated by the models using the habitat data in various ways, and base matrices have the same range of decision-choices but not using the habitat information in any direct way.

1.3 As a start on the journey, global experience in places where jurisdictions have started to take the real journey down the path to ecosystem-structured advice for ecosystem-based fisheries management (and not just fisheries) should be reviewed. A few success stories AND a few less than success stories with similarities to the challenges of the SE Region should be selected. Experts from those experiences should be invited to join with SE Regional experts and managers to discuss the international experiences in the context of relevance to the SE Region. A couple of pilot cases in the SE should be chosen jointly by science and managers – ones where the incremental ecosystem value is likely to be high,

but not under an intense political spotlight, and then the leap of faith should be taken with the pilots. Do the ecosystem based advice and science to support it *first.* Have it ready for the managers, in forms they agree they can understand and potentially use. And see what happens. In an ideal experiment, the business-as-usual assessments should be done as well, for a full comparison of the strengths and weaknesses of each approach. But if time really is the greatest constraint on what is possible to undertake, for the pilots planning should err on the side of getting the ecosystem work done, even if the single-species work is incomplete. This suggests choosing pilots where some key potential ecosystem influences are already suspected – not ones where everyone is guessing in the dark about what the ecosystem influences are important. Get this work ready, even if the single-species work isn't all ready. Then see if we really are better off or not. If we are, we have a case for more forgiveness. If we aren't, there is more foundation work to do somehow, outside the applied realm, before we try again.

Theme 2 – Ecosystem Data

- Observations

2.1 Social and Economic Data.
There are few if any parts of the ecosystem where we have sufficient data. Everyone needs more monitoring, longer time series, and greater breadth of coverage. But the greatest shortages of information are in the social and economic aspects of the ecosystems, their resources and their uses. For the same reasons the habitat issues are so important in the SE Region (see 1.2) this information is probably even more important to have available in the SE than in other NOAA Regions (except possibly the Pacific Islands). And for the same reasons, the "valuation" approach to socio-economic input to these marine and coastal ecosystem studies will be even more inadequate in the SE Region - and not just the Caribbean part of it - than in other Regions. Many of the values for residents of these coastal areas are cultural and aesthetic, and monetized in very artificial ways, of at all.

The presentations by and discussion with the very few social scientists working for or with NOAA in the SE Region showed tremendous enthusiasm and competence, but the only scale at which they can work is extremely local. Their studies, even if incomplete, are providing very valuable information, with obvious implications for improved advice to managers. But without a major rethinking of what role the social sciences are going to really play in the Ecosystem Approach on the SE, they will be doomed to either or both continuing to work only at these small scales on specific cases (where the work will be excellent, but for every success there may be dozens of comparably needy cases going unaided) or professional burn-out.

Given how many of NOAA's challenges in the SE Region (and elsewhere, but particularly the SE – see 1.1) are rooted in human decisions – and how many of those human decisions may not be consciously about the ocean and its resources to begin with) a strong social science presence is a requirement, if all the natural science work is going to really pay more than minor benefits.

- Recommendations to address issue
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2.1 There are no quick fixes here. Hiring more social scientists in an obvious step. But it will not be sufficient. There will have to be serious discussion at several levels of NOAA about how to acquire and use other knowledge systems in adding to the information on how human well-being in these areas is affected by (or its pursuit affects) the marine and coastal ecosystems . These experts also need to be much more integrated into ecosystem research teams on scales from local to coastwide.

Theme 3 – Ecosystem modeling and analysis

- Observations

3.1 Model parameterization.
Again, before going into observations of places where improvement might be desirable, I want to stress how impressed I was with the quantity and quality of modelling being achieved with an extremely limited team of experienced modellers. It is truly impressive, I was somewhat troubled however, with the approach to model parameterization being taken in some (very far from all) cases. This is particularly true of the trophodynamic modelling, but not exclusively there. We were reminded repeated over the week (and correctly) that the SE Region is comparatively data limited when compared to some of the other NOAA Regions. This tends to make even careful modellers grasp at insufficient data as better than no data at all, when they really want to run a model – particularly process-based models. (For statistical models, inadequacies in the parameterization data are more likely to show up at least in the model outputs and often even in the process of trying to develop the models.) In process-based models data deficiencies in parameterization can be less visible, particularly if the model structure is logical, and "results look logical" is about the level of model validation that is applied.

I will acknowledge at this point that within the trophodynamic modelling community I am considered to have quite high minimum standards for input data – both intensity of sampling and resolution of the data in space and time. But I base my standards on years of work with very extensive data sets, and the insights from that work about all the potential biases in model performance if the data were not adequately representative on the scales at which the models operated in space and time, and in resolution of predators and prey by species and size. Anyone from a Peter Yodzis background would have looked at the food web picture we saw in one of the presentations and noting that no single prey dominates the diet of almost any predator, would draw the conclusion that the whole system is mathematically in determinant. This indeterminacy in the predator-prey interaction data can be overcome by hard-wiring relationships into the model but then the model can't tell the user community anything other than that the model will faithfully output whatever was wired into it. That actually tells users very little about trophically mediated system responses to external pressures on the system.

On a much more positive note, there are alternatives. I was very impressed with the extent of use of Individually Based Models in looking at system dynamics, in the SE Region on many scales. This is particularly attractive given the potential importance of habitat factors in system dynamics, and IBMs allow their inclusion better than many other approaches. The IBMs are amenable to inclusion of predator-prey processes as well. This avenue might be the preferred option in most SE Region modelling studies that include trophodynamic interactions.

In addition, I was pleased to see the interest functional groups as an alternative brute-force species-based modelling. However, the internal dynamics within the functional groups (or "portfolios" have their stochastic processes, as well as possibly some internal rules. Simply treating a function group as a mega-species – with ecological compensatory processes acting almost deterministically at the portfolio, exchanges a disaggregated misrepresentation of system relationships for a more aggregated mis-representation of them. Good functional group models are no easier than any other good model.

- Recommendations to address issue

3.1a. The extent of geographic and possibly seasonal bias in diet sampling should be reviewed in all the diet data used to parameterize trophodynamic models. Unless the bias is small (and I think it is large) its effects on model performance should be invested rigorously before the data are used in models whose results are going to be taken as representing system trajectories.

3.1.b IBMs that are robust in representing the both the species (actually life history stage of species) – habitat relationships AND the predator – prey (taking size and species, as appropriate, into account) should be priorities for true performance validation. If they perform well, they should be the default option for at least applied ecosystem modelling efforts. In modelling efforts intended to test hypotheses about ecosystem processes, of course the model has to be compatible with the processes being tested, and sometimes IBMs may not be – or only compatible with extensive adaptation. Even so, more rigorous validation of the theoretical models may also be a wise mode.

Theme 4 – Incorporation into Management

- Observations

4.1 Baselines for assessments of change and attribution of causation
Many presentations through the week highlighted the difficulties of assessing change and attributing impacts, due to the lack of baseline data. This is a real problem everywhere (not just the SE Region of NOAA) and not easily solved completely. The experts making the presentations and NOAA leadership are clearly thinking about approaches to improve baseline information, which is laudable. However, the thinking seems canalized as developing solid time series of data for a set of selected ecosystem components (physical oceanographic measures, abundance of key life history stages of key species, key structural

features of "habitat") at key places in the SE Region. Such selectivity is unavoidable because there will never be sufficient resources to monitor everything everywhere. Moreover it is clear that a lot of thought and appropriate analyses are being done to choose the ecosystem attributes and places to monitor wisely.

This work is excellent science and should be encouraged. However, I fear it will provide adequate baselines for assessing change and attributing impacts in only a subset of the cases where such baselines are going to be needed in the future. In an area with what we were told is the most industrialized coastline in the US, with a wide range of natural and anthropogenic pressures, we cannot foresee today what events in the future may be episodic crises or new or dramatically altered pressures on these marine and coastal ecosystems. The data we saw on the time trend in number and depth of oil wells in the northern Gulf and the Deep Water Horizon crisis illustrates this point well. The experience of the IPCC in assessing GHG emission trends and drivers, and in a somewhat similar marine ecosystem context, the North Sea, an additional strategy was used and has proved useful in benchmarking. A year was chosen to serve as a historical benchmark year. The choice was made taking into account what information was available, and although to some extent had to be arbitrary, it at least provided a focus for as full a description of the relevant systems as possible at that point in time. The selection provided a focus for both pulling together known data sets and "data archaeology" – checking all the old records of information from scientists' shelves and library storage. Doing this for long historical periods is very time consuming, but having a focal year greatly increases efficiency. Such legacy data sets for a particular year (or window of years) can actually become a magnet for people to contribute other legacy data, knowing they may actually be used. Once the data assembly was as complete as possible for the particular window of time, there were projects and workshops to try to identify ecological linkages, DPSIR relationships etc, to the extent possible, and the descriptive type of "Integrated Ecosystem Assessment" or very extended "Ecosystem Status Report" for that historical time window was published. Uses of such historical benchmark time points have included adding substantial interpretational value to time series that have been maintained since the benchmarking year, retrospective performance testing of process and statistically based ecosystem models (whole or partial) parameterized with more recent data, added context to more recent studies of ecosystem structure, function, and responses to alternative pressures, and other uses.

Such historical benchmarks have limitations, of course, but so does reliance only on time series benchmarking where there are few time series and they are often only a few decades long (or less), and they may not track the species ecosystem features or places most relevant to a research or management question. In the case of the North Sea, there was even a "North Sea revisited" benchmarking exercise undertaken, to describe and where possible quantify, how structure, function and processes in the North Sea changed from one benchmarking year to another about 25 years later. Many experts feel that the comparison of those benchmark years provided a number of useful insights into the relative importance of different anthropogenic and oceanographic forcers on the whole systems – insights that were difficult to extract from looking at a few pairs of complete time series for linkages of trends.

4.2 - Throughout the week, managers from Fisheries Management Councils and other decision-makers / users of advice were included in the Panels. This was extremely helpful and the organizers of the session are to be particularly thanks for those efforts.

I was consistently impressed with how receptive some Council members and other decision-makers were to having ecosystem content in the advice that they received. Depending on the circumstances it may be more or less clear what they should do with the ecosystem information once they have it (and "depending on circumstances" includes both circumstances about the nature of the ecosystem information and the nature of the advice which it accompanies or is imbedded in, and the circumstances of the governance environment in which they will make their decisions).

At the same time, several times Panelists, mostly, but far from exclusively, from NOAA Science, referred to the possibility of providing model-based decision tables to their clients in management. The nature of the decision tables was never spelled out in detail, and requires some thought (see observation and recommendation 1.2). This seems an ideal time for the assessment and management communities to sit down together and start exploring the different types of Decision tables that could be presented to the Councils and other managers. Columns in these tables could be different scenarios about the state of key ecosystem / environmental attributes in the coming management time window (e.g., during next year's fishery) [the uncertainty about future states of nature], and/or different assumptions of how the ecosystem / environmental information is affecting the resources about which the decision is being made [uncertainty about the ecological processes]. The rows of the Decisions table could include multiple properties of the ecosystem and reflect the consequences of the various decisions available to the managers.

4.3 In the discussions of including "ecosystem relationships" in assessments and advice, there was little focused discussion of exactly what aspects of the "relationships" would be part of the assessment and advice. However, it seemed to be that thinking is largely along the lines of inclusion of environmental covariates in the assessment models. This *de facto* centers the "ecosystem information" on getting the accuracy (better first moment) and precision (second moment) of the things already being quantified with assessment models not containing the environmental covariates. There was some discussion that the ecosystem information might not actually improve accuracy all that much (unless there is a very strong and directional environmental signal, rather than seasonal or interannual variability), and not so much *reduce* uncertainly as *explain* why the uncertainty is present. There was some Discussion that a possibly different way to use environmental / ecosystem information in advice to management is to use the environmental information to estimate the probability of some undesirable event coming to pass or undesirable state being experienced for the resource were the environmental event to occur that year. This would be a different way to formulate the advice to managers – decision tables contingent on future states of nature, and likelihood of those states of nature. However, such decision tables *can* be used in management. Moreover, if there are other managers (for example, perhaps those who manage water releases, such contingency decision tables can form a

basis for dialogue on the interdependencies of decisions between the water managers and the fisheries managers, specifically at the times when the decisions of the water managers might have particularly important consequences for the options available to the fisheries managers. Such dialogue is going to be increasingly necessary for sustainable use and conservation of the SE Regions marine and coastal ecosystems (see 1.1) - One might as well start preparing now for them.

- Recommendations to address issue

4.1 A workshop might be held to simply review if there would be a year back in perhaps the 1980s or 1990s, when a coordinated exercise to assemble both systematically collected ecological data and all the opportunistic data sets that may exist, plus data on types and levels of as many pressures as possible (all the DPSIR cycle, in fact), for such an integrated historical benchmark assessment. If feasible, I think it should be conducted, but the feasibility assessment is the first step.

Regardless of whether or not the data consolidation, archive integration and assessment is conducted for a historical benchmark, there should be consideration given to undertaking such a benchmarking year in the near future (or very recent past). The Ecosystem status reports being prepared already are an excellent start on such a "Year of the Gulf" or "Year of the SE Coast". However, they have an important role in informing a broad range of audiences of what is happening in their ecosystems. Hence they extract and explain the messages that *right now* are our best judgement of what is important. The benchmarking exercises are a legacy, acknowledging that we do not know now which data, which relationships, and which forcers, will be the ones may be considered important a decade or two into the future. So this is a legacy for the future expert community rather than the public, and more encyclopedic than synthetic. But it may be a legacy the next generation of experts thank us for.

4.2a A series of informal meeting (informal in the sense of being exploratory and non-binding on any participants, not "informal" in the sense of not being taken really seriously by them) should be scheduled between managers and NOAA experts to discuss both the technical feasibility of developing various types of Decision Tables for use in advice (as described in Observation 4.2) and from the management side, the likelihood that the Decision Tables could actually be used in either tactical or strategy decision making.

4.2b Based on feasibility and utility in 4.2a, a few pilots should be identified and conducted in the next 2-5 years. These pilots would not be just illustrative science demonstrations that the tables could be developed. That is not in doubt. They should carry through to use in the decision-making process, to see if they do in fact lead to more explicit inclusion of ecosystem information in the decisions, and more acceptance by civil society of decisions that have ecosystem content explicitly in them. As part of these pilots, social scientists should be included from the outset, to be able to actually evaluate management effectiveness (sensu the GEF) of such Decision Table approaches.

4.3a. From the historical information in the region on occurrence of episodic extreme events, a few case histories should be selected for study. The study should include evaluation of how large the impact of the event was on the resource(s) about which management decisions were made, the simulated magnitude of the impact of the event on the resource(s) had other management decisions been made, and the abilities to have estimated the likelihood of the environmental event, prior to its occurrence.

4.3b As in 4.2a (and possibly in the same dialogue) and taking into account the results in 4.3a, the feasibility of having advice include the likelihood of specific environmental events that, if they occur, should be taken into account by a managers choices among the options in a decision table.

Theme 5 – Communication and Peer Review

- Observations 5.1

It was surprising how often groups of experts from one place or speciality professed little awareness of even what is being done in other sites or specializations at the same site. This was not universal, of course, but it was far more widespread than it should be, given how "breaking down stovepipes" has been a goal of every NOAA leader for decades. The stovepipes must be very deeply anchored to be so resistant to change.

It is simply obvious that whatever is being tried is not working in general. The more successful cases of greater interdisciplinarity seem to share a couple of traits – local geography of activities, and science that easily aroused passion in the researchers (e.g some of the coral reef projects). This is great when and where it happens, However it can only be a model for all of NOAA when we find a way to make all of NOAA work as passion-inspiring as protecting beautiful coral reef systems.

We need more incentives and I don't know what they would be. But I fear seminars, collective coffee breaks, and webpages are not enough. Everyone we heard from and talked to was doing extremely interesting work, and could speak about it with enthusiasm and often passion. Why many in the science community apparently are not insatiably curious about the work of the others around them, and just seeking out people with expertise they want to at least discuss their ideas with mystified me. Someone else has to address this problem.

- Recommendations to address issue

Other

- Observations
- Recommendations to address issue

Conclusions

Observations/Comments (Reviewer # 3)

In the section that follows I will attempt to address the specific set of overall questions posed to the reviewers in the terms of reference and provide specific observations and recommendations where possible. Since not all such fit within this framework I will then provide a bulleted list of additional comments more or less following the sequence of the presentations made to us during the review. Last, as requested, I will provide some overarching comments on the review process and its implementation.

Sincere apologies in advance if I have made naïve assumptions about the business and practice of fisheries management. I look to my fellow reviewers to provide corrections in that regard.

TOR Questions:

Q1

There is really no integrated Ecosystem Science (ES) program. There is therefore no strategic plan overall unifying all these activities nor in my opinion does there need to be except in the loosest sense. That said, every project briefed to us had clear goals and objectives. A better question is whether sufficient ES is being conducted by the Center to support each of the diverse mandates of NMFS and the SEFSC ES activities need to be evaluated primarily from that perspective. They are (in general) fully integrated with operational responsibilities and the ES investigators were all well aware of how they were contributing to the NMFS mission. **My personal view is a separate ES would be counterproductive (as would an ES Division) and contrary to the concepts of EAM or EBFM but that for the Stock Assessment (SA) folks to become more fully engaged will require some assistance/resources not with respect to ES but with their core responsibilities thereby "freeing" more of their time and attention.**

Q2

Based on what we heard from the Management Panel (and inferred from the individual presentations) most activities are directly addressing a management priority either "within" Fisheries (SERO and the FMCs) or outside (FKNMS, DEP, CERP etc.). That said, their needs are great and they are looking for a great deal more assistance and timely information. With respect to SERO, it was clear that greater Habitat input relevant to Port Development activities in our region and EFH would be more than welcome, with respect to CERP, more NOAA support is needed by the SEFSC for monitoring relating to specific water management projects already coming on line (or about to do so) in that these are primarily being sustained by diminishing reimbursable funding (USACE). **I am hopeful that the designation of Biscayne Bay as a habitat focus area will bring more resources to the SEFSC to support such activities.** The issues with respect to **coral reef ecosystems** (and the FKNMS) are very similar in that long term monitoring widely recognized as invaluable (as well as critical research into species resiliency to temperature and pH increases and recruitment controls) seems to be **entirely dependent upon**

short term programmatic competitive funding. This model is simply not sustainable and is not appropriate with respect to such core NMFS responsibilities. Moreover unique "local" to the SEFSC resources (the coral groups at the Atlantic Oceanographic Meteorological Laboratories (AOML) and the Rosensteil School of Marine and Atmospheric Science (RSMAS), the new Marine Technology Life Sciences Center (MTLSC) at RSMAS which has many of the capabilities of the Australian center one presenter highlighted are not as a result fully utilized.

Q3

There is no regional Climate Strategy as yet but a team is working on creating one. It is in a very early development and to date only addresses the Gulf of Mexico neither the Caribbean nor South Atlantic areas of SEFSC responsibility. **I agree that without question a systematic overall vulnerability analysis needs to be performed on time scales relevant to the changes anticipated and this needs to be done in all three subregions**. We did hear about some specific issues that already merit attention. **These include, potential loss of nursery habitat in the Northern Gulf of Mexico given freshwater marsh/wetland replacement by mangroves due to SLR and anthropogenic alteration of upstream water flows; potential changes in Loop Current strength and northerly extension (notably this will affect both the GoM and the SATL subregions); changes in Mississippi River discharge (and water quality) and elevated water temperatures in coastal waters with respect to species unable to shift their distributions north (or offshore).** There would appear to be lots of opportunities for information and methodological sharing between the IEA effort (which should also be extended beyond the Gulf of Mexico) and the Climate Strategy effort. To date this does not appear to have happened to the extent one might expect. Moreover only a very small fraction of the potential contribution of AOML (and RSMAS) climate scientists has been tapped in developing the regional strategy. I note that both (and other academic, ngo and industry experts) are being involved in the SAFMC effort to develop its climate strategy.

Q4

Data requirement are enormous and the distribution of data (in time and space) is very uneven. The DWH presentation highlighted this problem in that the available biological, physical and chemical data was insufficient for NRDA purposes and not just because it was not "litigation ready". The field and modeling efforts made were laudable but the absence of a rigorous baseline pre-DWH presented an enormous, in some cases intractable, challenge. **It would be more than unfortunate if all the data and samples collected were not analyzed, what one presenter called a "post-mortem" were not conducted and if the new funding coming to the Gulf over the coming decades did not support a comprehensive integrated Gulf-wide monitoring effort (by integrated I mean biological, physical, chemical measurements AND models).** Absent SEFSC leadership this will I fear not happen. I concur with the presenter and note that **where models are available that serve operational needs, an OSSE can help** and note that the SEFSC may be uniquely positioned in that regard in that its AOML and CIMAS neighbors have a joint OSSE and Ocean Modeling Center responsible for the first ocean

circulation OSSEs (atmospheric weather OSSEs have been common practice for more than a decade) and this was a Gulf of Mexico centered effort. Since the OSSE process requires commitment to an operational model that is a caveat.

Q5

With respect to ecosystem processes (indeed large scale cumulative impacts/changes) no specific regional programs are in place other than the long time series of SEFSC biological sampling programs on which we were briefed. SABRE and NECOP (in both of which SEFSC played a major role) were "one offs", there is no Southeast FOCI nor GLOBEC. **There is no question that the annual surveys need to be continued and thoughtfully integrated into a comprehensive monitoring program. It was apparent (and recognized by the nascent regional Climate Strategy group) that there is an enormous cost effective opportunity to piggyback** additional biological (lower tropic level typically), physical and chemical sampling using the survey platforms and this is true both in the GoM and SATL.

I was also very impressed by the ambitious Atlantic Menhaden multispecies SA approach which seemed to be off to a great start. It truly can become an EBFM poster child. That said to an outsider, this raises the unmentioned issue of **Gulf Menhaden. That is still an enormous (by poundage) fishery of a key forage fish with a small but significant bycatch of more valuable fishes. It is a situation crying out for a rigorous analysis of the economic returns of different management choices.**

Q6

I take this question to mean specifically, advice provided to the three Fisheries Management Councils. It would appear that the different Councils to whom the SEFSC provides advice take somewhat different approaches to ES and have a different receptivity to ES advice. In one case it appeared that the "environment" only made a marginal difference (the rule they were following limited the change to 1 or 2 % I believe) although the GMFMC representative did ask for more "fisheries independent" data. On the other hand, we heard examples from Richard Merrick about the wide latitude that Councils can in principal exercise and my own participation in a SAFMC strategic exercise suggests a lot of interest in climate scales and as well as offshore deep reef ES. We were provided no real "oceanographic" examples in this context, and perhaps on the time scales relevant to FMC decisions there are few possibilities at present in the SE. One participant observed, there are no major El Nino/La Nina related upwelling shifts that simply cannot be ignored). **As noted above with respect to Q5 I believe there are clear opportunities for inclusion of species interaction (predators/prey) ecological considerations in SAs and believe that really does need to be done along with consideration of oceanographic factors or indices where that is strategically necessary as well as where they improve prediction on the relevant (to FMC requirements) tactical time scales.** As in other systems, many oceanographic processes are likely to have tighter relationships to the success of

fast-growing short-lived species. In this last vein I wondered that while SABRE was cited a few times, no mention was made of one of its' conclusions (that recruitment across the shelf into the estuarine nurseries of NC depended upon a favorable circulation regime at just the right time). Is it possible that this process relationship has "tactical" applicability?

Q7

I can't comment here since I have no knowledge on the topic but am told this is inherent to the SEDAR process.

Miscellaneous Observations:

- Shrimp groups in the SEFSC at both the Galveston and Miami laboratories were appeared clearly generating information and models that either were already or potentially could be fruitfully incorporated into tactical SA advice.
- I really like the project on Bluefin tuna that applied downscaled climate models but caution it is very much a first step and limited in potential application. One, unless the circulation model is itself truly eddy-resolving there is a real chance of getting major system processes wrong in the Gulf. Two, given the significance of freshwater input and buoyancy driven flows in the Northern Gulf both improved resolution and a wider geographic scales are required to simulate probable changes in this highly dynamic system.
- I am strongly supportive of the use of simulation testing to understand the utility of incorporating ES data into SAs. That is a necessary conservative approach. It is the management equivalent of doing OSSEs with respect to observing systems.
- HMS work in the tropical Atlantic has the opportunity to leverage a lot of other NOAA efforts and focus (OAR, NESDIS in particular) and this has only begun to be tapped.
- The opening of Cuba given its size and proximity to both Florida and the U.S. Caribbean needs to be explicitly considered. Recent SEFSC cruises and participation in MarCuba2015 (and the NOAA MOU establishing Sister Sanctuaries) are exciting first steps.
- Partnerships will be the key to SEFSC success re. Ecosystem Science and the time may be ripe for joint funding initiatives with local NOAA partners (in particular NOAA/AOML and the NOS/FKNMS).
- We heard a lot about insufficient communication and I would encourage SEFSC leadership to facilitate every opportunity to enhance communication within your geographically dispersed workforce. Personally I love the idea of "virtual coffee break" assemblies. I recognize the problem is exacerbated by the overall NOAA restrictions on travel (and using SKYPE with government computers).

- Risk assessment can often serve as mechanism to focus management attention for ES even where it is hard to show immediate benefits in improved short term catch setting predictions. I encourage this approach.
- The scientific argument about whether environment indices or observation can improve SA's is very much a self-fulfilling prophecy dependent upon the species biology and the process/times scale of management decision making and actions. There is little doubt of strategic utility while tactical utility is variable.
- Social science data to address many of the issues raised by ES is simply not available yet despite recent efforts in recent years to ramp up SEFSC capacity in this regard. Such daa will not be cheap or be easy to obtain. Even simple examples (decrease forage fish harvest to get more predators = X extra dollars) quickly get complex in part because not only the "natural" ecosystem but the economy is highly dynamic. There is also a major scaling problem between available biological, physical and social data and this will take time and money to fix.
- There appears to be a dearth of foundational ELH research (in fact of fisheries independent data outside bottom trap surveys) in the SATL in comparison to the GoM. The U.S. Caribbean is in even worse shape in this regard.
- Ensemble analyses of increasingly complicated biophysical models will require SEFSC to get improved access to High Performance Computing platforms. A short term solution might be found through/with AOML and CIMAS (UM has HPC capacity and there is a CIMAS line item that gives SEFSC to this facility.
- One poster project stood out with respect to Return-on-Investment. SEFSC invests virtually nothing in the IGEL approach to education-by-immersion of state decision makers into the reality of ES yet the program has been a great success. It should be replicated again and again throughout the region.
- SEFSC input/leadership with respect to Gulf Restoration funding not only with what does need to be done but what if done will be a major waste of money (either it can't work or there is a poor ROI or by nature it has only a short term payout) is critically important.
- I remain surprised, given their widely recognized level of achievement, at both the limited amount of funding made available by NMFS to the SEFSC for coral ecosystem work but the small percentage of CRCP funding received by the SEFSC and that the financial situation has barely improved with additional ESA listings.
- A particularly important point was made that while there are many more listed Pacific coral species the ones in the Caribbean are the reef-building structural corals not the rare forms. This means their endangered status has far more ecological significance in this region.
- The SWAT team approach may work for specific product requirements (the Climate Strategy may be a particularly good example) or white paper development but it doesn't

appear to be applicable to other ES needs and with respect to the SA folks will require some additional resourcing to “buy back” personnel time.

The Review Process and its Implementation:

I believe the format adopted (thematic groups of project presentations, panel sessions and a poster session) could not be improved upon. It enabled our Panel to come up to speed quickly and efficiently. Based upon the overview slides I saw, I conclude that the overall NMFS ES conceptual framework to which the SEFSC efforts will contribute is sound and at the right level of generality to guide but not proscribe. That said, as should be clear in my answers to the TOR questions, not all appeared relevant or on point, given the overall progress of this ambitious effort.

Reviewer Report on Program Review of Ecosystem Science

Southeast Fisheries Science Center

Reviewer 4

Theme 1 – Management Context and Strategic Planning

- **Observations**

In the contexts of coral-reef fish population replenishment after harvest or natural mortality, ages or size distributions of individual fishes are more meaningful than are population biomass or abundance. Larger individuals are exponentially more fecund (one 61 cm snapper [12.5 kg] is as fecund as 212 40 cm snappers [256 kg]). Larger individuals often spawn over a longer period (effectively bet-hedging for good ocean conditions for larvae). In some species of fish, possibly more typical of reef fishes than pelagic fishes, large individuals produce larvae with more vitality (grow faster, able to live longer without food) by investing more yolk and oils per egg.

A study of 251 populations of fishes found that length of life was correlated with variability in recruitment success. When larger individuals of a potentially long-lived species are overharvested, there is not enough availability of reproductive stock to provide for population recovery after a prolonged sequence of years with poor reproduction. Therefore, the potential for replenishment is more directly indicated by the age or size distribution of individuals than by population biomass. Furthermore, some species are sequential hermaphrodites, which also makes the size or age distribution more meaningful than biomass.

The above discussion is about coral-reef fishes of which medium-sized to large-sized species potentially live for decades. This probably does not apply to relatively short-lived (less than a decade) pelagic fishes such as mahi-mahi, yellowfin tuna and menhaden for which biomass is probably a more useful metric. Coral reefs are generally hazardous for larval recruitment, a wall of mouths (dense populations of planktivorous fishes by day and extensive surface cover of corals, zoanthids, etc, at night), while recruitment of pelagic fishes is more reliable except for low-nutrient years such as those of El Niño. Coral-reef fishes may live for decades while even large pelagic fishes such as yellowfin tuna live for less than a decade (exceptions being pelagic bluefin tuna and large marlin, but even they do not live half as long as small coral-reef surgeonfishes) because coral-reef fishes need multiple reproductive attempts for successful recruitment.

- **Recommendations to address issue**

The monitoring of coral-reef fishes at SEFSC, as presented by Jim Bohnsack, was clearly in terms of size-structured abundance. This is much more meaningful than the usual practice of using abundance or biomass as the metric for fish surveys. The Atlantis management strategy evaluation indicates in a couple of places that it uses age structure as a metric, yet in the Harvest Control Rule, it uses biomass threshold rather than reproductive stock of large individuals as a reference point. The presence or absence of large individuals should be given more attention.

Theme 2 – Ecosystem Data

- **Observations**

I appreciate the recognition of climate in the background documents Climate Science Strategy Regional Action Plan for the Gulf of Mexico and the Emerging Adaptation Approaches for Climate-Ready Fisheries Management as a fundamental ubiquitous factor. Coral-reef publications typically give lip-service to climate change, then focus on the topic of resilience of the system. Numerous publications espouse building ecosystem resilience to withstand climate change (e.g., protecting herbivores to facilitate coral recruitment, transplanting the more temperature-stress-resistant genotype corals for "designer reefs"). There is a push to build resilience of coral-reef communities to climate change by reducing local stressful or damaging factors such as overfishing, sedimentation, pollution, etc. In contrast, there are studies that conclude the millions of dollars and thousands of hours invested in building resilience of coral reef communities are for naught unless there is explicit progress in reducing CO_2 emissions. The latest modeling studies have indicated that coral reefs are not going to persist without major progress in reducing both local anthropogenic factors and CO_2 emissions (warming, acidification, sea level rise and possibly more intense storms and waves action). The Great Barrier Reef is generally recognized as one of the most thoroughly managed reef systems to control anthropogenic factors, yet living coral cover has decreased by 50% in the past 27 years. Even studies focused on anthropogenic factors should be assessed in the context of climate change.

In the contexts of coral-reef ecosystem effects from fishes, ages or size distributions of individual fishes are more meaningful than are biomass or abundance. While studying coral reefs in Kenya, Tim McClanahan found that overfished populations of fishes recovered their natural biomass in 15-20 years but ecosystem function had not recovered until about 35 years when the fishes recovered their full size distributions. Peter Houk and colleagues studied the coral communities on several islands in the Marianas for 12 years before two years of intense disturbance from an outbreak of crown-of-thorns starfish *Acanthaster planci*, a predator of corals, and a typhoon, followed by variable success of reef community recovery. They determined that fish biomass before the disturbance was not a good predictor of reef recovery, but the presence of large individuals of fish species was a good predictor of reef recovery. Parrotfishes less than 20 cm in length tend to be browsers and so a given biomass of small parrotfishes from and overfished area would have little effect on algal dominance. Larger parrotfishes are scrapers and the same biomass of larger parrotfish could have ecosystem effects by controlling algae and facilitating coral recruitment.

A fundamental difference between the pelagic ecosystem and the coral-reef ecosystem is that the former is controlled by physical oceanographic factors such upwelling and overfishing does not alter the physical oceanographic factors. In contrast, overfishing herbivores in a coral reef ecosystem can eventually affect the physical structure of the ecosystem by reducing the ability of the foundation species (corals) to replenish their populations.

A key determinant of fisheries production in the future is likely to be ocean primary production. Satellite color imagery suggest the average chlorophyll concentration in the world ocean has dropped by 6% since the 1980s. It is patchy. The phytoplankton has declined by 30% in the past 16 years off Kenya and the macrozooplankton has decreased by 80% over the past 65 years off southern California. Respiration rates will increase more than production rates as ocean temperatures rise. Warming surface waters tend to increase stratification and reduce nutrient input into the photic zone from below.

Reduced nutrients predicts that smaller phytoplankton will tend to replace the large diatoms, and this will affect the food web.

- **Recommendations to address issue**

I believe some of the background documents such as Climate Science Strategy Regional Action Plan for the Gulf of Mexico and the Emerging Adaptation Approaches for Climate-Ready Fisheries Management are exemplary in recognizing the pervasive influence of CO_2 accumulation in climate change, sea level rise, ocean chemistry, and possibly cyclone strength. During the presentations, I had the impression that some of the large-scale studies were entirely focused on present day matters such as red tides and hurricanes and felt the need to urge adding a perspective of future changes. In view of the general increase in temperature of the world ocean, the widespread decrease in chlorophyll, the large-scale but patchy reduction in nutrients from below the photic zone and nutrient input from terrestrial input that has caused hundreds of dead zones, all studies should include their place in the background of climate change and change in ocean chemistry. Around 1978-1982, coral reefs changed from several thousand years of erratic disturbance events (evidenced from geologic cores) to a new pattern of continuous change (evidenced by disease and bleaching). With the circumtropical bleaching event of 1997/98, this continuous change is becoming clearly global. Satellite imagery provides accessible information on sea surface temperature and chlorophyll, analyses of past or present day events. Even if a report is basically about local anthropogenic effects, it always should be interpreted in the context of future changes in climate and ocean chemistry changes.

Reviewer Report on Program Review of Ecosystem Science
Science Center : SEFSC
Address : Miami, FL
Dates : March 14-18, 2016

General Observations and Recommendation
Key (Specific) Findings and Recommendations (as reviewer has comments on)

Theme 1 – Management Context and Strategic Planning

- Observations

Overall, the SEFSC research appears well focused on items of management concern; managed species and their habitat, including habitat restoration. Advanced techniques are being contemplated/evaluated in anticipation of climate-forced coral reef decline (i.e. management for resilience). This planning includes a consideration of the legal issues of such intervention.

There was a well-quantified recognition that recreational uses of the ecosystem are comparable to commercial ones in commercial value.

- Recommendations to address issue

No particular recommendations; the lab appears very much on top of the relevant issues

Theme 2 – Ecosystem Data

- Observations

Multiyear time series which quantify ecosystem-level processes have been constructed by SEFSC scientists. There was a huge increase in collected data during the Deepwater Horizon (DWH) episode, but impressive time series did exist beforehand. As at other NOAA centers (and in oceanography generally), these were typically derived from disparate programs and funding agencies, and their longevity depended on the dedication of individual scientists.

To the best of my knowledge, no specific time series of primary production were presented during the review. This would appear to be an important baseline, relevant to all trophic levels above. Is this work conducted elsewhere (e.g. at RSMAS), hence not a focus of SEFSC per se? If no one else provides this, it would seem a logical product from SEFSC.

I was impressed by the well thought out and executed field surveys of corals. Low-tech methods (divers, visual surveys) are used; apparently these are the most efficient way to gather data (a human mind needed to identify species; can't do it with Artificial Intelligence methods). The stratified sampling design in the coral work provides data

that feeds directly into management, e.g. the evaluation of MPAs.

I was likewise impressed by the sampling of tuna, which entails broad spatial surveys over many years, and comparisons with the Mediterranean. The isotope analysis adds value to these surveys and helps to place the data in an ecosystem context. At a minimum such data helps to set the boundaries on species groups in models, and to establish the length of the food chain, which impacts the resilience of upper trophic levels to sudden changes at the lower trophic levels.

There was rather limited mention of DWH findings at the review (e.g. "total biomass loss equal to one year of menhaden"). This limited detail was somewhat surprising considering the scale of the disaster and the unexpectedly rapid disappearance of the surface oil. Do legal issues prevent the SEFSC from taking a more public stance, or reporting more detailed results at this time?

It was very exciting to hear about recent cruises around the island of Cuba. This has surely been a big gap in the Caribbean coverage and will reveal previously undiscovered spatial patterns (and trends, if such surveys are allowed to continue).

- Recommendations to address issue

Has the coral group's careful statistical approach (a stratified sampling scheme which minimizes variance within regions) been applied to other managed species at SEFSC? It would appear beneficial to do so; perhaps this is not possible/beneficial due to the habitats of more migratory fish.

Has the lab fully utilized new technologies such as autonomous vehicles? Emerging technologies such as sail drones could be useful in some cases. I expect much of the work will remain hands-on (eyes and local brains needed). There was a mention of stereo cameras and virtual dives, which could accelerate data collection.

I believe the lab could benefit from emerging satellite data. In particular, a planned geostationary ocean color satellite system (in the planning stages in Europe and the US; the South Koreans have an operating unit) would be a tremendous asset for this near-equatorial region, providing extremely fine scale information in space and time. This could reveal both sediment transport and primary production at fine scales throughout the GOM and the Caribbean (e.g. diurnal and tidal cycles of chlorophyll).

If geopolitics permit, I would absolutely continue the new Cuban surveys, which add fundamentally new information useful in modeling and management.

Theme 3 – Ecosystem modeling and analysis

- Observations

ECOPATH and related models are being used in the shrimp research, in addition to IBMs

of tidal advection. These have already been used by SEFSC to assess the effects of runoff, so ultimately could be part of an ecosystem-level MSE tool. As noted by the presenters, more data is needed on predators and prey to inform such a model.

Several of the programs appear to be blending habitat (correlative) and dynamical models in their future projections. This is a solid hybrid approach, which circumvents the pitfalls of a purely statistical or purely dynamical approach in isolation.

Most of the models presented at the review, like most of the models used in oceanography and fisheries, assume that the basic mathematical relationships connecting state variables, and the species composition of the most significant state variables, will remain relatively constant in future decades. This is a necessary assumption for basic model building, but not necessarily a correct assumption for the real world.

There is a need for improved hydrological modeling to inform the Biscayne Bay restoration work. It was mentioned that cutbacks to the Florida water management agencies have limited this type of product. The SEFSC scientists have instead been using statistical approaches, relating upstream conditions to the runoff into the Bay. This could ultimately help to set statistics on the present/anticipated frequency of hypersaline events. I would note that some of the IPCC models include coastal runoff, albeit at very coarse scale.

There appears to be limited regional biophysical modeling of the GOM, although there is some usage of global/regional resources such as the global/regional HYCOM models. The specific regional models being run and utilized by the lab scientists (and their collaborators) include ROMS and FCOM. The modelers noted the intrinsic difficulty of complementary use of different models for a single hindcast, due to the intrinsic natural variability of the system (i.e. each model realization will be different), and the different spatial resolutions of the models. There is presently no operational physical/bio-physical model of the GOM being run at SEFSC (and probably not at RSMAS either). It appeared that regional HYCOM (operated by US agencies) is probably the closest to an operational, data-assimilating model of the GOM - but HYCOM presently includes no biology.

The only spatially-explicit, vertically-integrated (that is, plankton through upper trophic levels and fisheries) model presented was the Atlantis work, apparently based at USF. Thus far that modeling project is using a single looped year for the physical forcing, and hence there is no inter-annual variability to that forcing element. Ideally this model would be made both inter-annual and operational, and modeling activities would include an exploration of uncertainty given the many assumed parameters. The expense of simulations likely prevents this. Even with limited sensitivity analyses, the Atlantis resource could benefit many of the programs at SEFSC, and could be used for strategic planning at multi-decadal scales. Of the models presented, it comes closest to the goal of a spatially-explicit ecosystem-level management tool, which could be applied for MSE. The FCOM model was used to generate the temperatures and fluxes among Atlantis polygons, which is a logical choice given its fine resolution near the coastline, and the

complicated geometry of the polygons themselves near the coast. It bears noting that the physical forcing of Atlantis is itself a significant source of uncertainty, since a single model run is a single realization of a highly variable environment (in particular, the mesoscale eddies would be different in each realization).

A NASA-funded project was described which downscales IPCC projections to the GOM in order to assess the effects of multi-decadal trends on tuna. Physical output was described, but no NPZ dynamics were included in those simulations. It was unclear how large of an ensemble was simulated in this work. (Again, I appreciate how CPU-consuming these runs can be). The slowdown of the loop current was the major physical prediction from those runs, which results in a cooling of the GOM, esp. in the northern basin. This is a very significant result, which deserves a few more realizations to see if it is robust.

The coral group also noted use of a regional downscaled model – is this the same one as the tuna group (and if not, could they consolidate their efforts)? It is possible that very fine-scale dynamical downscaling could illuminate the effects of sea level rise (perhaps they are already looking at this). For example, there was some mention of a bigger temperature range within the reef than outside of it - could this change as sea level rises?

The general consensus of the lab scientists appeared to be that climate change would be devastating to the corals, through both temperature and pH effects. My own impression is that pH may have more predictability than temperature on inter-annual scales, as it exhibits a slow and steady decline each year, driven by the steadily rising atmospheric CO2.

It was noted that skillful short-term and seasonal forecasts of the ocean could help anticipate coral bleaching events. It was less clear to me what the management "response" to these events entails (this just reflects my limited knowledge of the topic).

It was gratifying to see IBMs directly informing an ecosystem model; i.e. larval connectivity established via an IBM-type drift model was used in the Atlantis model to close the life cycle of some species.

- Recommendations to address issue

If there were to be a dedicated effort to expand regional downscaling of global projections (both seasonal and inter-decadal) to the GOM, it will probably require more sustained interaction with the AOML and/or RSMAS labs. There is undoubtedly considerable local expertise available that would benefit SEFSC. As was stated at the review, money is the best possible attractor of expertise, but more social engagement between labs would expedite this process.

The cheapest way forward is probably to re-use the existing NASA-funded downscaling model with new IPCC drivers to get a larger ensemble of projected conditions. It was unclear whether that NASA funding is ongoing, or has ended. It would certainly benefit

NMFS to continue supporting this work.

Silicon, storage, and staff are all needed to significantly expand an ensemble of runs. Mundane activities such as interpolating data from global to regional models can be a big choke point in this process. Models sometimes unexpectedly blow up under strong forcing and need temporarily smaller time steps, which requires intermittent human intervention (although some of that can be automated).

There was no specific mention of computer resources at SEFSC. It might be possible to rent or purchase time on another academic resource if NMFS were willing to fund it; alternatively, as noted at the meeting, it might be possible to obtain some the considerable NOAA/NWS resources. It is worth emphasizing that cloud computing (sometimes promoted by NOAA headquarters) is usually not helpful for regional hydrodynamic models, whose execution requires fast communication between processors.

Data communication between labs can be a limiting factor in biophysical modeling work, as the models produce terabytes of output. Different data formats used by physical vs. biological scientists are an additional hurdle. Could AOML/SEFSC present a unified front to NOAA management for more computer time, and/or shared tech support, to facilitate both additional runs and communication between physical and biological scientists?

I agree with the lab's consensus that the 2-10 year range is the most difficult to forecast, even though it is probably of great interest to stakeholders intending to invest in equipment or real estate or time. It could be argued that is all the more reason to conduct an ensemble of downscaling runs on that time scale to at least assess the uncertainty of various metrics. There may still be demonstrable (albeit limited) skill in that range which could translate into economic value. Different metrics have different predictability, and some regional-scale indices, which are more predictable than fine-scale details, are potentially the most useful to managers - especially for migratory stocks such as tuna and menhaden.

If possible (and I realize it is not always feasible or desirable), it would be advantageous for the coral/tuna/Altlantis/other regional modeling groups to coordinate their use of large-scale model forcing and boundary fields, if they are not already doing so. A shared set of global-scale hydrodynamic/NPZ/carbonate model output could serve multiple purposes for regional GOM model downscaling, and a unified regional model of those fields in the GOM could in turn serve as the boundary conditions on the finer models (e.g. coastal wetlands). There is of course nothing new about spatial nesting of models (several of the groups are already doing this within their projects), but perhaps there are products needed in common which could be generated from a central source at SEFSC/AOML, saving time and freeing up resources for other work.

Theme 4 – Incorporation into Management

- Observations

It was apparent that SEFSC has many direct links with management agencies. This strong communication and contact derives both from the quality of SEFSC science and the pressing needs of the stakeholders.

The coral group described experiments on direct physical intervention (snipping) to improve coral recruitment of affected species. These experiments are informative, but it is hard for this reviewer to see how this procedure would be feasible on a really large scale. The regulation of the parrotfish fishery to promote coral growth appears to be a very solid approach. Selective breeding and the consideration of more drastic (i.e. genetic engineering) approaches is also promising, as new genotypes could spread more rapidly than the pace of direct physical planting.

The shrimp and wetlands survey data has apparently been useful in environmental impact studies (value of wetlands vs. value of developed real estate)

Some of the SEFSC groups are explicitly considering the reduction of uncertainty possible in single stock assessments, given adequate information about the environment and interacting species. This is a logical path to full EBM. It was suggested at the review that large-scale physical indices are presently being underutilized in stock assessments. Also noted was the inherent integration of physical conditions by the fish themselves; the use of ecosystem model output in management would inherently contain that information as well.

As at other NOAA fisheries labs, there appears to be increasing effort (and hopefully funds) to support IEA acitivites.

- Recommendations to address issue

Ease of access to data and models is a one key factor in management use of scientific findings. I would suggest more effort be focused on end products such as publically viewable web pages. If the links with management agencies/councils are already strong (regular reports and meetings), perhaps such websites are less vital, but still very useful for general outreach.

For what it's worth, I fully support the exploration of genetic engineering solutions to the coral problem. Ocean acidification is unfortunately here to stay.

Some of the same models used for IPCC downscaling could be used for IEA research (and even utilized in operational settings).

Theme 5 – Communication and Peer Review

- Observations

None of the presentations focused explicitly on peer review; however, the lab has obviously been generating many peer-reviewed publications.

The oversight of DWH work by BP was mentioned as an impediment rather than a virtue (I tend to agree; working with an adversary is not generally a benefit).

As noted above, there was limited mention of end-user websites during the review.

- Recommendations to address issue

It is highly beneficial for a lab to present easily navigable websites to the public. These ideally include both summaries of data and animations of model output. If it is not the case already, could a member of the lab staff be dedicated to that outreach?

Other

- Observations

I was highly impressed by the level of coordination and cooperation amongst the NOAA staff and the fisheries councils.

My major concern is the apparently limited interaction between physical science (AOML/RSMAS) and SEFSC laboratories. At other NOAA labs the Cooperative Institutes help to facilitate that linkage; hopefully that could be the case at SEFSC as well.

During the review, it was sometimes hard to tell which work was done at SEFSC vs. some other non-NOAA lab or institution (e.g. USF). There may be close enough collaboration that it does not matter, but it does complicate the business of recommendations to SEFSC (as they do not control activities at the other labs).

There was not much discussion of marine mammals – is there insufficient capacity for that type of research at SEFSC, or is it someone else's responsibility?

Artificial reefs were mentioned but there is apparently no specific research program at SEFSC to investigate their impact – should this be a new focus?

If developed, an operational biophysical (physical plus NPZ) model of the GOM would be of great benefit and serve many research divisions. As noted above this would require greater interaction between AOML and SEFSC.

- Recommendations to address issue

An invited lecture series and more social gatherings between the labs would help to facilitate interaction leading to collaboration. This would be of mutual benefit to all scientists. This collaboration is especially useful to advance the modeling work. It is true that not all scientists seek interdisciplinary collaboration, but the trend is definitely in that direction.

Conclusions

SEFSC is a very high quality lab doing world-class science. I was especially impressed by the level of coordination within the coral reef group, which has taken full advantage of the spatially localized nature of this ecosystem, and the infusion of CRCP funds, to sample and manage it in a systematic manner.

Each group at the lab is blending modern and historical data to generate multi-decadal time series, and such series are the bedrock of applied earth science.

Stronger links need to be established with AOML (or other institutions), if the future downscaling work is to be enhanced or operationalized.

Opportunities for joint research around Cuba and with Cuban scientists would be a huge benefit; these will expand both databases and knowledge. Access to relatively pristine habitat will add significant new data.

It was emphasized by several of the staff and directors that there is no dedicated overall "ecosystems science program", as such, and most units are suffering from cutbacks in external funding. Much of the ecosystem science is now achieved by volunteer extracurricular effort. It was suggested that teams could be designated, and the relevant work could get written more formally into individual work plans. In the short term (and given limited resources) this appears to be a sensible approach.