Background information on the ORAP report

In May 2000, the Office of Science and Technology Policy (OSTP), through the National Ocean Research Leadership Council (NORLC), requested that the Ocean Research Advisory Panel (ORAP) prepare a strategic plan (primary topics and their initial priorities) for a U.S. research program to study marine biological resources within the 200-nautical mile U.S. exclusive economic zone. The OSTP requested that the plan also address the means to make these resources economically and ecologically sustainable by 2010.

The ORAP was asked to build on and synthesize the many available studies, stakeholder inputs and ongoing programs to reach a broad framework for a U.S. research agenda over the next decade, to be revisited periodically. The plan was to address two areas: 1) ecological sustainability, including the marine food web, impact of pollution on living marine resources, and tools for management and conservation of living and non-living marine resources and 2) economic sustainability, including marine biotechnology and health of marine fisheries and research on marine organisms.

This request resulted in the following plan, "Strategic Vision for Achieving Sustainable Marine Resources within the U.S. EEZ." The deadline for summary comments has passed. Comments submitted are posted here with attribution.

Strategic Vision for Achieving Sustainable Marine Resources Within the US EEZ

Prepared by the Ocean Research Advisory Panel
of the National Oceanographic Partnership Program
January, 2001

Introduction

In 2000, the Ocean Research Advisory Panel (ORAP) of the National Ocean Partnership Program (NOPP) was requested by the White House Office of Science and Technology Policy (OSTP) to perform two tasks. The first was to prepare a strategic vision (primary topics and their initial priorities) for a US research program to study marine biological resources within the 200-nautical mile US Exclusive Economic Zone (EEZ). The vision is to include the means to make these resources economically and ecologically sustainable by 2010. ORAP was asked to respond to this request by the end of the calendar year.

The second task is to work with NOPP's OCEANS.US Office to determine appropriate observational strategies in support of the research program and the sustainability goals of 2010 outlined in the first task. ORAP is asked to respond to this charge by the end of calendar year 2001.

This report is intended to respond to the first of these tasks. ORAP's view on executing this charge was that any recommendations must be based on sound scientific analysis and backed by strong community support and consensus. Because of the short time available to complete this report, it was not possible to convene panels of experts to craft the recommendations or to submit the report to a lengthy and thorough review process. For that reason, the ORAP relied on a number of recent reports from the National Academy of Sciences (NAS), the National Science

Foundation (NSF), the National Ocean and Atmospheric Administration (NOAA), and other groups, all of which had the benefit of expert input and peer review. Conclusions and recommendations taken directly from published reports are referenced in the footnotes. All documents consulted are listed in the bibliography at the end of the report. In many cases the recommendations from these reports were not prioritized, nor had there been an attempt to prioritize the recommendations among different reports. Nevertheless, the ORAP was able to assign initial priorities to the recommendations based on their immediate relevance to the topic at hand, as well as a consideration of what common themes span the full spectrum of coastal resource issues.

Ecological Sustainability

No part of the ocean is unaffected by human activities. Marine ecosystems experience substantial impacts from commercial fishing, aquaculture, introduction of non-native species, destruction of habitat, excess nutrients, and the addition of pollutants[1]. The coastal ocean is affected most profoundly, on account of its proximity to a population increasingly concentrated along the shoreline, and the US EEZ is no exception[2]. These effects are manifested increasingly by outbreaks of harmful algal blooms, microbial pathogens, and in some instances, the complete collapse of commercially important invertebrate and fisheries populations. Natural variability due to climate change is also affecting the coastal ocean, but at this time such impacts are smaller in magnitude than the human influence. However, if the wind systems were to change significantly, coastal circulation and ecosystems could be strongly altered. At the very least, the natural changes can exacerbate the problems induced by human activities[3]. There is thus an urgent need to understand and predict the factors and subsequent effects leading to the alteration or the collapse of marine communities and the ecosystem services that they provide. Ultimately, strategies must be developed to mitigate the damage to marine ecosystems inflicted by humans and nature.

We focus on three important components of ecological sustainability that require enhanced attention through research and development: research on the interactions and interdependence of the marine food web; research on marine pollution, particularly excess nutrients; and the development of resource management and conservation tools.

Marine Food Web

Better sustaining the biological resources in the coastal EEZ requires a better understanding of the marine food web. Research objectives should include determining the functional and structural dynamics of these biological assemblages and how they respond to environmental perturbations. A better understanding is needed of the linkages between primary and secondary productivity. Also of underlying importance is the need to understand the interactions between marine biota and various biogeochemical cycles, including any influence of global climate change. These interactions can occur from the individual organism level to the ecosystem level. Better mechanistic understanding of these interactions through observation and controlled experimentation is required to meet future threats to marine ecosystems. For example, warming of the surface ocean over the past decade has lessened the upwelling of cold, nutrient-rich waters, leading to a dramatic drop in primary productivity in some coastal areas. Although it is beyond humankind's immediate control to change the temperature of the surface waters throughout the coastal ocean, are there other ways to compensate for this reduction in natural upwelling?

Improved technologies for observing and characterizing the distribution of food web components and their associated interactions across time and space will be required. Extensive time series data from both remote sensing and in-situ systems4 will be necessary to compensate for the substantial heterogeneity that exists in the marine environment and to improve the resolution of paleontological patterns. Emerging molecular, chemical, optical, and acoustical technologies should lead to significant improvements in remote sensing capabilities. However, a substantial investment is still needed to bring in-situ systems to the state such that they can be deployed for long periods on autonomous platforms5. It is imperative that that investment be made now such that these systems are ready for deployment on coastal observing systems within the next few years.

Effect of Excess Nutrients on Living Marine Resources

Nutrient (nitrogen) over-enrichment in coastal waters is a complex, priority resource management issue that could be addressed through this marine resource strategy. Nutrient enrichment can have a range of effects on coastal systems. Direct and indirect ecological impacts include increased primary productivity and phytoplankton biomass, reduction in water clarity, increased incidences of low oxygen events, and changes in the food web structure and dynamics. Harmful algal blooms may become more frequent and extensive and the growth of some marine pathogens may be promoted. Coral reefs and submerged aquatic vegetation, such as seagrass and kelp beds may be degraded or destroyed. Fish kills may occur, and more importantly, subtle changes in ecological structure may lead to lowered fishery production. Generally, nutrient over-enrichment leads to ecological changes that decrease the biotic diversity of the ecosystem6.

Management strategies must be designed for controlling or mitigating the effects of nutrients. The need for improving the scientific basis for these approaches is pressing. For example, water quality criteria and standards and load levels will need to be established, as well as a system for evaluating the effectiveness of various approaches, such as wetlands restoration or reduced fertilizer applications. The following are critical areas for continued research: determining the appropriate parameters for measuring environmental properties associated with this condition; understanding and being able to predict the fate and transport mechanisms of nutrients from land-based and riverine, atmospheric, and oceanic sources; identifying the factors influencing the susceptibility of various coastal ecosystems to nutrient over-enrichment; understanding the impacts of nutrient enrichment leading to such conditions as harmful algal blooms and their implication for all levels of the food web; and determining the effects of alterations to the nitrogen cycle on global climate change7.

Marine Protected Areas for Resource Management and Conservation

Current declines in commercial fisheries raise concerns that conventional management strategies are not working and have prompted managers to seek alternative strategies for achieving goals for the conservation of habitat, fisheries, or biological diversity. Marine protected areas, which may include no-take reserves, are a management tool that is being applied with greater frequency. Unfortunately, there is no scientific consensus on how these areas should be designed or their effectiveness evaluated over time.

Marine reserves present a unique opportunity for researchers to address important questions about marine populations and their habitat requirements. Research is needed to determine: the dispersal ranges of various life history stages of marine populations and the role of oceanography, physiology and behavior in dispersal; the impact of reserves on both exploited and unexploited species; and whether such areas serve as sources or sinks of larval recruits, including the minimum size necessary for efficacy in supporting sustainable, healthy populations and ecosystems8.

It is imperative that the research and management communities work together to develop a science-based approach for designing, managing, and evaluating the effectiveness of marine reserves and in a broader geographic context than individual managed areas. In order to learn from both intentional and unintentional manipulations observing strategies need to be in place to monitor the positive and negative impacts of these large-scale experiments in ecological sustainability9.

Pilot programs to determine the most cost-effective strategies for mapping habitat, sampling marine biota, and monitoring physical, biological, and chemical parameters should be initiated as soon as possible in order to guide larger programs. Such programs can help to determine the appropriate measurable criteria for designing and evaluating the effectiveness of marine reserves in meeting various goals, including the sustainable management of marine resources.

Economic Sustainability

The oceans are important to the world's continued food security and contain unknown potential for new drugs and marine products. Two key research areas requiring enhanced attention are marine biotechnology and the decline in fisheries.

Marine Biotechnology

Exploratory research shows the great potential for exploiting the biochemical capabilities of marine organisms to provide new classes of pharmaceuticals, polymers, enzymes, analytical reagents, and food sources10. Overall, sales of biotechnology products reached $13 billion in 1998, and could go as high as $24 billion by 200511. Surprisingly, this boon in new products has been based primarily on terrestrial biota and has barely begun to tap the potential from the 80 percent of Earth's phyla that are found only in the sea. Japan has recognized the untapped market potential in marine biotechnology, and now outspends the U.S. by a factor of 10 in this area.

Marine biotechnology is also providing new tools and approaches for understanding biological diversity, the ecological relationships among marine organisms, and the state of marine populations. This is knowledge that is required to establish resource conservation strategies. Biotechnological approaches will aid in many other areas, such as monitoring and assessing the impact to organisms and ecosystems from toxic contaminants, detecting harmful algal blooms, and understanding the diseases of marine organisms. Also promising is the potential application of techniques for marine bioremediation in the aftermath of oil spills and for the restoration of damaged coral and reef habitats12.

Realizing the potential of living resources in the U.S. EEZ for commercial and research applications will require a multidisciplinary, coordinated, and integrated approach, beginning with systematic exploration and taxonomic description of organisms ranging from microbes to megafauna13. With the coastal environment experiencing degradation, time is of the essence. Organisms with such potential may become extinct before anyone even knows that they exist. The COMPASS (Coordinated Marine Programs to Assess and Sustain the Sea) initiative has been proposed to the NSTC as a mechanism for federal investment, management, coordination, and promotion of marine biotechnology14. Augmented support for basic research, as well as the development of new policies that encourage private sector investment in pre-commercial R&D, could greatly accelerate the discovery and development of new products from the sea.

Along with the identification of organisms with commercial potential should also come the obligation to protect such resources from over-exploitation. In most cases, taking from wild populations will not be a viable option to supply the development and marketing of marine bioproducts. Therefore, stakeholders mush invest in research on environmentally sustainable use of marine resources, including options such a aquaculture, microbial fermentation, chemical synthesis, and transgenic production15.

Marine Fisheries

Many marine fisheries are in decline, and some fishing practices have had a detrimental effect on marine habitats and non-commercial species16. Several fisheries have been entirely closed in an attempt to restore them to a healthy state, and in many other cases increasing effort is required to achieve the same catch. The biomass of fish and invertebrates killed by ocean fishing every year (including catch, by catch, and inadvertent mortality) probably exceeds 110 million metric tons per year. This number is likely in excess of the total productivity of ocean ecosystems17, which itself might be declining because of habitat destruction, pollution, and climate change. Long term, the latter effects may do more harm than the direct effects of fishing on targeted species18.

Clearly, the ocean's resources are not inexhaustible, and it is important to adopt an ecosystem approach to managing them19. Broad-based research is required to provide the fundamental understanding of ecosystem functioning necessary for informed policy decisions. Important areas of research include the need to: identify and characterize fisheries populations and to understand the ecological processes that limit these populations; determine the interaction between wild marine populations and aquaculture species; and understand how the collapse of one species or the entry of an invasive species may impact the food web and ecosystem health. More research is also needed on the biological effects of fishing, such as the alternation of gene pools and population structures as a consequence of fishing. Modeling approaches that incorporate environmental variability into fishery, multispecies, and tropic models need further development, testing, analysis, and calibration. As discussed previously, expansion of marine protected areas and thorough monitoring of their local and regional impact on fisheries would be important elements in fisheries research.

Cross-cutting Research Needs

Progress in addressing these categories of research providing a stronger scientific basis for supporting the conservation and sustainable use of marine resources within the U.S. EEZ would be accelerated by developing the capability to observe and monitor the changes in complex ecosystem dynamics in response to natural and human-induced perturbations. The most important first steps in establishing this monitoring capability are as follows:

1. Expand programs to characterize coastal ecosystems and monitor their response to intentional and unintentional perturbations using all relevant biological, chemical, and physical sensors (including those still in prototype stage). This expansion will require additional support for the development of suitable indicators of sustainability and stress. Monitoring programs in support of resource management would be most effective if they could be set up to include both protected and unprotected areas to determine the relative impacts of natural variability and human activities on ecosystem functioning and productivity in marine protected areas and reserves of various sizes[20].

2. Improve methods of data collection, management, and dissemination across government agencies and between public and private sectors[21]. More uniform data collection standards are needed so that data can be made more widely accessible and aggregated to reveal the bigger picture. Relevant scientific information also needs to be made available to decision-makers and other stakeholders in useful formats.

3. Invest in biological and chemical sensor research, to bring these systems to the same level of maturity and reliability as the current suite of physical sensors[22]. Some science questions and monitoring applications can only be addressed through the deployment of in situ analyzers[23]. Promising prototypes exist, and their development should be brought to completion as soon as possible. Partnerships with commercial developers should be sought to increase availability and reduce production costs.

4. Support the development of joint coastal ocean circulation and ecosystem models. Even with better observing systems, data dissemination, and sensors as advocated above, it will still be impossible to observe everything of interest. Models constrained by observations are essential for ultimate understanding of these complex systems and prediction of their future evolution.

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