

Invasive Species Program Review Final Report:  
A Synthesis of Reviewer Comments and Recommendations

Submitted to Dr. Gary Matlock, Director  
National Centers for Coastal Ocean Science  
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By

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NOAA's National Centers for Coastal Ocean Science  
Invasive Species Program Review  
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## **Invasive Species Program Review Final Report: A Synthesis of Reviewer Comments and Recommendations**

NOAA's National Centers for Coastal Ocean Science (NCCOS) strives to conduct reviews of its scientific programs every three to five years. The goal of a program review is to "ensure that NCCOS scientists are conducting high quality scientific investigations of significant value to NOAA and the nation".<sup>1</sup> According to review guidelines, NCCOS identified twelve areas as its principal programs by virtue of spending plans, among them is invasive species. Research and programming efforts related to invasive species were deemed to meet the minimum criteria for a program, which are: existence of multi-year activities; research or activities that are mandated or otherwise meet stakeholder needs; and activities that are multi-disciplinary with a management component or implications.

Consequently, on September 11-12, 2007, NCCOS conducted a formal, external review of its Invasive Species Program. Six reviewers were tapped to evaluate the program, including:

- 1) Dr. Britta Bierwagen  
U.S. Environmental Protection Agency  
Office of Research and Development  
National Center for Environmental Assessment
- 2) Mr. Seth Blitch  
Florida Department of Environmental Protection  
Apalachicola National Estuarine Research Reserve
- 3) Dr. James T. Carlton  
Williams College  
Mystic Seaport Maritime Studies Program
- 4) Ms. Pam Fuller  
U.S. Geological Survey  
Florida Integrated Science Center
- 5) Mr. Stephen Phillips  
Pacific States Marine Fisheries Commission  
Aquatic Nuisance Species & Invasive Species
- 6) Dr. Ellen Woodley  
Liana Environmental Consulting

The scope of the review included multiple aspects of NCCOS' research activities related to aquatic invasive species:

- Legislative guidance and mandates
- Goals and objectives of research efforts
- Design and components of projects
- Scientific contributions and leadership
- Usefulness of data and information products
- Interactions and collaborations
- Adequacy of funding and staffing
- Data management, dissemination and assimilation

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<sup>1</sup> [Draft] Proposal to Establish Systematic Processes for Regular Peer Review of NCCOS' Intramural Research. Memo signed 17 April 2006.

- Direction of future research programming

Reviewers were asked to consider a range of topics including, but not limited to, the quality of research projects, the effectiveness of program structure and leadership (including the setting of research and programmatic priorities) and the adequacy of internal and external collaborations. Most importantly, reviewers were asked to provide recommendations about where the program might go in the future based on present goals/objectives and capabilities. While given guidance on the focus of the evaluation, reviewers were also encouraged to comment on any aspect of the program they believed was important. The reviewers examined written materials and heard oral presentations on past, present and future research and programming efforts related to aquatic invasive species. They also interacted with NCCOS researchers and staff both formally and informally over the course of the one and one-half day period. Each reviewer drafted his or her own critiques, comments and recommendations, which were submitted to staff in NCCOS Headquarters and compiled into this report. A brief summary of the reviewers' general conclusions is below, followed by a detailed discussion of individual reviewer assessments and recommendations.

### ***Action-Specific Recommendations--Summarized***

- Organize and integrate NCCOS' capabilities into a unified program
- Abandon the Early Warning System concept and redirect program resources to areas more relevant to management needs and NCCOS capabilities
- Connect program priorities, projects and products to NCCOS stakeholders, clients and resource user-groups--actively engage these groups
- Conduct ongoing assessments to evaluate the relevance and value of existing projects and programs
- Engage social scientists to develop human dimensions capabilities within NCCOS
- Do a better job of branding products; highlight products of interest to the scientific community, decision makers and the general public
- Regularly brief the Aquatic Nuisance Species (ANS) Task Force and Invasive Species Council on products and services
- Request input on invasive species programming from this panel as well as other groups in the public and private sector
- Encourage cross-Center, collaborative work; consider offering incentives for collaborations
- Conduct a one day workshop or annual meetings where Centers present their strengths and capacities for invasive species work, how they will collaborate and their central mission
- Re-visit the definition of invasive species to make it more clear what does and does not constitute an invasive species (e.g., harmful algal blooms (HABs) and species that are not introduced but become 'invasive' due to other pressures and ecosystem changes)

### **Program Priorities, Structure & Direction**

The six reviewers were unanimous in their view that the NCCOS Invasive Species Program is, in fact, not yet a program. For example, Woodley indicated that a more appropriate description

might be an “initiative”, Blitch used the term “effort”, while Fuller suggested that NCCOS’ efforts were more aptly described as a “random collection of stuff with no integration”. The reviewers observed that the many capabilities across NCCOS have not been fully, or in some cases effectively, inventoried and mobilized in the context of invasive species, and that there is no coordinated theme or purpose under which the collection of research projects are organized. While the reviewers recognized that efforts have been made within NCCOS to move in the direction of a program, they commented that much work needs to be done to create the “threads that bind”. Each of the reviewers made specific recommendations about how this process of organization might occur and offered ideas about the most fruitful direction for the nascent program to take.

To bring more structure to the invasive species effort, both Bierwagen and Woodley suggested NCCOS connect program priorities to NCCOS’ stakeholders, clients and resource user-groups. Bierwagen advised NCCOS to conduct a systematic “inventory [of] the types of decisions that [resource managers] are making with respect to invasive species”. This inventory should “identify research needs, knowledge gaps, tool development needs, etc”, thereby creating a methodical way for NCCOS to set research and program priorities. This process of identifying priorities should replace the ad hoc, opportunistic method that is presently utilized, which would accomplish two goals important to an applied science agency:

1. defining project endpoints and products with the specific needs of managers, decision makers, or resource users in mind; and
2. directing research efforts toward ecosystems and species of concern to clients, thereby justifying research on particular species/ecosystems beyond researcher interest and opportunity.

The utilization of resource managers as the means for setting priorities would, ideally, be ongoing “because a science program should be forward looking and use the articulated needs of managers as a basis for research that also tries to anticipate how these needs might change in the future”. Bierwagen advised NCCOS to routinely evaluate research projects in light of managers’ needs. In her view, the following questions should be posed to assess the value of new and existing research projects, as well as future research investments:

1. Will further research results enable more effective management?
2. Is there any hope for control methods based on current research?
3. What other information is needed by managers and resource users that NCCOS could or should provide?

Similarly, Carlton suggested that NCCOS Centers determine the unifying themes of their research efforts “with specific species used as model systems to investigate broader questions and hypotheses”. Research should not be packaged by species, but rather research on a particular species should be used to explore more fundamental questions related to invasive species.

Woodley’s recommendations were also focused on the “process that NCCOS uses to develop [its] projects”. She suggested that NCCOS rethink the “one-way” flow of information, knowledge and technology transfer that relegates coastal managers and resource users to the role of passive recipients of knowledge. In application, NCCOS should recognize “the value of local resource users’ knowledge” and seek ways to utilize “practitioner knowledge” in a “two-way”, ongoing flow of information. This would include, in the spirit of adaptive management, developing a clear and uniform mechanism for getting feedback from coastal managers and

resource users, and for using this information to improve the program. (She suggests this type of exercise would have been helpful during the Hawaii pilot for the Early Warning System.) Woodley commended the Center for Coastal Fisheries and Habitat Research's (CCFHR) collaborations with Reef Environmental Education Foundation (REEF) as an "excellent" example of how stakeholders can be incorporated into scientific programs, observing that "hearing from those who are in direct contact with aquatic ecosystems on a daily basis for their livelihoods can be invaluable for early detection, monitoring and the source of identification of priority issues on the impacts of ecosystem changes to human health, livelihoods and cultures".

Finally, Woodley advised NCCOS to reach out more broadly than the coastal resource management community, to more effectively and productively include local resource users who "also have an interest in what NCCOS does and how NCCOS decides which research to conduct". NCCOS should continue and expand efforts to "utilize and draw upon different kinds of knowledge" within communities or groups that may be influenced or impacted by invasive species. She inquired, however, about how NCCOS can most effectively implement such a strategy, meaning how can NCCOS effectively draw on "resource users' input to *assist* NCCOS and coastal managers in the process of defining NCCOS priorities"[emphasis in original] given acknowledged budgetary constraints and bureaucratic impediments thwarting such initiatives (for example, a budgeting process that does not allow for pro-active planning and the Paperwork Reduction Act that limits social survey research capabilities). Nevertheless, NCCOS should be more cognizant of how it provides "the key link between the science of academia and the needs of the coastal managers" and others, and should develop a "clearly thought out mechanism" for connecting research priorities to management needs.

Blicht also commented on the importance of finding out what stakeholders need in the field and how these products should be delivered. Phillips was unclear about which external groups NCCOS presently regards as 'coastal managers', saying "I assume that this means state, tribal, county, as well as federally managed waters and resources, as they are important contacts in any comprehensive management effort". However, he qualified this observation, noting he is not familiar with what groups NCCOS might be working with on the East Coast, as he is on the West Coast where NCCOS has less of a presence.

Beyond describing a general process by which NCCOS might move toward a more integrated program, all of the reviewers made specific recommendations about the direction in which NCCOS might move into the future. From the perspective of a coastal resource manager, Blicht cited both prevention and eradication/control as high priority needs, saying "I am more interested in preventing the introduction of invasive species through the myriad vectors available, and in the eradication, or at least control (if at all possible), of established invasive species".

Both Carlton and Fuller concurred with Blicht's assessment about the importance of invasion prevention, suggesting that NCCOS might develop programming in this area. Carlton pointed out, and Fuller agreed, that scientific research on vector management could be expanded by NCCOS beyond ballast water. Carlton suggested that NCCOS is "positioned to assume leadership in vector science" because of its "technical capabilities" and "existing strengths". NCCOS might expand vector science to include other critical vectors such as:

- non-ballast aspects of vessels (i.e., sea chests, anchoring systems, bilge water, hull fouling, through-hull fitting fouling, seawater systems, etc),
- aquaculture and mariculture,
- online national and international commerce in species (a largely unregulated source of living organisms),
- industries of high vector-risk (e.g., the bait, aquarium, horticultural and live seafood industries), and
- recreational and commercial fishing communities.

In Carlton’s view, a strong, focused research program expanding vector science would be valuable, particularly one that “seeks to interfere with and disable these mechanisms as viable dispersal agents”.

Carlton offered an additional, related direction in which NCCOS could contemplate program development: a rapid response capability for invasive species, similar to what NCCOS has in place for HABs and natural disasters. Given NCCOS’ resources, capabilities and expertise, it is “clearly equipped” for relatively rapid response or reactions when a new, potentially invasive species is discovered. Coordinating the capabilities across the Centers and developing a rapid response program would, in Carlton’s view, “find considerable appeal scientifically and politically, and potentially attract further funding”. While he acknowledged that “setting up shop as a fire department has potential challenges”, he added that “these response modes could be clearly delimited and circumscribed, and yet go far to underscoring that NCCOS has its finger on the pulse of timely events”.

In terms of control and eradication, speaking specifically about lionfish and *Didemnum*, Phillips suggested that research on these projects should be directed toward finding ways to remove or thwart the spread of these species. Fuller pointed out that the Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) has the capabilities necessary to develop much needed detection and control tools, such as transgenics, genetic identification and chemical control. Blicht, Carlton, Fuller and Phillips all suggested that NCCOS may want to direct its limited resources toward the investigation of prevention and eradication science, strategies and technologies.

Because eradication and control are important goals, however, Blicht also described the timely identification of novel species as very important, although he indicated that the exact identification of a species is not a prerequisite to managerial action (family level identification is generally enough to ascertain risk and contemplate a management response). Thus, the cultivation and consolidation of taxonomic resources, as described by the Center for Coastal Monitoring and Assessment (CCMA), was also highly appealing to Blicht. Blicht offered that “perhaps NCCOS could cultivate and support efforts of taxonomists, both new and established” because it would be advantageous for managers to know who, locally and regionally, specialize in what taxa. Other reviewers agreed with this perspective, such as Bierwagen who thought that CCMA’s Cadre of Taxonomists (hereafter, Cadre) was a “good idea”, but pointed out that the “USGS<sup>2</sup> is already covering this area”. To find a more unique niche, she suggested that

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<sup>2</sup> Fuller notes that the experts database, referred to by Bierwagen, was created by U.S. Geological Survey, but is owned and under the direction of the Aquatic Nuisance Species Task Force (ANSTF).

development of “easier and quicker methods” to identify species, particularly new species, “would be more valuable and possibly a better fit with the labs and expertise within NCCOS”.

Fuller also felt that CCMA’s Cadre was duplicative of other efforts in this area. Moreover, she suggested that NCCOS’ Cadre is an “odd list”, being too limited to experts in Hawaii and excluding key taxonomic experts. Furthermore, she criticized the long period of development and the ultimate failure of NCCOS to launch the website, pointing out that contributing experts have been continually promised the activation of this resource to no end. The Cadre, she advised, should be rolled into the ANS Task Force Experts Database, a recommendation echoed by Phillips.

Like Blich and Bierwagen, Fuller viewed taxonomy as an important area where NCCOS could make significant contributions. She liked the “idea of training for parataxonomists and coastal managers” and the fact that NCCOS supports the “training of graduate students in taxonomy”. In terms of capabilities, Fuller noted that CCEHBR was poised to contribute to the identification of species, donor regions and founder populations. Finally, she encouraged NCCOS to pursue collaborations in taxonomy by partnering with the Southeastern Regional Taxonomic Center (SERTC) located in the Marine Resources Research Institute--South Carolina Department of Natural Resources, Charleston, South Carolina. In Fuller’s view, by focusing resources on enhancing and developing taxonomic techniques, services and products, NCCOS could make a “big difference” at relatively little expense.

Finally, Bierwagen indicated that in order to be responsive to the long-term and dynamic needs of its client base, NCCOS must find a way to integrate the invasive species program “across disciplines and stressors”. She provided three ideas for how this might be done. First, NCCOS could determine the common needs for its primary client-group, such as the National Estuarine Research Reserves (NERRs), National Marine Sanctuaries (NMS), and Marine Protected Areas (MPA), or risks to its focal ecological systems, including estuaries, coral reefs, and coastal ocean systems. This would make it possible to define a program that addresses these broader issues. One way to do this might be with biogeographic assessments.

A second option would be forecasting. NCCOS management and staff mentioned the idea of forecasting in relation to invasive species. Bierwagen suggested that forecasting, including “future scenarios”, would be “valuable to managers to project where the next occurrence may be, where to monitor, what to expect, and possibly even to forecast what species are likely to be the next invaders”. However, she noted that integrating abiotic and biotic variables, along with changing conditions, into models would be necessary if forecasts were to be of value. “Climate change, land use change, and resource use change can all contribute to the creation of new habitats that allow range expansions and new species”. Only by integrating the impact of multiple stressors on systems can scientists anticipate which species will be able to establish and successfully reproduce, and why, given changes in ecosystems. She recalled that “genetic forecasting was mentioned briefly in one of the presentations and seems worth exploring”. Bierwagen observed, however, that “this expertise for forecasting is not currently fully realized within the NCCOS program” and cautioned that such an endeavor would be “an extremely large undertaking”. Consequently, any such program “would need to be clearly and narrowly defined” and “rooted in client needs, current or future”. Fuller also noted that forecasting might be a

useful exercise to help managers identify the “predicted spread [of an invasive species] in an effort to find incipient populations that might be eradicated or contained”, but agreed with Bierwagen that NCCOS did not presently have staff to do this type of work.

The final option for NCCOS to integrate disciplines and stressors, in Bierwagen’s view, is via the human dimensions angle. However, she noted that this approach has currently only been used in the context of HABs, that it is not well developed and that NCCOS lacks expertise and capability in this area. A more specific discussion of human dimensions assessments and recommendations is provided below.

## **Center-Specific Comments**

### ***Headquarters***

- Fuller—“[The] Compendium [of Invasive Aquatic Species in the Coastal and Great Lakes U.S.]– in my opinion, [was] probably not worth the money spent on it. I see it is supposed to include Great Lakes species. Were you aware that GLERL (Great Lakes Environmental Research Laboratory) is essentially already doing that? They have contracted with Tony Ricciardi to write fact sheets for all Great Lakes species that are then put into our (U.S. Geological Survey (USGS)/Nonindigenous Aquatic Species) system. In return we give them a filtered Great Lakes view back for their web site. I think the money spent on this would have been better used to support your own people to build the same product”.
- Fuller—“ [The Integrated Assessment of the Potential for Further Invasion of the Marine Tunicate, *Didemnum lahillei*] – Sounds like a good idea and needed information, but it appears from the documentation we received and from discussions with others that it was not the right way to go about getting the information”.
- Phillips— “...the *Didemnum* assessment document from the University of Michigan (based on the last draft I reviewed) still needs further revision before being finalized. On page 26 of the briefing book (4.1.2) it states under ‘Anticipated Products for Customers’—‘This work could be used as a model for future integrated assessments addressing other non-indigenous species.’ As stated above, the document needs further work, especially if it is to be used a model for further assessments” [parenthetical statements in original].

### ***Center for Coastal Environmental Health and Biomolecular Research (CCEHBR)***

- Blich—“Of particular interest to me was the work Jeff Hyland is doing on the National Benthic Inventory (NBI) and the genetic work that addressed tracking the source population of a species. One of the gaps that many coastal resource managers have is information on the benthic community in a particular system or regions, and I feel development of the NBI will assist managers’ knowledge of both native and invasive species. Also, any tools that can be developed to assist law enforcement in making cases against illegal introductions or spread of invasive species would be of great merit. There was mention of a remote sensing project that used other data to detect the spread and



potential occurrence of *Phragmites*. I did not hear, and to be fair did not ask, if there was any collaboration with the Coastal Services Center (CSC) on this. I do know that CSC does work to develop similar types of tools, and that these products have much use in the field”.

- Fuller—Fuller commented that CCEHBR offered “exciting capabilities”.
  - “Good for identifying species, donor region and founder population. A real benefit is if you could also use it for control. I think James Morris may have talked to Tom Greig about a system developed by John Teem and others. I don’t know if it is a realistic option for lionfish. Perhaps they can come up with another one that is!”
  - “We have found that our partners (managers) really need more control options. They are desperate for something that will work. Seems like transgenics may be a solution”.
  - “Another possibility is using genetics to detect invasives before we know they are present. Rusty Rodriguez (USGS, Seattle lab) uses micro-assays of plankton to identify spread of species before they show up. Could also be used to identify species in ballast water”.
  - “An expertise in chemical controls was mentioned. Again, invasive species managers are desperate for new control options. Are you in the position of developing and/or testing existing chemicals on various species?”

### **Center for Coastal Fisheries and Habitat Research (CCFHR)**

- Blitch – “Of all the invasive species efforts the work with lionfish seems the most robust because it has elements of detection, prevention, education and outreach and partnering. The body of work that has been published in peer-reviewed journals appears to have gone a long way in informing the scientific community about the status of the invasion and its impact on native ecology. Working with the diving and fishing community, producing educational materials about lionfish has not only drawn attention to the issue and gotten some local investment, but may also prevent further introductions (although that may, ultimately not influence the spread of the fish). Establishing a relationship with REEF has increased awareness, accounted for travel restrictions and furthered what is known about the life history of the Atlantic population of lionfish. I would submit that projects that are able to exploit partnerships and bring a new level of awareness to both scientific and lay communities through education and outreach are the ones that have the potential to enjoy wide support and can increase the chance for success”.
- Fuller—
  - “Lionfish - stellar work!”
  - “It will be useful in showing these characteristics in the first marine aquarium fish to ever become established and used as a cautionary tale against the next one. James and I have discussed a collaborative project to eradicate reported individuals in Florida using a group called REEF. We can send out alerts; NOAA can look into risk assessments and management implications; REEF can do the eradication”.
  - “Do you have a plan for communicating lionfish dangers to fisherman, SCUBA divers, [the] medical community? They’ve been out there for several years now”.

- “Question about temperature tolerance – I think I read it was done with fish purchases from a store. You might want to do it again with wild fish to see if they are any different – as invasives often are”.
- “I was happy to hear that you do take precautions to contain exotics in [the] event of a hurricane!”
- “Found work on scallop settlement on *Didemnum* very interesting!”
- Phillips—
  - “The lionfish and *Didemnum* research work at CCFHR are particularly outstanding”.
  - “Lionfish: The work to date has been enlightening. Though likely not feasible since they are so widely distributed, control efforts need to be fully scrutinized. They are not frightened easily and thus may make themselves available to easy removal. It may have been mentioned that a pilot removal project is moving forward, and this is encouraged”.
  - “*Didemnum*: Based on NCCOS research, the spread of *Didemnum* in the Atlantic could have serious economic impacts to the fishing industry. If fishing gear and activity spreads this tunicate, then efforts and resources need to be directed to minimizing the spread through cooperative projects. It is these types of applied projects that NCCOS needs to consider as a priority in the future, over, for example, monitoring population status of lion fish”.
  - “Alaska: The NCCOS lab in Alaska needs to take on more aquatic nuisance species projects. We are particularly concerned about aquatic nuisance species impacts to the fisheries resources in Alaska in light of global warming. These types of aquatic nuisance species/global warming projects seem very attractive to funding agencies”.

### **Center for Coastal Monitoring and Assessment (CCMA) & the Early Warning System (EWS)**

Five reviewers expressed the unanimous view that, given the findings reported by CCMA, the EWS project should be discontinued or, in Phillips’ case, put on hold until the “inherent problems with the program design” can be rectified. Carlton, in agreement with Bierwagen and Fuller’s view, argued that the successful application of the EWS concept relies upon the existence of thorough baseline surveys of native species so that the system can detect new, potentially invasive species, as opposed to detecting native species previously undetected, native species previously detected but not yet identified, native species taxonomically split into one or more species, etcetera. These three reviewers concurred that comprehensive and reliable baseline surveys are not presently available for enough taxa to enable the EWS to be fully functional. Carlton elaborated, saying: “There are few robust baseline inventories out there in enough sites to form a national early warning detection network”, as evidenced by the lack of comprehensive species lists for “America’s iconic estuaries– Long Island Sound, Chesapeake Bay, San Francisco Bay, [and] Puget Sound”.

Moreover, Carlton asserted that even if a species was identified as a new invader by comparing a new list to an old list of species in a region, it is probable that the new arrival would have already been recognized by experts as such during the capture and identification process. This opinion

was also offered by Blich who “concur[s] with the sentiment that often when something new is discovered in a system local resource managers usually know it’s new” and Fuller who argued that “the [EWS] concept is flawed” because a local biologist will recognize something as new prior to an automated comparison, especially because the species must be identified prior to its being entered into a database. Fuller also observed that the EWS could, in fact, “never be totally automated [because] a person must be there to review ‘new’ species”.

Another weakness of the EWS design according to Fuller is that “no communication plan was ever proposed to let people know of new invasions” in “donor regions”. She agreed with observations summarized in the “Hawaiian Prototype for an Aquatic Invasive Species Inventory, Early Detection, and Warning System: Results and Lessons Learned” that it is very important for resource managers to be notified of new invasions in adjacent regions because of the potential risk of spread; managers will already know of new species in their own jurisdiction by virtue of detecting and identifying them, which can be done without the aid of the EWS. Finally, Fuller was skeptical that the “firewall issue” described by CCMA staff was an impediment to the EWS concept. She observed that many “networks” have already been created to connect datasets from multiple partners, such as the Global Invasive Species Network (GISIN).

Rather than directing additional funds to the EWS project, both Carlton and Fuller recommended that NCCOS might instead support expansion of USGS’ Nonindigenous Aquatic Species Alert System, which is already operational and has an alert component. Fuller suggested that a more valuable contribution in the area of invasive species detection “would be to help build geo-referenced baseline information”. If financial resources were available, ideally, “NOAA would do more monitoring and detection for invasive species”. If this is not possible, in Fuller’s view, NCCOS “should partner much more strongly with others who do biological monitoring (such as the National Estuarine Research Reserves, National Marine Sanctuaries, National Benthic Inventory, State of Texas, and the Southeast Area Monitoring and Assessment Program or SEAMAP)... to help bring all this data together”. In this way, NCCOS could actively address the gaps in available baseline data. Phillips, however, discouraged efforts in this area because “databases are budget suckers” and that NCCOS would likely find little support in the current fiscal climate to continue work in this area. Blich offered that the “decision not to continue to develop the current warning system is good” and recommended that funds be redirected toward research on prevention and eradication efforts. Bierwagen suggested “realigning [the EWS] efforts towards more forecasting types of results [because this] may be a better fit with expertise and other products existing within NOAA”.

### ***Center for Sponsored Coastal Ocean Research (CSCOR)***

- Fuller—“I was not previously aware of [CSCOR]. I don’t know the politics behind it or how it was determined, but an awfully large portion goes to Hawaii (between the reef initiative \$1M+ and the algae in Maui). This isn’t necessarily a criticism; I know it is a very important problem out there and they are doing a reasonably good job at managing it. It’s just an observation that many more projects could be funded with an extra million dollars”.

## **Hollings Marine Laboratory (HML)**

- Fuller—“Sounds like great capabilities. Pathogen source tracking seems like a good capability – especially as we have more new diseases making their way into the country”.

## **Comments and Recommendations on General Programmatic Components**

### ***Leadership***

Of those reviewers commenting specifically on leadership, there was a consensus that leadership on the Center level was good. Fuller advised that in order to bring about a more integrated invasive species program, more effective leadership will be needed at the Headquarters level. However, she added that this leadership should “make sense” and be incentive-based, not forcing integration where it is not appropriate. For example, NCCOS leadership might set aside funding specifically for collaborative science amongst the Centers. This strategy is currently employed at the USGS’ Florida Integrated Science Center.

### ***Qualifications of Scientific Staff***

Among those reviewers commenting on the expertise and qualifications of NCCOS’ scientific staff working on invasive species issues, there was agreement on the high level of competency, expertise and experience. The range of disciplines and scientific approaches employed across the Centers was also positively acknowledged, despite the challenges this circumstance could pose for finding unifying programmatic themes. The only gaps in personnel and expertise noted by the reviewers for the program were social scientists.

### ***Program Funding***

All of the reviewers were cognizant of the limited amount of funding available for invasive species work and expressed awareness that an inability to procure additional resources would necessarily impose limitations on program expansion and development. Carlton, in particular, discussed the issue of funding explaining that the scantiness of resources made available for invasive species work on the federal level, in general, is an acculturated and institutionalized problem, one that is beyond the power of NCCOS to address alone. He explained, “Most programs funded at \$20K, \$30K, \$50K, \$100K, and so on, would be considered ‘*programs not operational due to funding levels*’ in many federal agencies. This draws a line in the sand, and sends the message that no progress can be made or studies conducted based upon the monies allocated or appropriated” [emphasis in original]. However, this was never done by federal agencies in the case of invasive species. Consequently, in Carlton’s experience, “The result has been that in my nine times testifying before Congress, I have been asked about half of those times to explain why so little progress has been made, in the face of the ‘consistent funding’ made available to agencies”. In his view, invasive species programs have been chronically underfunded, a problem not recognized by Congress or acknowledged by federal agencies.

Given the low levels of funding devoted by NCCOS toward invasive species work, Carlton pointed out the “irony of spending federal dollars to detect the reproduction and escape of the Asian oyster *Crassostrea ariakensis*, both within Chesapeake Bay and in and to other estuaries”. As the research findings will be of most benefit to the industrial sector, Carlton argued that “The Virginia Seafood Council, VIMS [The Virginia Institute of Marine Science], and others involved in this introduction should provide a substantial portion of the funding to develop the genetic and other techniques to permit independent monitoring of reproduction and spread. VSC and VIMS, by so funding, would not compromise the independent nature of the research, nor its application”.

Finally, because the reviewers were keenly aware of resource limitations, they, for the most part, urged NCCOS to consider its programmatic priorities carefully.

### ***Collaboration & Partnership***

Most of the reviewers commented that NCCOS was doing a good job with external collaborations and partnerships. Bierwagen, for example, observed that NCCOS is “already adept at partnering with other agencies and across other NOAA offices and procuring resources to accomplish joint projects”. In her view, this type of partnering will continue to be critical in the context of invasive species: “It is clear that this is the only way to begin to address the scope of the invasive species problem and it will be even more important when integrating data across locations or programs; other stressors such as climate change; and expertise and resources for any type of forecasting”.

Carlton and Fuller suggested more cooperative interaction with USGS. Phillips commented that, although NCCOS appears to do a good job of collaborating within NOAA, “outside of NOAA there seems to be some territoriality”. He cited the Early Warning System as an example of this difficulty to work cooperatively with external entities, pointing out use of the word “competitors” in background materials<sup>3</sup> to describe other entities working on detection. Phillips suggested, “This thinking should be changed to more of a collaborative viewpoint”.

### ***Information Products***

Several reviewers observed that very few of the research projects included an education and outreach component. Blich, in particular, saw this as an area for expansion. Other reviewers suggested that if NCCOS moves more in the direction of prevention, that education and outreach programs would need to be bolstered and made regular components of research projects, and that this would be a worthy use of resources if deemed appropriate for a “science agency”.

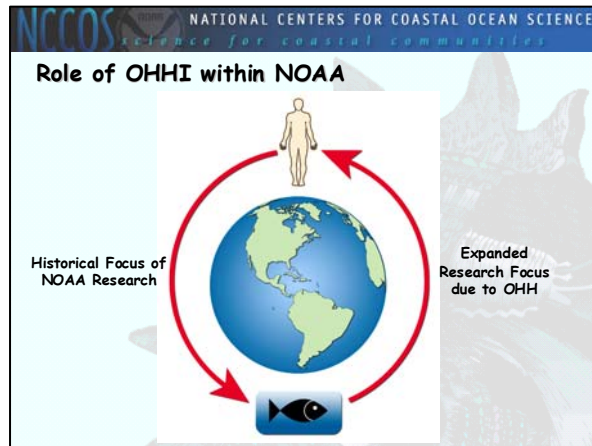
One reviewer, Fuller, observed that some of NCCOS’ invasive species research projects had few publications to show for the amount of money invested in the research. She notes that this may or may not be an issue, however, depending upon NCCOS’ practices and requirements related to peer-reviewed publications.

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<sup>3</sup> See Section 2.1, page 12, of the *National Centers for Coastal Ocean Science: Invasive Species Program Review Program Briefing Book*.

## Human Dimensions

Bierwagen observed that “clearly, integrating the human dimensions angle is a goal” and agreed that such efforts would be worthwhile for achieving more integration of disciplines and stressors. Bierwagen suggested that this approach may fit nicely with the “microbiology and genetics expertise that exists within the centers”, but noted that the Centers do not presently have “a social science expert and economist to make the links to human welfare and health”. She thought that “partnering with NOAA’s Coastal Services Center may be one venue, as well as the Centers for Disease Control and EPA” to help address these gaps in expertise.



**Figure 1: HML Presentation Slide Noted by Reviewer Woodley**

Woodley suggested an addition to the HML diagram, Figure 1. She noted that conceptualization and consideration of the effect of ecosystem changes, such as invasive species on people, “should not be limited to economic terms and health impacts, but [should be considered] in *cultural terms* as well” [emphasis original]. She argued that, “Cultural implications of ecosystem change mostly affect those communities that are dependent on particular resources for cultural expression and identity”.

Consequently, Woodley recommended that “careful attention” be paid to the pending implementation of NCCOS’ Human Dimensions

(HD) Strategy. She noted that “This is an important strategy and implementation will likely require the input of qualified staff who are versed in the social or anthropological sciences, to assist researchers in the process of incorporating the HD strategy into their work”. She also commented on NCCOS’ long term goal of integrating Traditional and Ecological Knowledge into research and management programs, stating that such reservoirs of knowledge are not widely used because of “unfamiliarity of environmental scientists and managers with social science methods required for documentation,<sup>4</sup> again justifying the need for someone with anthropological experience to work with NCCOS staff [if] this objective is to become realized”.

In the context of human dimensions, Woodley noted a potential pitfall for NCCOS to contemplate. There is a lack of consensus across NOAA about what constitutes an Integrated Ecosystem Assessment, particularly as it relates to the conceptualization of the role of humans as both a driver of ecosystem change and a benefactor/victim of such changes. She suggested that the conceptual framework used by the Millennium Ecosystem Assessment<sup>5</sup> is ideal, and may be a good model for NCCOS to consider. The Millennium Ecosystem Assessment conceptual framework “assumes that a dynamic interaction exists between people and other parts of ecosystems, with the changing human condition serving to both directly and indirectly drive

<sup>4</sup> Huntington, H. 2000. Using Traditional Ecological Knowledge in Science: Methods and Applications. *Ecological Applications* 10(5), 1270-1274.

<sup>5</sup> <http://www.millenniumassessment.org/en/index.aspx>

change in ecosystems and with changes in ecosystems causing changes in human well-being”.<sup>6</sup> Key is the reciprocal interaction between humans and ecosystems, which should be recognized in integrated assessments.

Woodley suggested that humans should be incorporated into NCCOS’ research programming both conceptually and practically. In other words, critical aspects of the human dimensions of ecological change should be considered when setting research priorities and program goals, as well as in the articulation of individual research projects. In addition, more practically, people should be incorporated into NCCOS’ programs by including stakeholders, resource users and coastal managers in all aspects of NCCOS’ research efforts, from the setting of priorities to, where possible, data collection. According to Woodley, the HDS should be able to accomplish these tasks. However, she articulated basic questions for NCCOS to consider related to the HDS and attempts to integrate the human or social aspects of resource issues:

- “With limited financial and human resources, is it feasible to draw on the broader implications of the link between ecosystem change on humans, as suggested in the [HML] diagram? There should be clarity in developing and understanding this important link and both broadening the scope of what is implied and what can be taken on within NCCOS”.
- “Is the NCCOS mission statement too broad and inclusive? How does the mission for each center fit into the NCCOS overall mission – are these goals too dispersed and not cohesive enough? NCCOS’ four strategic goals address the “natural and social aspects of ecosystem management”.

Fuller was not convinced that a human dimensions approach was as valuable as other approaches NCCOS might take in the context of invasive species because she tends “to think more about our impact on the environment and personally sees that as more important”. Nevertheless, she recognized that by packaging projects in a way that focuses attention on the negative impact of species/ecosystems on humans (as opposed to the reverse) may be “the best way to get money, especially in the current political climate” and “in the long run”. It should be noted that a basic difficulty underlying discussions about HD during the review was a lack of understanding and agreement among/between participants about what HD means and, from a research and programming standpoint, what it does and does not include. Woodley, an expert in the area, suggested that implicit in the HD approach is taking into account the impact that ecosystems have on people - on their health, culture and economies. In turn, the condition of a society's health, culture and economy will influence how people impact ecosystems and whether people can live sustainably within them. The interaction is cyclical, as opposed to linear.

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<sup>6</sup> Page 28, in “Chapter 1: MA Conceptual Framework,” 2005 Ecosystems and Human Well-being: Current State & Trends Assessment, Volume 1, Edited by Hasasan, Rashid, Robert Scholes & Neville Ash. Island Press: Washington. Available online at: <http://www.millenniumassessment.org/documents/document.765.aspx.pdf>