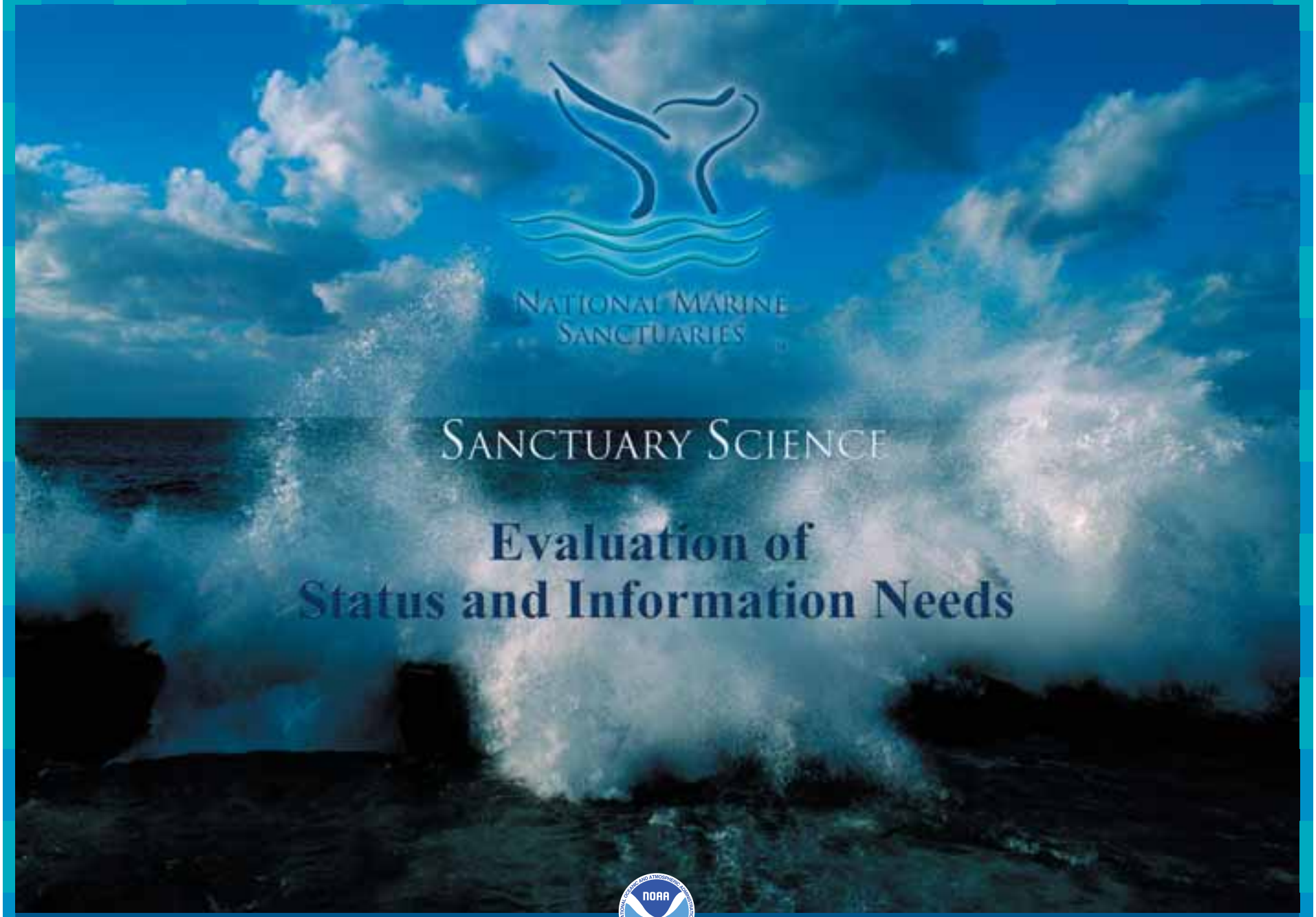


Sanctuary Science

Evaluation of Status and Information Needs

NATIONAL MARINE SANCTUARIES™

NOAA Ocean Service

U.S. Department of Commerce
Donald L. Evans, Secretary

National Oceanic and Atmospheric Administration
VADM Conrad C. Lautenbacher, Jr. (USN-ret.)
Under Secretary of Commerce for Oceans and Atmosphere

National Ocean Service
Margaret Davidson, Assistant Administrator (Acting)

Silver Spring, Maryland
July 2002

Written and Produced by:

Stephen R. Gittings

Kimberly E. Benson

Paula J. Souik

Mitchell S. Tartt

Graphic Design:

Sandra Nitchie

Executive Summary

A system of 13 National Marine Sanctuaries (NMS) protects over 18,000 square miles of U.S. waters containing nationally significant natural and cultural resources. Science activity in the NMS Program (Program) promotes understanding of the changing nature of these resources and the threats they face. It also provides for response capabilities, evaluates management effectiveness, supports policy development, and strengthens the Program's support of broader, NOAA-wide objectives for coastal management.

An understanding of environmental processes and the function of natural systems is vital to ensure that these areas are properly protected and managed while trade and leisure activities continue within them. The target for the Program's science is to learn how environmental systems function so we can recognize, understand, forecast, and respond to natural and human-caused environmental change.

A deliberate effort is underway to improve the Program's research and monitoring capacities to support the management of natural resources in the sanctuaries. First, we are working to assess our current scientific strengths and weaknesses and to identify our priority information needs at all relevant spatial and temporal scales. Second, we are developing capabilities that improve our ability to address these needs, including strategic planning, infrastructure, funding mechanisms, and partnerships.

This report completes the first objective. It uses information gathered from sanctuary management and research staff, experts in a number of scientific fields, and other resource management practitioners to identify the most important science and information needs for natural resource management in the marine sanctuaries, and evaluates how well these needs are being addressed by current and planned activities. The results will be used to direct or modify research efforts, establish priorities for future initiatives, build strategic partnerships, provide science guidance for other agencies, and respond to queries regarding information and funding needs.

Workshop and Survey

During a 2001 science workshop, participants identified 150 priority scientific "endpoints" (objectives that address an information need) within the following management issues:

- **Habitat Delineation** - determining location and extent of biotic and abiotic components of sanctuary habitats and relationships between habitat and living marine resources.
- **Zoning** - criteria for determination of location and size of zones, as well as evaluating effectiveness.
- **Assessment of Living Marine Resources** - determining status and trends, as well as measures of ecological fitness.

- **Water Quality Protection** - preventing, tracking, and controlling land and sea-based threats to water quality and understanding impacts on sanctuary resources.
- **Fishing/Harvest Effects** - impacts of harvesting flora and fauna, as well as unintended impacts (e.g. ghost gear impacts).
- **Wildlife Disturbance** - evaluating threats of various types of human activity to sanctuary resources.
- **Event Response** - reacting to spills, groundings, harmful algal blooms, etc. Actions may include trajectory forecasting, impact assessment, and counter-measures.
- **Restoration/Rehabilitation** - techniques and evaluation of measures to restore or enhance recovery rates for natural resources impacted by human activities.
- **Industrial Uses** - potential impacts from and capacities needed for dealing with industrial activities within sanctuary boundaries (e.g., cables, pipelines, platforms, marine transportation, bioprospecting, aquaculture).

Staff at each of the sanctuaries focused on natural resource management were asked to provide pre-defined numerical ratings of the relevance, current scientific activity level, and state of knowledge for each endpoint identified in the workshop. Based on a model of recommended levels of research and monitoring activity derived from an endpoint's relevance and the current state of knowledge, appropriate levels of activity were recommended for each endpoint and compared to current levels. Recommended changes ranged from –3 (substantial decrease) to +3 (substantial increase). Zero (0) indicates that no change in activity is recommended. The data were analyzed from programmatic, site-specific, regional, and resource-specific perspectives.

Note: *The sanctuaries focused on cultural resources, Monitor National Marine Sanctuary and Thunder Bay National Marine Sanctuary and Underwater Preserve, were not evaluated by this process. Research and monitoring activities for cultural resources are addressed separately by the Program.*

Findings

Based on the judgment of sanctuary staff at each site, 79% of 150 endpoints identified in the workshop were judged to be of medium or high relevance, on average. Further, no single endpoint was judged as less than medium relevance by every site. This strongly suggests that the issue groups in the workshop identified endpoints of legitimate importance to management of natural resources in the marine sanctuaries.

The data suggest that all sites should enhance science activities for almost all management issues. Overall, the increase averaged +0.9, with individual issues ranging from –0.2 to 2.0. The highest percentages of endpoints meriting substantial increases in activity were in the following management issue groups: Zoning, Fishing/Harvest Effects, and Restoration/Rehabilitation. Two other groups, Water Quality and Industrial Uses, appeared to be the issues most appropriately addressed on the whole.

Of the 150 endpoints identified during the 2001 workshop, 136 were recognized as requiring substantially more attention by at least one site. Twelve endpoints were identified by at least eight of the eleven participating sites as requiring substantial increases (+2 or +3), suggesting a particular need to address these endpoints. They are:

- Biological Resources: Factors controlling the success of year classes for species: Competition between key species
- Biological Resources: Factors controlling the success of year classes for species: Predator-prey relationships
- Biological Resources: Factors controlling the success of year classes for species: Recruitment
- Biological Resources: Pertinent information on species of special interest: Ecological indicators
- Harvesting: Data on spatial and temporal habitat changes caused by fishing
- Harvesting: Effects of fishing/harvest on predator-prey dynamics
- Harvesting: Factors controlling year class strength of targeted species: Competition between species
- Harvesting: Factors controlling year class strength of targeted species: Growth, reproduction, and mortality
- Harvesting: Factors controlling year class strength of targeted species: Recruitment
- Harvesting: Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting
- Industrial Uses: Identification of sources of invasive species
- Mapping Capabilities: GIS compatible data: Source areas for critical species

Coral Reef Information Needs

A number of other endpoints consistently appeared among sites with similar attributes, demonstrating unique needs dictated by the nature of the resources protected. In addition to the needs listed above, 12 endpoints with suggested substantial increases in activity were identified at four of the five sites containing coral reefs or coral resources:

- Biological Resources: Factors controlling the success of year classes for species: Habitat use at various life stages
- Biological Resources: Pertinent information on species of special interest: Keystone species (e.g. apex predators, critical herbivores)
- Event Response: Linkages between causes of events
- Event Response: Risk assessment: Probability of future events
- Water Quality: Incidental contaminants from vessels (merchant, fishing, tourism, private)
- Water Quality: Levels and mechanisms of contaminants causing mortality
- Water Quality: Levels and mechanisms of sublethal stressors
- Water Quality: Temporal changes in levels of pathogens and pathogenic indicators within biological samples
- Zone Performance: Effectiveness of zoning regime
- Zone Performance: Impacts of unrestricted human activities within zones areas: Intensity
- Zone Performance: Impacts of unrestricted human activities within zones areas: Spatial distribution
- Zone Performance: Impacts of unrestricted human activities within zones areas: Types of impacts

Marine Mammal Information Needs

Five endpoints with recommended substantial increases in activity appeared particularly relevant among sites that protect marine mammals:

- Biological Resources: Pertinent information on species of special interest: Ecological indicators
- Restoration: Valuation of sanctuary resources
- Wildlife Disturbance: Susceptibility and response of species of concern: Acute and chronic response (e.g. behavioral, reproductive, physiological, physical injury)
- Wildlife Disturbance: Susceptibility and response of species of concern: Verification of cause-and-effect relationships
- Wildlife Disturbance: Threat assessment for sources of wildlife disturbance: Range of influence for potentially vulnerable species

West Coast Information Needs

Finally, for sites along the west coast of the U.S., six additional high priority endpoints were identified at four of the five sites, suggesting unique regional needs:

- Biological Resources: Factors controlling the success of year classes for species: Condition and trends of critical habitat
- Harvesting: By-catch data
- Harvesting: Comparisons of impacts of fishing and harvest pressure in areas of high, low, and no activity
- Harvesting: Factors controlling year class strength of targeted species: Food requirements
- Harvesting: Level of effort, spatial and temporal distribution, and density for recreational fishing/harvesting
- Industrial Uses: Characterization of vessel traffic: Ballast exchange requirements and protocols

Individual Site Information Needs

For each of the natural resource sanctuaries, science activities were evaluated to answer the following questions:

1. Are the information needs for management issues being appropriately addressed by science activities at the sanctuary?

2. To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

Furthermore, for each sanctuary, a summary table provides a list of high relevance endpoints with recommended changes in activity of +2 or +3. This is intended to provide the sanctuaries and relevant partners with the details necessary to identify management issues and, more specifically, endpoints with the greatest need for additional attention. Among these endpoints, priority consideration for the targeting of science resources should be considered for 1) endpoints with recommended increases in activity of 3 units, 2) endpoints that are broadly applicable across management issues, and 3) clusters of endpoints similar in nature that might be addressed collectively by future projects. Below are summaries of the evaluations conducted for each sanctuary.

Channel Islands

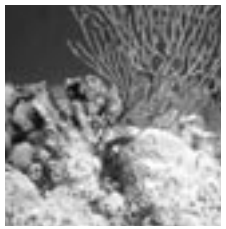
Compared to other sites, the Channel Islands NMS had a fairly low percentage of endpoints that require substantial increases in activity. Two management issues, Fishing/Harvest Effects and Industrial Uses seem to warrant the greatest increase in scientific effort. In addition, a number of endpoints in the areas of Zoning and Wildlife Disturbance may warrant greater attention. Substantial increases in activity were recommended for 28 endpoints of high relevance. Priority information needs for the Channel Islands NMS include developing predictive models to understand the dynamics of habitat distribution; growth, reproduction and mortality of targeted species; ecological indicators of biological resources; incidental contaminants from vessels; ballast water exchange requirements and protocols; and acoustic signatures of vessel traffic.

Cordell Bank

Like the Channel Islands, Cordell Bank NMS also had a fairly low percentage of endpoints that require substantial increases in activity. Zoning and Fishing/Harvest Effects seem to warrant the greatest increase in scientific effort, as do a number of endpoints in the area of Industrial Uses. Substantial increases in activity were recommended for 34 endpoints of high relevance. Priority information needs for Cordell Bank NMS include effectiveness of zoning regimes; ecological, biological and habitat criteria affecting year-class strength; natural and anthropogenic factors affecting sanctuary habitats and harvested stocks; tourism and vessel traffic profiles; dredge and fill activities; and invasive species. In addition, staff interviews indicated that certain aspects of habitat characterization, non-point source pollution, and harmful algal blooms are priority information needs for the site.

Fagatele Bay

Fagatele Bay NMS had a comparatively high percentage of endpoints with recommended substantial increases in activity. Though Zoning, Restoration/Rehabilitation, and Event Response appear to warrant the greatest increase in attention, endpoints with the highest recommended changes in activity are distributed among most management issues. Substantial increases in activity were recommended for 42 endpoints of high relevance. Priority information needs for Fagatele Bay NMS include physical and biological criteria that affect the success of biological resources (e.g. currents, recruitment, growth, reproduction, and mortality), including how they affect zoning and restoration efforts; impacts of fishing activities on species of interest; and predicting, verifying, and tracking events or disturbances of various types within and adjacent to the sanctuary.



Florida Keys

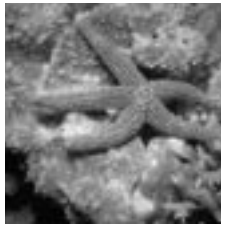
The Florida Keys NMS's average recommended change for all relevant endpoints combined was closer to zero (0) than any other site. The average was 0.2, well below the Program-wide mean of 0.9 and the lowest of all sites. Furthermore, this sanctuary had a comparatively low percentage of endpoints requiring substantial increases in activity. Zoning, Living Marine Resources, and Fishing/Harvesting Effects appear to be the management issues warranting the greatest increases in scientific effort. Substantial increases in activity were recommended for 22 endpoints of high relevance. Priority endpoints that should be considered for greater activity include oceanographic data on wave forces, including temporal variation, in and around areas of concern or particular interest; food requirements as they affect the success of year classes for species; mechanistic links among geologic, biologic, oceanographic, and atmospheric processes as they influence habitat; ballast exchange requirements and protocols; socioeconomic effects of water quality on commercial and recreational uses and profits; and by-catch data.

Flower Garden Banks

The average recommended change in activity at the Flower Garden Banks NMS was 1.2, or 0.3 higher than the Program average. Three management issues, Zoning, Fishing/Harvest Effects, and Restoration/Rehabilitation, require the greatest increase in scientific support. The first two appear to warrant the most attention. Substantial increases in activity were recommended for 34 endpoints of high relevance. Priority information needs for the Flower Gardens are understanding recruitment; effects of fishing on predator-prey dynamics; harvest levels and impacts; recovery trajectories following various impacts; population dynamics of key species; and community dynamics, including trophic structure and species interactions.

Gray's Reef

The average recommended change in activity at the Gray's Reef NMS was 1.3, or 0.4 higher than the Program average. Nearly two-thirds of high priority endpoints require substantial increases in activity. Five issues appear to warrant the greatest increase in scientific activity: Habitat Delineation, Zoning, Living Marine Resources, Water Quality, and Fishing/Harvest Effects. Substantial increases in activity were recommended for 25 endpoints of high relevance. Priority information needs for the Gray's Reef include various types of oceanographic data; specific types of GIS compatible data; effects of fishing/harvest on predator-prey dynamics and levels; mechanisms of contaminants causing mortality; and population trends for key species and communities, including rates of growth, mortality, and fecundity.



Gulf of the Farallones

The average recommended change in activity at the Gulf of the Farallones NMS was 0.4, or 0.5 below the Program average. Compared to other sites, this site has a fairly low percentage of endpoints that require substantial increases in activity. Two issues seem to warrant the greatest increase in scientific activity: Fishing/Harvesting Effects and Zoning. Substantial increases in activity were recommended for 31 endpoints of high relevance. Priority topic areas for future investigation for the Gulf of the Farallones include factors controlling year class strength of targeted species and factors controlling the success of year classes for other species of concern. In addition, staff interviews indicated that certain aspects of non-point source pollution, harmful algal blooms, and agricultural runoff are priority information needs for the site.

Hawaiian Islands Humpback Whale

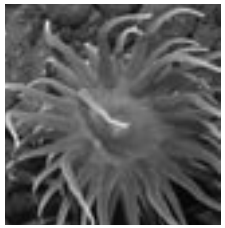
The average recommended change in activity at Hawaiian Islands Humpback Whale NMS was 1.4, the highest level in the Program and 0.5 higher than the Program average. Over two-thirds of high priority endpoints require substantial increases in activity. Four issues seem to warrant the greatest increase in scientific attention: Restoration/Rehabilitation, Zoning, Living Marine Resources, and Wildlife Disturbance. Substantial increases in activity were recommended for 61 endpoints of high relevance. Priority topic areas for future effort at the Hawaiian Islands Humpback Whale NMS are factors controlling the success of year classes for species, information on key species and communities, pertinent information on species of special interest, and GIS compatible data.

Monterey Bay

The average recommended change in activity at Monterey Bay NMS was 1.3, or 0.4 higher than the Program average. Zoning, Fishing/Harvest Effects, Wildlife Disturbance, and Industrial Issues appear to be the management issues warranting the greatest need for additional scientific attention. Substantial increases in activity were recommended for 38 endpoints of high relevance. Priority areas of investigation include factors controlling the success of year classes for species, information on key species and communities, nature and sources of threats to wildlife, and characterization and monitoring along potential cable routes.

Olympic Coast

The average recommended change in activity at the Olympic Coast NMS was 1.0, just above the Program average of 0.9. Fishing/Harvest Effects, Zoning, Living Marine Resources, and Restoration/Rehabilitation appear to be the management issues warranting the greatest increase in activity. Substantial increases in activity were recommended for 54 endpoints of high relevance. Priority areas for investigation at the Olympic Coast NMS include factors controlling year class success, information on key species and communities, oceanographic data in and around areas of concern, and GIS data related to habitat and critical species.



Stellwagen Bank

The average recommended change in activity at Stellwagen Bank NMS was 0.9, equal to the Program average. Endpoints related to Zoning may warrant the greatest increase in scientific effort, followed closely by Living Marine Resources, Fishing/Harvest Effects, and Wildlife Disturbance. Substantial increases in activity were recommended for 32 endpoints of high relevance. Priority information needs for Stellwagen Bank NMS include factors controlling the success of year classes for species (target species and those of special concern); oceanographic data, specifically tides; tourism profiles; information on species of special interest; susceptibility of species to disturbance; and impacts of human activities within zoned areas.

Table of Contents

Background **2**
Science Plan **2**

A Plan to Strengthen Science for Management in the National Marine Sanctuaries **4**

Evaluation of Existing Programs **6**
Development and Administration of the Evaluation **6**
Analysis Methods **8**
Sources of Bias **10**

Programmatic Analysis **11**
Endpoint Relevance **11**
Change Analysis **13**
Analysis by Relevance Category **15**
Endpoints of High Relevance **16**
Endpoints of Moderate Relevance **17**
Endpoints of Low Relevance **18**

Site Analyses and Summaries **19**
Channel Islands **20**
Cordell Bank **23**
Fagatele Bay **27**
Florida Keys **30**
Flower Garden Banks **34**
Gray's Reef **37**
Gulf of the Farallones **40**
Hawaiian Island Humpback Whale **43**
Monterey Bay **47**
Olympic Coast **50**
Stellwagen Bank **54**

Needs, Directions, and Targets **57**
Program Information Needs **57**
Coral Reef Information Needs **59**
Marine Mammal Information Needs **59**
West Coast Information Needs **60**

Next Steps **61**

Appendix 1 – Survey Form **62**

Appendix 2 – Survey Participants **71**

Appendix 3 – Endpoints Recommended for Substantial Increase in Activity **72**

Background

The National Marine Sanctuary Program (Program) is entrusted with the protection of 13 marine sanctuaries comprising over 18,000 square miles of ocean and Great Lakes waters. These waters contain significant natural and cultural resources designated for national protection by virtue of their ecological, historic, scientific, educational, or aesthetic value. Scientific efforts directed at assessment, protection, monitoring, maintenance, and restoration are crucial to effective conservation and adaptive management. Sanctuary managers and staff have a continual need for information to assess the condition and trends of structural and functional components of these protected ecosystems.

The National Marine Sanctuaries (NMSs) currently facilitate and conduct research and monitoring primarily on a site-by-site basis. The degree of success in these endeavors varies greatly. Staffing, site size and accessibility, and partnerships all influence a sanctuary's access to the scientific information required to inform management actions. In order to improve the utility of site-based information at local, regional, and national scales, and to leverage and benefit from other on-going research and monitoring initiatives, there is a need within the Program to implement both nationally-coordinated and site-specific planning, monitoring, and research programs. For this reason, we are developing plans to complement and enhance on-going site efforts as well as implement ecosystem-based, issue-driven, and Program-wide efforts.

Science Plan

The 1999 Science Plan for the National Marine Sanctuary System presents a strategic vision for a science program, including such priorities as:

- Establishing an infrastructure that ensures adequate staffing, effective short- and long-term planning, productive partnerships, and efficient information management and dissemination.
- Understanding the status and trends of sanctuary resources on local, regional, and national scales; the nature, level, and trends of human use; and nationally significant themes (e.g., essential habitat identification, biodiversity, and conservation).
- Conducting a management-based science program that emphasizes capacity-building (e.g., GIS training and use) and focuses on information needs for management (e.g., zoning effectiveness, fisheries impacts, human use).

Over the last year, the Program has taken steps to apply the Science Plan to its activities and responsibilities. Drawing on the findings of an internal assessment and advice from experts, we are developing strategies to expand and improve the way research and monitoring support management, protection, conservation, and policy actions and decisions.

Thunder Bay
Stellwagen Bank
Olympic Coast
United States
Monitor
30° N
Cordell Bank
Gulf of the Farallones
Monterey Bay
Gray's Reef
Atlantic Ocean
Northwestern Hawaiian Islands
Channel Islands
Flower Garden Banks
Florida Keys
Gulf of Mexico
Hawaiian Islands Humpback Whale
Equator
Pacific Ocean
Fagatele Bay American Samoa (U.S.)
150°
90° W
120°
Existing Locations
Proposed
Scale varies in this perspective.
Adopted from National Geographic Maps.

A Plan to Strengthen Science for the Management of National Marine Sanctuaries

In the fall of 2000, the Program initiated a deliberate process to strengthen the links between science and management of natural resources. This process involves two distinct phases: 1) assessment of existing science activities and 2) implementation of new strategies (Figure 1).

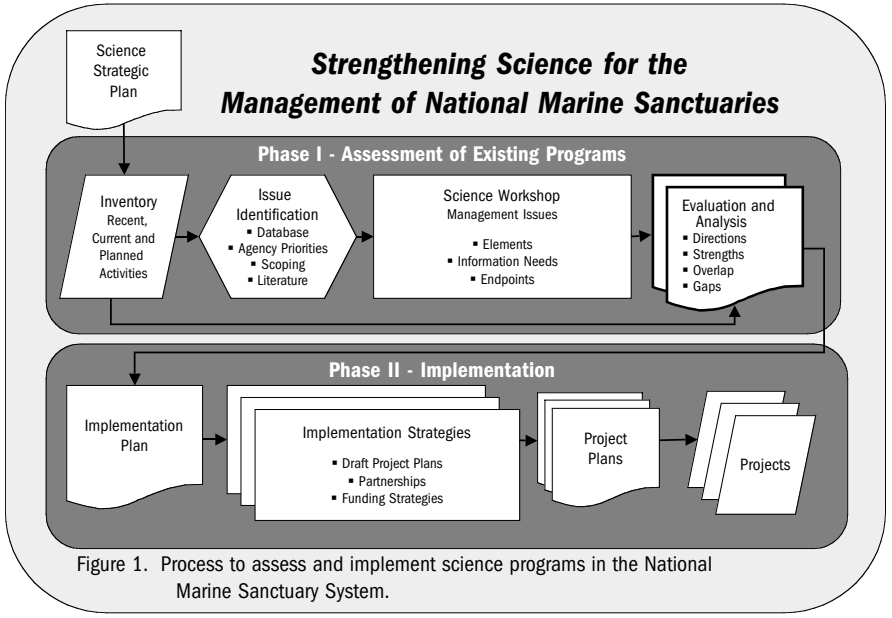


Figure 1. Process to assess and implement science programs in the National Marine Sanctuary System.

Phase 1, the assessment of existing science programs, consists of a series of activities that began with an inventory of recent, current, and planned research and monitoring activities in the 11 marine sanctuaries that protect natural resources. The inventory was compiled in a database that, among other information, presents the management applications and related management issues for each science activity.

The database and other sources were used to identify the highest priority management issues of concern to the Program. Input from the other sources was provided through interviews with sanctuary staff, the identification of agency and program priorities, research planning documents generated by the sites and in previous workshops conducted by NOAA and other agencies, and current conservation biology literature. These issues, in no particular order, are

a. **Habitat Delineation** – determining location and extent of biotic and abiotic components of sanctuary habitats, and relationships between habitat and living marine resources.

b. **Zoning** – criteria for determination of location and size of different categories of zones, as well as evaluating effectiveness.

c. **Assessment of Living Marine Resources** – determining status and trends, as well as measures of ecological fitness.

d. **Water Quality Protection** – preventing, tracking, and controlling land and sea-based threats to water quality and understanding impacts on sanctuary resources.

e. **Fishing/Harvest Effect**s - impacts of harvesting flora and fauna, as well as unintended impacts (e.g., ghost gear impacts).

f. **Wildlife Disturbance** – evaluating threats of various types of human activity on sanctuary resources (e.g., light and noise pollution, ship strikes).

g. **Event Response** – reacting to spills, groundings, harmful algal blooms, etc. Actions may include trajectory forecasting, impact assessment, and counter-measures.

h. **Restoration/Rehabilitation** – techniques and evaluation of measures to restore or enhance recovery rates for natural resources impacted by human activities.

i. **Industrial Uses** – potential impacts from and capacities needed for dealing with industrial uses within sanctuary boundaries (e.g., cables, pipelines, platforms, marine transportation, bioprospecting, aquaculture).

A workshop was then conducted with sanctuary research staff and invited experts to identify specific science objectives that address information needs related to these management issues. For purposes of the workshop and this report, the following definitions apply:

Management Issue: a general topic or area of concern for which effective management of natural or cultural resources requires specific information (e.g., zoning)

Information Need: the areas of investigation critical to the understanding required for effective management (e.g., larval dispersion and post-settlement processes as they affect spillover).

Endpoint: Science objectives to address an information need (e.g., the spatial and temporal patterns of dispersal and recruitment for selected species, the spatial abundance patterns of various size classes for these species).

Endpoints for each management issue were identified through a series of breakout sessions held during the workshop. For more information on this workshop, refer to Strengthening Science for the Management of National Marine Sanctuaries—Science Workshop Report.

Endpoints generated during the workshop formed the basis of an internal evaluation to assess how well science activities in sanctuaries contribute to management information needs (see Evaluation and Analysis on Figure 1). The results of this evaluation are the subject of this report.

The seasonal catch of herring in Tomales Bay, CA.

The second phase of the plan to strengthen science in the National Marine Sanctuary Program will require the development of targeted implementation plans. Strategies will be designed to continue, adjust, or initiate science activities that address priority endpoints identified through the evaluation process. Implementation mechanisms to be considered include the development of suitable partnerships, refinement of existing partnerships, identification of funding sources and mechanisms to enable intramural and extramural projects, and promotion of directed research among federal agencies and other associates with related interests and responsibilities.

Evaluation of Existing Science Programs

This document presents the results of the last step of Phase I, evaluation and analysis. The purpose of the evaluation was to elucidate the extent to which current activities address the information needs and endpoints identified in the workshop.

The evaluation and analysis process involved 1) the creation of a survey form consisting of clearly stated endpoints; 2) ratings by sanctuary staff as to the relevance, level of activity, and information availability for each endpoint; and 3) the analysis of ratings data to determine programmatic and site-specific status with regard to the endpoints to which they pertain. The analysis effort provides feedback to sanctuary staff and others on Program strengths, gaps, and apparent surpluses of effort, as well as guidance for future efforts.

Development and Administration of the Evaluation

Nearly 600 endpoints were identified during the workshop. These were reviewed by the Program science staff for consistency and clarity. Because endpoints identified by independent breakout groups frequently pertained to more than one management issue, numerous overlaps were evident. Similar endpoints were combined and duplications were removed, resulting in a manageable, yet comprehensive, evaluation form with 150 endpoints (Appendix 1).

Endpoints in the evaluation form were organized in topical categories. The management issues to which each endpoint applies are indicated in the columns on the right (Figure 2). Site staff filled in the first three columns after each endpoint. They considered each endpoint as it pertains to their site and provided a rating for the following three categories:

A) **Concern/Relevance**: Level of concern/relevance the site ascribes to the endpoint:

1=not applicable
2=low
3=medium
4=high

B) **Current Activities:** Extent to which recent, planned, or current science efforts address the endpoint:

1=not addressed

2=somewhat addressed

3=moderately addressed

4=well addressed

C) State of Knowledge: Availability, from all sources, of quality information/data pertaining to the endpoint and the utility of this information in decision making:

1=not available

2=limited availability/utility

3=moderate availability/utility

4=fully available/useful

Assessment of the Status of Science in the National Marine Sanctuaries	A) Concern/Relevance	B) Current Activities	C) State of Knowledge	1) Habitat Charact.	2) Zoning	3) Living Marine Res.	4) WQ Protection	5) Fishing/Harvest	6) Wildlife Disturbance	7) Event Response	8) Restoration/Rehab.	9) Industrial Uses	**Comments**
I. OCEANOGRAPHIC REGIME													
Oceanographic data, including temporal variation, in and around areas of concern or particular interest:													
Currents	4	3	3	√	√	√	√	√	√	√	√	√	lack circulation model
Tides	2	3	3	√		√	√	√	√	√		√	microtidal region
Upwelling	4	2	2	√		√	√	√		√			internal waves also
Salinity	3	4	4	√		√	√	√					extensive monitoring
Temperature	4	4	4	√		√	√	√	√				
Turbidity	3	3	3	√		√	√	√		√	√	√	
Light penetration/PAR	4	3	3	√		√	√	√					
Chemistry	2	2	2	√		√	√	√				√	depending on what is meant by chemistry
Nutrient Flux	4	3	3	√		√	√	√					budgets and sources
Oxygen	2	4	4	√		√	√	√					
Wave forces	4	2	2	√		√		√	√	√	√	√	storm events
Chlorophyll-a	4	3	3	√		√	√	√					4x/year
II. HABITAT													
Mechanistic linkages among geologic, biologic, oceanographic, and atmospheric processes as they influence habitat	4	2	2	√	√	√			√	√	√		bioerosion, CO2 increase, coral recruitment
Predictive models to understand dynamics of habitat distribution and factors that influence it (e.g., substrate burial, gear impacts, climate change impacts)	3	3	2	√	√				√	√	√		
Identification of anthropogenic habitats (e.g., shipwrecks, artificial reefs, oil platforms, piers, dumps, bottom fishing gear scars)	3	2	2	√	√	√		√				√	
Geological characterization (including tectonism and diapirism)	3	3	3	√									
Sediment characterization within areas of concern	3	3	3	√				√				√	

Figure 2. Example of a portion of a completed evaluation form.

Analysis Methods

To analyze the ratings provided by the sites, a general model (Figure 3) was developed to relate the levels of Concern/ Relevance and State of Knowledge to a recommended level of activity (i.e., research or monitoring effort). Activity levels were determined subjectively, with recommended activity levels increasing as relevance increases or as knowledge levels decrease. For approximately half the 16 possible combinations, judgments as to recommended activity level were straightforward. For combinations that did not have a clear resolution (e.g. Concern/Relevance=2, State of Knowledge=2, where Recommended Activity Level could be 1 or 2), the fact that the endpoint was at all relevant was deemed to justify the higher recommended activity level.

State of Knowledge \ *Concern/Relevance*	**1**	**2**	**3**	**4**
1	1	2	3	4
2	1	2	3	4
3	1	1	2	3
4	1	1	1	2

Figure 3. Model showing the recommended levels of science activity (numbers in shaded boxes) for each combination of ratings of Concern/Relevance and State of Knowledge (see text for description of numerical ratings).

Current Activity levels provided by the sites for each endpoint (column B on the evaluation form) were compared to the model, and a recommended change in activity level was calculated. Figure 4 illustrates outcomes for the four possible Current Activity levels. For example, if geological characterization of a site was rated as highly relevant (4), but the state of knowledge was rated as low (1), then a high level of recommended activity (4) would be appropriate, according to Figure 3. If the Current Activity level at the sanctuary was rated as low (level 2), an increase of activity of two units would be recommended (Figure 4b). Thus, as resources become available, the sanctuary might want to consider increasing science activities directed at geological characterization from “somewhat addressed” to “well addressed.”

a. Current Activity Level 1

State of Knowledge \ Concern/Relevance	1	2	3	4
1	0	+1	+2	+3
2	0	+1	+2	+3
3	0	0	+1	+2
4	0	0	0	+1

b. Current Activity Level 2

State of Knowledge \ Concern/Relevance	1	2	3	4
1	-1	0	+1	+2
2	-1	0	+1	+2
3	-1	-1	0	+1
4	-1	-1	-1	0

c. Current Activity Level 3

State of Knowledge \ Concern/Relevance	1	2	3	4
1	-2	-1	0	+1
2	-2	-1	0	+1
3	-2	-2	-1	0
4	-2	-2	-2	-1

d. Current Activity Level 4

State of Knowledge \ Concern/Relevance	1	2	3	4
1	-3	-2	-1	0
2	-3	-2	-1	0
3	-3	-3	-2	-1
4	-3	-3	-2	-2

Figure 4. Models indicating the degree to which science activity would have to change for a given knowledge and relevance level at each of four different Current Activity levels to match the model shown in Figure 3. Zero (0) indicates that no change in activity is recommended (see text for description of numerical ratings).

For purposes of discussion in this report, terms were adopted to describe the output of the evaluation. Endpoints with recommended changes in activity of –3 and –2 were considered to merit "substantial decreases" in activity. Those with recommended changes of –1, 0, or +1 warranted "little or no change" in activity. Those with +2 or +3 may merit "substantial increases" in attention. Further distinctions were avoided, for the most part, due to the subjective nature of the rating system and subsequent analysis.

Terms used to describe recommended changes in science activity:

Substantial decrease: -3, –2

Little or no change: -1, 0, +1

Substantial increase: +2, +3

Sanctuary research vessel Jane Yarn heads out to Gray's Reef National Marine Sanctuary to support science operations

Sources of Bias

The analysis was inherently subjective, with several sources of potential bias. One evaluation survey was completed for each of 11 marine sanctuaries with each rating representing the collective opinions of up to three people. With two exceptions, no evaluators participated in more than one site evaluation (see Appendix 2). Ratings for relevance, activity levels, and knowledge reflect the evaluators' breadth of research and management experience, their level of expertise, and their specialty.

Responses to the question of an endpoint's relevance may have required the most subjective judgment of the three questions posed. Activity and knowledge levels are much easier to judge quantitatively (e.g., number of projects supported, number of publications). Comparisons among sites' activity and knowledge levels might, however, be problematic because inflated or depressed values in these categories might be perceived as advantageous by the evaluator for a variety of reasons. Similar bias could occur if evaluators interpreted an endpoint or question too narrowly or too broadly. Furthermore, judgments of activity and knowledge levels were based on comparison among endpoints at that particular site. An increase of one unit for an endpoint at one site might require different consideration than a similar increase at another site.

Despite bias in surveys, there appeared to be fairly good consistency among site surveys. For the purpose of quality assurance, selected science staff reviewed completed evaluations for apparent errors, oversights, inconsistencies, and anomalous ratings. Identified irregularities were referred back to the original evaluator to confirm or reconsider. While these activities were not focused on removing bias per se, they may have resulted in increased consistency among the sites.

Evaluator bias was possibly compounded by the structure of the survey itself. Endpoints were organized in topic areas (e.g., oceanographic regime, habitat). If an evaluator considered a topic area to be of particular importance or need, they might tend to judge all endpoints within that topic area to be of higher relevance or lower state of knowledge.

An additional effect of the survey structure also reduced the strength of the data analysis. Because endpoints are not equivalent in scale or scope, analysis based on direct comparison is not as robust as it might be. Yet, while the evaluation is not statistically rigorous, it is extremely valuable. Its purpose was to determine the status of scientific efforts in the program and their application to priority management issues. It was also intended to assist the Program and our partners to determine where efforts might be redirected or targeted. For these purposes, we believe that the data and the analyses are appropriate and adequate.

Programmatic Analysis

Analyses were conducted for the Program as a whole and on a site-by-site basis. For the Program, relevance data were analyzed to determine whether the endpoints identified in the workshop were, in fact, information needs considered important by sanctuary staff. Data on recommended changes in activity level were also analyzed to determine what the greatest needs are within the Program. Finally, relevance data were broken down by level (4, 3, 2, and 1) and combined with data on recommended changes in activity level to more specifically identify the status of current science efforts and provide specific direction for future effort.

Endpoint Relevance

Table 1 shows the number of endpoints associated with each management issue. While this does not represent an exhaustive list of endpoints applicable to any issue, these endpoints were considered priorities by the workshop attendees. As many of the endpoints provide information essential to a variety of management issues, the suite of endpoints ascribed to each management issue is not mutually exclusive. For example, knowledge of larval dispersal mechanisms is required to make decisions about both Zoning and Restoration/Rehabilitation. Assessment by this organizational structure helps to correct for differences in scale and scope of endpoints by emphasizing basic information that services multiple issues.

Table 1. Number of the 150 endpoints listed in the evaluation form applicable to each priority sanctuary management issue.

Management Issue	*Number of Applicable Endpoints*
Habitat Delineation	42
Zoning	43
Assessment of Living Marine Resources	49
Water Quality Protection	45
Fishing/Harvest Effects	58
Wildlife Disturbance	41
Event Response	29
Restoration/Rehabilitation	34
Industrial Uses	45

Endpoints are scientific objectives that address information needs. A single endpoint may apply to several management issues. For instance, it is important to understand temporal variations in upwelling to accurately characterize habitats, assess living marine resources, address water quality issues, understand the effects of fishing, and respond to unforeseen events.

The NOAA Ship McARTHUR arrives at Southeast Farallon Island for a round of submersible dives.

The validity of the endpoints identified by workshop participants is demonstrated by the relevance ratings shown in Table 2. Based on the judgment of sanctuary staff at each site, an average of almost 80% of endpoints were judged to be of medium or high relevance, with a rating of either 3 or 4. Further, no single endpoint was judged as less than medium relevance (3) by every site. This suggests strongly that the breakout groups in the workshop identified endpoints of legitimate importance to marine sanctuary management.

Table 2. Percentage of endpoints within each of four relevance categories, as judged by each marine sanctuary.

Percentage of Endpoints by Relevance Level

Relevance	*CB***	*CI*	*FB*	*FG*	*FK*	*GF*	*GR*	*HI*	*MB*	*OC*	*SB*	*Mean*
1 (na)	7	7	8	8	1	5	15	15	1	1	9	7
2 (Low)	13	7	19	15	15	12	24	8	10	13	17	14
3 (Med)	19	31	30	31	23	23	35	20	41	30	17	27
4 (High)	61	55	43	47	62	60	26	57	48	56	57	52
3+4*	80	86	73	77	85	83	61	77	89	86	75	**79**

* The row "3+4" is the sum of those two levels.

** Abbreviations for this and subsequenct tables: CB, Cordell Bank; CI, Channel Islands; FB, Fagatele Bay; FG, Flower Garden Banks; FK, Florida Keys; GF, Gulf of the Farallones; GR, Gray's Reef; HI, Hawaiian Islands Humpback Whale; MB, Monterey Bay; OC, Olympic Coast; SB, Stellwagen Bank.

Interestingly, the Florida Keys, Olympic Coast, and Monterey Bay were among the sites with the highest percentage of endpoints of medium to high relevance (3 or 4). This may reflect, in part, the fact that these are the three largest sanctuaries. All three contain coastal segments and are also quite complex with regard to management issues of concern.

On average, sites judged only 7% of endpoints to be irrelevant (i.e., relevance of 1) and none were considered irrelevant by all sites. Florida Keys, Olympic Coast, and Monterey Bay considered only 1% of endpoints to be irrelevant to their sites. In contrast, Gray's Reef and Hawaii considered 15% to be irrelevant.

Change Analysis

Note - For the remainder of analyses in this report, endpoints at any given site with relevance of 1 (i.e., irrelevant) were excluded.

Table 3 shows the comparatively high percentage of endpoints pertaining to three management issues, Zoning, Fishing/Harvest Effects, and Restoration/Rehabilitation, that may merit an increase in activity of either two or three units. The table also suggests that Water Quality and Industrial Uses may be the issues that are most appropriately addressed on the whole. At least 70% of endpoints within these issues had recommended changes in activity within one unit of zero (-1, 0, or +1). Also of note, for any management issue, between 1% and 5% of endpoints may warrant substantial decreases in activity.

Table 3. Average percentage of endpoints within each level of recommended change in activity for priority management issues in the National Marine Sanctuary Program.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	0	4	8	29	29	23	6	**5**	66	29
Zoning	0	1	5	21	24	41	9	1	49	**50**
Living Marine Resources	0	1	6	25	30	32	6	2	61	37
Water Quality	0	3	5	29	36	21	4	3	**71**	26
Fishing/Harvest Effects	0	2	5	23	27	35	8	2	55	**43**
Wildlife Disturbance	0	1	7	25	29	31	6	1	62	37
Event Response	0	5	3	27	32	28	5	**5**	62	33
Restoration/Rehabilitation	0	2	3	24	30	35	6	2	57	41
Industrial Uses	0	2	9	30	32	22	6	2	**70**	28

Individual site data may be more illustrative and useful than the Program means. Sites can use their data to identify issues that require increased attention, those that might warrant a decrease in effort, and those that are being addressed at appropriate levels. All sites indicated that their science activities should be enhanced for almost all management issues (see Figure 5). The means for each issue ranged from –0.2 (Gulf of the Farallones: Event Response, the only negative mean) to 2.0 (Hawaiian Island Humpback Whale: Restoration/Rehabilitation). Overall, judgments by the staff members at Hawaii (1.4), Monterey Bay (1.3) and Gray's Reef (1.3) suggest that their sites need the greatest increase in activity (Table 4). Data from the Florida Keys (0.2) and Gulf of the Farallones (0.4) suggest that they may require the least average change in activity level.

Surveys of sanctuary staff revealed areas that require substantial increases in scientific attention. The highest percentage of endpoints requiring the greatest attention were within the following issues: Zoning, Fishing/ Harvest Effects, and Restoration/ Rehabilitation.

Figure 5. Average recommended changes in activity level for each sanctuary and the NMSP for each management issue. Scale below figure shows the numerical ranges for each level of shading.

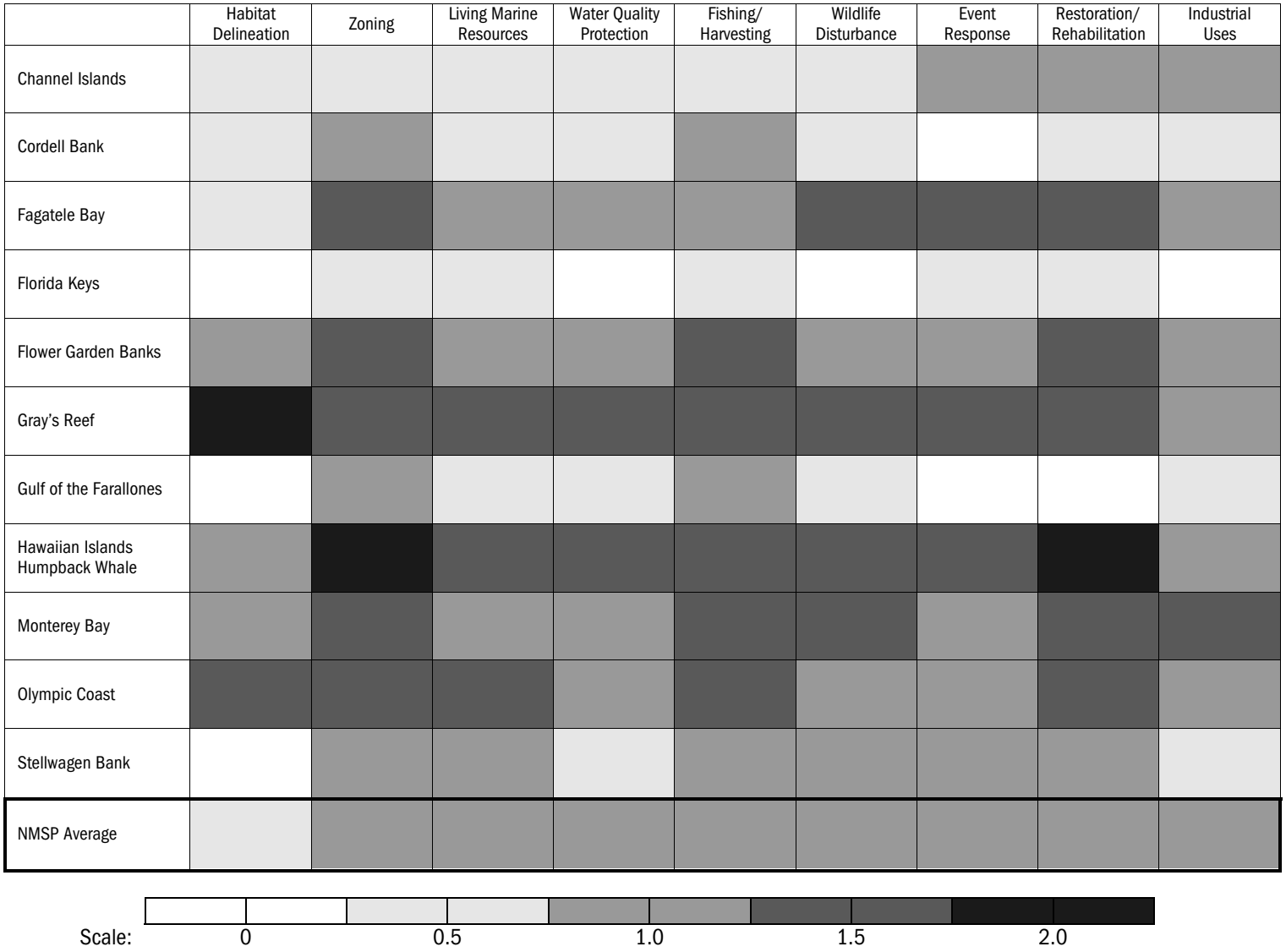


Table 4. The recommended change in activity levels were averaged for all relevant endpoints for each marine sanctuary, and a Program-wide mean was calculated.

Average Recommended Change in Activity for all Relevant Endpoints	
Channel Islands	0.9
Cordell Bank	0.6
Fagatele Bay	1.1
Florida Keys	0.2
Flower Garden Banks	1.2
Gray's Reef	1.3
Gulf of the Farallones	0.4
Hawaiian Islands Humpback Whale	1.4
Monterey Bay	1.3
Olympic Coast	1.0
Stellwagen Bank	0.9
System-Wide Mean	0.9

Analysis by Relevance Category

In order to evaluate the appropriateness of science activity at the sites for information needs of differing levels of relevance, data were divided according to relevance levels. Program averages were also calculated for comparison to site data (Table 5). Of note, almost a third of endpoints had a recommended change in activity of +1, nearly half of high relevance endpoints required substantial increases in activity, and nearly all endpoints of low relevance were judged to require little or no change in activity.

Table 5. The average number and percentage of endpoints considered relevant in the marine sanctuaries within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	Number *of Total Endpoints with Recommended Change in Activity of*								***Percentage*** *of Total Endpoints with Recommended Change in Activity of*								*Percentage* ***Among*** *Relevance Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	0	0	2	11	13	na	na	27	0	0	2	8	10	na	na	20	2	**98**	na
3	0	0	4	5	18	9	na	37	0	0	3	4	13	7	na	27	1	**74**	25
4	na	3	3	20	12	26	7	72	na	2	2	15	9	20	5	53	4	49	**47**
Total	0	4	10	36	42	36	7	**135**	0	3	7	27	**31**	26	5	100	3	**65**	32

Sanctuaries were asked to rank the relevance of science endpoints, allowing a more detailed evaluation of the areas of greatest need. Importantly, almost half the endpoints judged to be of high relevance also required substantial increases in attention.

Endpoints of High Relevance

Sites considered an average of 52% of endpoints to be highly relevant (Table 2). Over a third of these endpoints warranted a substantial increase in activity, with a recommended change of +2, on average (Table 6). In fact, 65% of endpoints identified by the sanctuaries to be of high relevance were judged to warrant an increase in activity (+1 to +3). Over half the endpoints rated by Hawaii and Olympic Coast staff as highly relevant warranted an increased activity level of 2. Sites with a particularly high proportion of endpoints with a recommended change in activity of +3 were Gray's Reef and Fagatele Bay. Endpoints in either the +3 or +2 categories for the Hawaiian Islands, Fagatele Bay, Olympic Coast, and Gray's Reef totaled 71%, 66%, 64%, and 64%, respectively. This reflects the need for considerable increases in targeted research at these sites.

A comparatively high proportion of highly relevant endpoints (62%) were judged to require no change in activity for the Florida Keys, and 73% warranted no or minimal change (i.e. change in activity of –1, 0, or 1). The Channel Islands had 65% in the latter category. By contrast, Fagatele Bay, Gray's Reef, and the Hawaiian Islands had no more than 35% of endpoints within one unit of zero.

A comparatively low percentage (8%) of highly relevant endpoints appear to merit a reduction in activity, and only 4% may warrant a considerable reduction (-2 units). Sites with endpoints in these categories may want to evaluate their commitments to these particular efforts.

Table 6. The number and percentage of endpoints of high relevance (4) within each of the "recommended change in activity" categories for each sanctuary.

High Relevance (4) Endpoints

	Number of Endpoints with Recommended Change in Activity of							**Percentage** of Endpoints with Recommended Change in Activity of						
Sanctuary	-2	-1	0	1	2	3	Total	-2	-1	0	1	2	3	-1 to 1
CB	7	5	25	21	33	1	92	8	5	27	23	36	1	55
CI	1	5	26	22	25	3	82	1	6	32	27	30	4	65
FB	0	0	10	12	21	21	64	0	0	16	19	33	**33**	35
FG	0	0	13	23	27	7	70	0	0	19	33	39	10	52
FK	3	3	58	7	19	3	93	3	3	62	8	20	3	**73**
GF	12	7	27	13	31	0	90	13	8	30	14	34	0	52
GR	2	0	9	3	10	15	39	5	0	23	8	26	**38**	31
HI	0	3	12	10	51	10	86	0	3	14	12	**59**	12	29
MB	2	2	12	18	29	9	72	3	3	17	25	40	13	45
OC	0	0	26	4	48	6	84	0	0	31	5	**57**	7	36
SB	7	10	18	19	23	9	86	8	12	21	22	27	10	55
Total	34	35	236	152	317	84	858	4	4	28	18	**37**	10	50

Endpoints of Moderate Relevance

Endpoints rated to be moderately relevant to the sanctuaries comprised 27% of all rated endpoints, on average (Table 2). Almost three quarters of these were judged to warrant some increase in activity with ratings of +1 or +2 (Table 7). Nearly half (49%) of the moderately relevant endpoints required only a slight increase in activity (+1). A total of 73% warranted no change or slight adjustments in activity (i.e. change in activity of –1, 0, or +1). Olympic Coast, Gulf of the Farallones, and Cordell Bank were at or near 100% in this category.

Three sites (Gray's Reef, Stellwagen Bank, and Monterey Bay) had particularly high percentages of moderately relevant endpoints that warranted some increase in activity. Fifty-eight percent of the moderately relevant endpoints rated by Gray's Reef warranted a +2 change of activity level. Corresponding percentages at Stellwagen Bank and Monterey Bay were 50 and 43, respectively. Note, however, that the numbers of endpoints rated by staff at Monterey Bay and Gray's Reef to be of moderate relevance were high compared to Stellwagen Bank.

On average, only 12% of the moderately relevant endpoints appeared to merit some decrease in activity. Florida Keys was the only sanctuary for which the assessment indicated a substantial surplus of activity for any endpoint (i.e. recommended change of -3) for a moderately relevant endpoint (specifically, salinity information).

Table 7. The number and percentage of endpoints of moderate relevance within each of the "recommended change in activity" categories for each sanctuary.

Moderate Relevance (3) Endpoints

	Number of Endpoints with Recommended Change in Activity of							**Percentage** of Endpoints with Recommended Change in Activity of						
Sanctuary	-3	-2	-1	0	1	2	Total	-3	-2	-1	0	1	2	-1 to 1
CB	0	1	3	3	21	0	28	0	4	11	11	75	0	**96**
CI	0	0	1	9	29	8	47	0	0	2	19	62	17	83
FB	0	0	5	13	16	11	45	0	0	11	29	36	24	76
FG	0	0	4	5	22	15	46	0	0	9	11	48	33	67
FK	**1**	1	15	3	10	4	34	3	3	44	9	29	12	82
GF	0	1	7	3	24	0	35	0	3	20	9	69	0	**97**
GR	0	0	7	3	12	**31**	53	0	0	13	6	23	**58**	42
HI	0	0	0	9	12	9	30	0	0	0	30	40	30	70
MB	0	0	0	8	27	**26**	61	0	0	0	13	44	**43**	57
OC	0	0	8	2	35	0	45	0	0	18	4	78	0	**100**
SB	0	0	0	2	11	**13**	26	0	0	0	8	42	**50**	50
Total	1	3	50	60	219	117	450	0	1	11	13	49	26	**73**

Most endpoints judged to be of moderate relevance were considered to be fairly well addressed. Roughly a quarter, however, require substantial increases in attention.

Endpoints judged to be of low relevance to sanctuaries were, on the whole, considered to be well addressed, though about half may warrant some additional scientific attention.

Endpoints of Low Relevance

On average, sites considered only 14% of endpoints to be of low relevance (Table 2). Despite their low relevance, however, over half (52%) of these endpoints were judged to merit some additional activity (Table 8). Nevertheless, at nine out of 11 sites, the recommended change in activity level for all low relevance endpoints was minimal (–1, 0 or +1).

Overall, 9% of the low relevance endpoints appeared to merit a decrease in activity. Florida Keys was the only sanctuary where the assessment indicated a substantial surplus of activity (i.e., recommended change of -3) for a low relevance endpoint (namely, oxygen information).

Table 8. The number and percentage of endpoints of low relevance within each of the "recommended change in activity" categories for each sanctuary.

Low Relevance (2) Endpoints

	Number of Endpoints with Recommended Change in Activity of						**Percentage** of Endpoints with Recommended Change in Activity of					
Sanctuary	-3	-2	-1	0	1	Total	-3	-2	-1	0	1	-1 to 1
CB	0	0	4	16	0	20	0	0	20	80	0	100
CI	0	0	0	3	7	10	0	0	0	30	70	100
FB	0	0	4	14	11	29	0	0	14	48	38	100
FG	0	0	1	4	17	22	0	0	5	18	77	100
FK	**1**	**4**	1	14	2	22	5	18	5	64	9	78
GF	0	0	5	13	0	18	0	0	28	72	0	100
GR	0	0	0	0	36	36	0	0	0	0	100	100
HI	0	0	0	2	10	12	0	0	0	17	83	100
MB	0	0	0	4	11	15	0	0	0	27	73	100
OC	0	1	0	10	9	20	0	5	0	50	45	95
SB	0	0	1	8	16	25	0	0	4	32	64	100
Total	1	5	16	88	119	229	0	2	7	38	**52**	97

Site Analyses and Summaries

For each sanctuary, science activities were evaluated with respect to relevance and to determine how well information needs for management are being met. Data from each site were analyzed to answer the following questions:

1. Are the information needs for management issues being appropriately addressed by science activities at the sanctuary?
2. To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

To answer the first question, the subsets of endpoints associated with each management issue were evaluated. Management issues with the highest percentage of applicable endpoints requiring little or no change in activity (-1, 0, or +1) were considered the most appropriately addressed. Less than adequate attention was indicated by substantial recommended increases in activity (+2 or +3) while substantial decreases (-2 or -3) were considered indicative of adequate, though potentially excessive, attention.

For the second question, specific endpoints were examined. Any endpoints recommended for substantial decreases in activity level were noted as areas where the sanctuary should reconsider its commitments. All endpoints recommended for substantial increases in activity are potential areas to direct future science resources. However, the endpoints that were also rated as highly relevant to the sanctuary were considered to represent priority targets with respect to fulfilling the information needs of the sanctuary.

For each sanctuary, a summary table provides a list of high relevance endpoints with recommended changes in activity of +3 or +2. This is intended to provide the sanctuaries and relevant partners with the details necessary to identify management issues and, more specifically, endpoints with the greatest need for additional attention. Among these endpoints, priority consideration for the targeting of science resources should be considered for 1) endpoints with recommended increases in activity of three units, 2) endpoints that are broadly applicable across management issues, and 3) clusters of endpoints similar in nature that might be addressed collectively by future projects.

Note: *Terms used to describe recommended changes in science activity in the following sections are consistent with those previously defined and used in the programmatic overview. A "substantial decrease" in activity is suggested if the change in activity is -3 or –2; "little or no change when the recommended change is -1, 0, or +1; and a "substantial increase" when the change in activity is +2 and +3.*

One of the most important information needs in marine sanctuaries involves understanding recruitment and the processes that influence it. This is a tiny juvenile Smooth trunkfish (Lactophyrys triqueter)*, smaller than a bumblebee.*

Key Findings

- *Compared to other sites, the Channel Islands NMS has a fairly low percentage of endpoints that require substantial increases in activity.*
- *Among management issues, the best addressed at the Channel Islands appears to be Living Marine Resources, followed closely by Habitat Delineation.*
- *No significant surpluses in scientific activity are evident.*
- *Three management issues, Restoration/ Rehabilitation, Fishing/Harvest Effects and Industrial Uses, seem to warrant the greatest increase in scientific effort. In addition, a number of endpoints in the areas of Zoning and Wildlife Disturbance may warrant greater attention.*

Priority Endpoints

- *Developing predictive models to understand the dynamics of habitat distribution*
- *Growth, reproduction, and mortality of targeted species*
- *Incidental contaminants from vessels*
- *Ballast water exchange requirements and protocols*
- *Acoustic signatures of vessel traffic*
- *Vessel traffic patterns*

Site Analysis

Channel Islands National Marine Sanctuary

For the Channel Islands NMS, 139 of the 150 endpoints were considered relevant to management information needs. The average recommended change in activity for these was 0.9, equal to the Program average (Table 4). All low relevance endpoints appear to be appropriately addressed at this site, as none had a recommended reduction in activity (Table CI-1). Slight increases in activity, however, may be warranted for 7 of the 10 endpoints of low relevance. Those of moderate and high relevance also appear to be comparatively well addressed. Only 34% percent of the 82 high relevance endpoints may merit substantial increases in attention (an increase of two to three units), well below the Program average of 47% (Table 5).

Table CI-1. The number and percentage of endpoints considered relevant at the Channel Islands NMS within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	Number *of Endpoints with Recommended Change in Activity of*								***Percentage*** *of Endpoints with Recommended Change in Activity of*								*Percentage* ***Among*** *Relevence Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	0	0	0	3	7	na	na	10	0	0	0	2	5	na	na	7	0	100	na
3	0	0	1	9	29	8	na	47	0	0	1	6	21	6	na	34	0	83	17
4	na	1	5	26	22	25	3	82	na	0	0	19	16	18	2	55	1	**65**	**34**
Total	0	1	6	38	58	33	3	**139**	0	0	1	27	42	24	2	96	1	**73**	**26**

Are the information needs for management issues being appropriately addressed by science activities at Channel Islands NMS?

Channel Islands appears to be doing well addressing the information needs associated with management issues. For all issues, percentages of associated endpoints recommended for little or no change in activity (Table CI-2) exceed corresponding Program averages (Table 3); several of these represent the highest percentages for an individual sanctuary. Endpoints related to Living Marine Resources and Habitat Delineation appear to be particularly well addressed compared to other issues at Channel Islands. Ninety-two percent and 88%, respectively, of the endpoints in these management issues suggest no change or only slight adjustments in activity (Table CI-2). These substantially exceed the corresponding Program averages of 61% and 66%.

Restoration/Rehabilitation and Industrial Uses appear to warrant the greatest attention of all management issues, having the highest percentage of endpoints recommended for an increase of 2 or 3 units (Table CI-2). Industrial Uses is the only management issue for Channel Islands that is higher than the Program average, exceeding it by two percentage points.

At the Channel Islands, only one endpoint may merit a decrease in activity (Table CI-1). This endpoint related to data on water temperature in the sanctuary.

Twenty-six percent of endpoints (36) appear to warrant substantially greater science activity (Table CI-1). Of these, 28 endpoints were rated as highly relevant (Table CI-3). For the most part, these endpoints were fairly specific, each relating to a small number of management issues. However, two management issues were associated with the greatest numbers of these endpoints: Fishing/ Harvest Effects and Industrial Uses, each with 9 associated endpoints. Seven endpoints were associated with Zoning and Wildlife Disturbance.

Table CI-2. Percentage of endpoints with each level of recommended change in activity for each management issue in the Channel Islands NMS. Data of particular note are underlined and emphasized in bold.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	0	2	12	49	27	10	0	2	**88**	10
Zoning	0	0	5	37	42	16	0	0	84	16
Living Marine Resources	0	2	6	52	33	6	0	2	**92**	6
Water Quality	0	2	5	34	46	10	2	2	85	12
Fishing/Harvest Effects	0	2	5	43	34	14	2	2	82	16
Wildlife Disturbance	0	3	3	38	40	15	3	3	80	18
Event Response	0	0	7	31	41	17	3	0	79	21
Restoration/Rehabilitation	0	0	3	35	35	26	0	0	74	**26**
Industrial Uses	0	0	8	27	35	22	8	0	70	**30**

To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

Endpoints in Table CI-3 that may warrant priority consideration for the targeting of science resources are those 1) with recommended increases in activity of three units, 2) that are broadly applicable across management issues, and 3) that are both numerous and similar in nature. The three endpoints recommended for increase of +3 were all associated with vessel use in the sanctuary. These concerned ballast exchange, acoustic signatures, and incidental contamination from vessels of various types. In the same general area of investigation, a fourth endpoint was recommended for an increase of +2 and concerned the need for data on vessel traffic patterns. Two endpoints in Table CI-3 address needs within five issues. These endpoints are 1) developing predictive models to understand the dynamics of habitat distribution and 2) growth, reproduction, and mortality of targeted species.

The kelp forest in Channel Islands National Marine Sanctuary provides habitat to a wide array of species. To better protect sanctuary habitats and species more information is needed on potential impacts associated with contaminants, ballast water, and noise from vessels transiting sanctuary waters.

Table CI-3. High relevance endpoints with recommended changes in activity of +3 or +2 at the Channel Islands National Marine Sanctuary.

Endpoints		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
BIOLOGICAL RESOURCES*	Pertinent information on species of special interest: Ecological indicators	2		M	M	M				M	
EVENT RESPONSE	Identification of impacts at appropriate scales	2							M		
	Risk assessment: Consequences of events (including collateral consequences)	2							M		
	Risk assessment: Data/statistics on the occurrence of past events (for each type of event)	2							M		
HABITAT	Processes that create and change seabed forms in the following contexts: Oceanographic (e.g., turbidity flows, erosion)	2	M								
	Processes that create and change seabed forms in the following contexts: Atmospheric (e.g., precipitation, atmospheric deposition, air/sea exchange, atmospheric loading)	2	M								
	Predictive models to understand dynamics of habitat distribution and factors that influence it (e.g., substrate burial, gear impacts, climate change impacts)	2	M	M				M	M	M	
HARVESTING	Effects of fishing/harvest on predator-prey dynamics	2		M			M				
	Effects of natural events on harvested organisms and yields: Global warming	2					M				
	Effects of natural events on harvested organisms and yields: Currents	2					M				
	Factors controlling year class strength of targeted species: Competition between key species	2		M	M		M				
	Factors controlling year class strength of targeted species: Growth, reproduction, and mortality	2		M	M		M	M	M		
	Data on spatial and temporal habitat changes caused by fishing	2		M			M				
	Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting	2		M			M				
INDUSTRIAL USES	Characterization of vessel traffic: Ballast exchange requirements and protocols	3									M
	Characterization of vessel traffic :Acoustic signatures of vessel traffic	3						M			M
	Tourism profile: Activities of vendors	2									M
	Identification of sources of invasive species	2									M
	Characterization of vessel traffic: Vessel traffic patterns	2									M
MAPPING CAPABILITIES	GIS compatible data: Shoreline	2	M			M					
RESTORATION	Valuation of sanctuary resources	2					M			M	M
WATER QUALITY	Incidental contaminants from vessels (merchant, fishing, tourism, private)	3				M	M		M		M
	Temporal changes in levels of pathogens and pathogenic indicators within: Water column	2				M					
	Temporal changes in levels of relevant organics and metals within: Water column	2				M					
WILDLIFE DISTURBANCE	Susceptibility and response of species of concern to wildlife disturbance: Verification of cause-and-effect relationships	2						M			M
	Susceptibility and response of species of concern to wildlife disturbance: Acute and chronic species response (e.g. behavioral, reproductive, physiological, physical injury)	2						M			
	Susceptibility and response of species of concern to wildlife disturbance: Sensory capabilities, physiological tolerances, and thresholds	2						M			
	Spatial and temporal variability in levels of wildlife disturbance	2						M			M
	Endpoints related to management issue		4	7	3	5	9	7	6	3	9

* Note that endpoints are listed by topic category and not management issue. Endpoints may relate to more than one management issue.

Site Analysis
Cordell Bank National Marine Sanctuary

Staff at Cordell Bank considered 140 of the 150 endpoints to be relevant to addressing management issues at the sanctuary. For these endpoints, the average recommended change in activity was 0.6, or 0.3 below the Program average (Table 4). Nearly all low relevance endpoints appear to be appropriately addressed at this site, as all had little or no recommended change in activity (Table CB-1). Those of higher relevance are relatively well addressed compared to most sites. Only 37% percent of the 92 high relevance endpoints and none of the 28 moderate relevance endpoints appear to warrant substantial increases in attention (an increase of two to three units), well below the Program averages of 47% and 26%, respectively (Table 5). In fact, seven high relevance endpoints had recommended decreases in activity of –2, the second highest number in the Program.

Table CB-1. The number and percentage of endpoints considered relevant at Cordell Bank NMS within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	***Number** of Endpoints with Recommended Change in Activity of*								***Percentage** of Endpoints with Recommended Change in Activity of*								*Percentage* **Among** *Relevance Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	0	0	4	16	0	na	na	20	0	0	3	11	0	na	na	14	0	**100**	na
3	0	1	3	3	21	0	na	28	0	1	2	2	15	0	na	20	4	**96**	0
4	na	**7**	5	25	21	33	1	92	na	5	4	18	15	**24**	**1**	66	8	55	37
Total	0	8	12	44	42	33	1	140	0	6	9	31	30	24	1	100	6	70	**24**

Are the information needs for management issues being appropriately addressed by science activities at the Cordell Bank NMS?

For eight of the nine management issues at Cordell Bank, the percentage of associated endpoints recommended for little or no change in activity exceeded the corresponding Program averages. The sanctuary appears to be doing particularly well addressing endpoints related to Water Quality and Event Response. Ninety-three percent of the endpoints associated with Water Quality warranted no change or only slight adjustments in activity (Table CB-2). This value exceeds the Program average by 22% and equals Gulf of the Farallones for the highest value of all the sanctuaries (Table 3). Despite these data, follow-up interviews with sanctuary staff indicate that certain water quality parameters, including non-point source pollution and harmful algal blooms, are not adequately addressed.

For Event Response, 89% of the applicable endpoints were either considered appropriately addressed or warranted decreased activity. This suggests that this management issue generally has been well addressed, though 10% of its associated endpoints were recommended for substantial increases in activity.

Key Findings

- *Compared to most other sites, Cordell Bank NMS has a fairly low percentage of endpoints that require substantial increases in activity.*
- *Among management issues, the most appropriately addressed at Cordell Bank appear to be Water Quality and Event Response, though non-point source pollution and harmful algal blooms may require additional attention.*
- *Potential surpluses in activity may exist for Event Response, and the site may want to evaluate its investment in this issue relative to other needs.*
- *Two management issues, Zoning and Fishing/Harvest Effects, seem to warrant the greatest increase in scientific effort. In addition, a number of endpoints in the area of Industrial Uses may warrant greater attention. Staff interviews indicated that certain aspects of habitat characterization are also a priority for the site.*

Priority Endpoints

- *Ecological, biological and habitat criteria affecting year-class strength*
- *Natural and anthropogenic factors affecting sanctuary habitats and harvested stocks*
- *Tourism and vessel traffic profiles*
- *Dredge and fill activities*
- *Sources of invasive species*

At Cordell Bank National Marine Sanctuary, management activities require additional habitat characterization and life history information on key species, such as this mixed school of rockfish.

Two issues, Zoning and Fishing/Harvest Effects, appear to merit increased science activity compared to other issues at Cordell Bank. Nearly half the endpoints within these two issues had recommended changes in activity of at least 2 units (Table CB-2). Nevertheless, Fishing/Harvest Effects was the only one of the nine issues to exceed the Program average for the percentage of endpoints requiring additional science activity (Table 3). Though not reflected in this analysis, follow-up interviews with sanctuary staff indicted the need for considerable increases in activity related to habitat characterization at Cordell Bank.

Table CB-2. Percentage of endpoints with each level of recommended change in activity for each management issue in Cordell Bank NMS. Data of particular note are underlined and emphasized in bold.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	0	3	8	35	35	20	0	3	78	20
Zoning	0	0	12	21	21	44	2	0	53	**47**
Living Marine Resources	0	0	15	27	29	29	0	0	71	29
Water Quality	0	0	7	48	38	7	0	0	**93**	7
Fishing/Harvest Effects	0	0	5	29	20	45	2	0	54	**46**
Wildlife Disturbance	0	0	18	30	25	25	3	0	73	28
Event Response	0	**17**	7	41	24	10	0	17	72	**10**
Restoration/Rehabilitation	0	6	3	38	26	24	3	6	68	26
Industrial Uses	0	0	8	45	25	23	0	0	78	23

To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

Surpluses of activity were noted in eight of the relevant endpoints at Cordell Bank NMS. Seven of the eight were rated highly relevant. Five of these were predominantly applicable to the issue of Event Response: 1) mitigation alternatives; 2) identification of impacts at appropriate scales; 3) event path tracking and identification of likely consequences; 4) relevant and appropriate data to identify and verify an event inside or adjacent to the sanctuary; and 5) contingency plan for relevant events. It should be stated that this analysis is not meant to suggest that investments in these activities are, in fact, excessive. It is only meant to point out that, given the high activity levels relative to stated knowledge and relevance levels in the evaluation, the sanctuary should consider its investment and judge whether it is appropriately directed.

Twenty-four percent of endpoints appear to merit substantially greater research activity (Table CB-1). Zoning and Fishing/Harvest Effects had the largest percentages of these endpoints (47% and 46%, respectively; Table CB-2). The single endpoint having a recommended change of +3 was the effectiveness of zoning regimes. Significantly, all endpoints that required an increase in activity of 2 or 3 were judged to have a relevance of 4 (Table CB-1).

Endpoints in Table CB-3 that may warrant priority consideration for the targeting of science resources are those 1) with recommended increases in activity of 3 units, 2) that are broadly applicable across management issues, and 3) that are both numerous and similar in nature. The only endpoint recommended for an increase of three units pertains to the effectiveness of zoning regimes. Other areas of need include investigations of the effects of natural events on harvested organisms and yields and factors controlling year class strength between populations and within targeted species populations. Endpoints relating to these areas were broadly applicable across management issues and were similar in nature to other endpoints identified with substantial need. GIS compatible data: critical habitat for species of concern was also found to be a priority endpoint because of it applicability to eight of the nine management issues.

Table CB-3. High relevance endpoints with recommended changes in activity of +3 or +2 at Cordell Bank National Marine Sanctuary.

Endpoint		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
BIOLOGICAL RESOURCES*	Pertinent information on species of special interest: Ecological indicators	2		√	√	√				√	
	Factors controlling the success of year classes for species: Condition and trends of critical habitat	2	√	√	√		√	√	√	√	√
	Factors controlling the success of year classes for species: Multi-species relationships	2			√		√	√		√	√
	Factors controlling the success of year classes for species: Competition between key species	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Predator-prey relationships	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Recruitment	2	√	√	√		√	√		√	
	Information on key species and communities: Community dynamics (e.g., trophic structure, species interactions)	2		√	√	√	√	√		√	√
HARVESTING	Effects of fishing/harvest on predator-prey dynamics	2		√			√				
	Effects of natural events on harvested organisms and yields: Global warming	2					√				
	Effects of natural events on harvested organisms and yields: El Niños	2					√				
	Effects of natural events on harvested organisms and yields: Hurricanes	2					√				
	Effects of natural events on harvested organisms and yields: Currents	2					√				
	Factors controlling year class strength of targeted species: Competition between key species	2		√	√		√				
	Factors controlling year class strength of targeted species: Predator-prey relationships	2		√	√		√				
	Factors controlling year class strength of targeted species: Condition of critical habitat	2	√	√	√		√				
	Factors controlling year class strength of targeted species: Food requirements	2		√	√		√				
	Factors controlling year class strength of targeted species: Recruitment	2	√	√	√		√				
	Factors controlling year class strength of targeted species: Growth, reproduction, and mortality	2		√	√		√	√	√		
	By-catch data	2					√				
	Age of target organisms at time of harvest	2		√			√				
	Data on spatial and temporal habitat changes caused by fishing	2		√			√				
	Level of effort, spatial and temporal distribution, and density for recreational fishing/harvesting	2		√			√				
	Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting	2		√			√				
	Vessel types used for fishing and harvesting	2					√				
	Comparisons of impacts of fishing and harvest pressure in areas of high, low, and no activity	2		√			√				
INDUSTRIAL USES	Characterization of dredge and fill activities: Impact on localized flow dynamics	2				√					√
	Tourism profile: Activities (location, intensity) of tourists	2									√
	Tourism profile: Proximity of sanctuary resources to populated areas	2									√
	Identification of sources of invasive species	2									√
	Characterization of vessel traffic: Proximity of major vessel traffic to sensitive resources	2						√			√
MAPPING CAPABILITIES	GIS compatible data: Critical habitat for species of concern	2	√	√	√		√	√	√	√	√
	GIS compatible data: Sediment types	2	√								
WILDLIFE DISTURBANCE	Threat assessment for sources of wildlife disturbance: Range of influence for potentially vulnerable species	2						√			
ZONE PERFORMANCE	Effectiveness of zoning regime	3		√			√	√		√	
	Endpoints related to management issue		8	20	14	3	26	11	3	9	9

* Note that endpoints are listed by topic category and not management issue. Endpoints may relate to more than one management issue.

Site Analysis
Fagatele Bay National Marine Sanctuary

For Fagatele Bay NMS, 138 of the 150 endpoints were considered to be relevant to management information needs at the sanctuary. The average recommended change in activity for these endpoints was 1.1, or 0.2 above the Program average (see Table 4). All low relevance endpoints appear to be appropriately addressed at this site, as all had recommended changes within one unit of zero (Table FB-1). Those of moderate relevance are, for the most part, adequately addressed, as only 24% had recommended changes in activity above +1 (the Program average was 26%, Table 5). Many endpoints of high relevance, however, require substantially greater attention, with 66% having recommended increases of 2 or 3 units, compared to a Program average of 47%.

Table FB-1. The number and percentage of endpoints considered relevant at Fagatele Bay NMS within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	Number *of Endpoints with Recommended Change in Activity of*								***Percentage*** *of Endpoints with Recommended Change in Activity of*								*Percentage* ***Among Relevance*** *Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	0	0	4	14	11	na	na	29	0	0	3	10	8	na	na	21	0	100	na
3	0	0	5	13	16	11	na	45	0	0	4	9	12	8	na	33	0	76	**24**
4	na	0	0	10	12	21	21	64	na	0	0	7	9	15	15	46	0	34	**66**
Total	**0**	**0**	9	37	39	32	21	138	0	0	7	27	28	23	15	100	0	62	**38**

Are the information needs for management issues being appropriately addressed by science activities at Fagatele Bay NMS?

Fagatele Bay NMS appears to be doing particularly well addressing endpoints related to Habitat Delineation, Water Quality, and Industrial Uses. Over 75% of endpoints within these issues warranted no change or only slight adjustments in activity, exceeding Program averages by 4-11% (Table 3). Other issue areas that exceeded Program averages were Living Marine Resources and Fishing/Harvest Effects. It should be noted, however, that a comparatively high number of endpoints of high relevance within these two issues may warrant substantial increases in activity (Table FB-3).

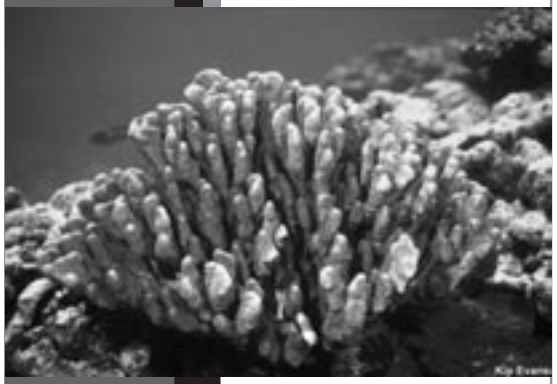
Three issues, Zoning, Restoration/Rehabilitation, and Event Response, appear to warrant the greatest increase in science attention at Fagatele Bay. Roughly half the endpoints within these issues had recommended changes in activity of at least two units (Table FB-2). For these three issues, the percentages of endpoints requiring substantial increases in activity exceeded the corresponding Program averages (Table 3).

Key Findings

- *Compared to other sites, a fairly high percentage of endpoints at Fagatele Bay NMS require substantial increases in activity.*
- *Among management issues, the best addressed appear to be Habitat Delineation, Water Quality, and Industrial Uses.*
- *No surpluses in activity exist.*
- *Zoning, Restoration/Rehabilitation, and Event Response appear to warrant the greatest increase in attention, but endpoints with the highest recommended changes in activity are distributed among most management issues.*

Priority Endpoints

- *Physical and biological criteria that affect the success of biological resources (e.g. currents, recruitment, growth, reproduction, and mortality), including how they affect zoning and restoration efforts*
- *Impacts of fishing activities on species of interest*
- *Predicting, verifying, and tracking events or disturbances of various types within and adjacent to the sanctuary*



Management at Fagetele Bay National Marine Sanctuary has a critical need to understand the impacts of fishing activities. Sanctuary regulations prohibit the use of dynamite to stun or kill fish, but blast-fishing violations still pose a threat to the sanctuary's coral resources, such as this Porites *sp.*

Table FB-2. Percentage of endpoints within each level of recommended change in activity for each management issue in Fagatele Bay NMS. Data of particular note are underlined and emphasized in bold.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	0	0	10	36	31	15	8	0	**77**	23
Zoning	0	0	2	19	26	26	26	0	48	**52**
Living Marine Resources	0	0	2	29	35	21	13	0	67	33
Water Quality	0	0	8	28	40	18	8	0	**75**	25
Fishing/Harvest Effects	0	0	7	32	25	21	16	0	63	37
Wildlife Disturbance	0	0	3	23	33	25	18	0	58	43
Event Response	0	0	3	14	38	24	21	0	55	**45**
Restoration/Rehabilitation	0	0	0	18	32	32	18	0	50	**50**
Industrial Uses	0	0	11	31	33	11	14	0	**75**	25

To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

All 138 endpoints relevant to the information needs of Fagatele Bay NMS are either being appropriately addressed or were recommended for increased activity. No surpluses were identified (Table FB-1).

Fifty-three endpoints warrant substantially greater science activity (Table FB-1), and 42 of these are considered highly relevant (Table FB-3). These endpoints are distributed broadly across all management issues, with the greatest number applying to Zoning, Fishing/Harvest Effects, and Wildlife Disturbance. A large number of endpoints apply to several of the management issues and pertained to impacts of fishing activities on species of interest, and the physical and biological criteria controlling populations (e.g., currents, recruitment, growth, reproduction, and mortality). Those related to Event Response deal with predicting, verifying, and tracking events of various types within and adjacent to the sanctuary.

Endpoints in Table FB-3 that may warrant priority consideration for the targeting of science resources are those 1) with recommended increases in activity of three units, 2) that are broadly applicable across management issues, and 3) that are both numerous and similar in nature. Eighteen endpoints listed in Table FB-3 were recommended for in increase of +3. In general, these endpoints represent fairly specific areas of investigation applicable to a few endpoints. However, several are particularly noteworthy because of broad applicability or similarity to other listed endpoints. One endpoint, oceanographic information on currents in and around the sanctuary, is relevant to all issues. Several endpoints applicable to six issues relate to factors controlling year class strength of living resources (e.g. inter-species relationships, stresses, growth, and reproduction) and habitat affinities for different life stages. These include endpoints recommended for increases of both +2 and +3.

Table FB-3. High relevance endpoints with recommended changes in activity of +3 or +2 at Fagatele Bay National Marine Sanctuary.

Endpoint		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvesting Effects	Wildlife disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
BIOLOGICAL RESOURCES*	Pertinent information on species of special interest: Ecological indicators	3		√	√	√				√	
	Factors controlling the success of year classes for species: Multi-species relationships	3			√		√	√		√	√
	Pertinent information on species of special interest: Keystone species (e.g. apex predators, critical herbivores)	2			√					√	
	Factors controlling the success of year classes for species: Indicators of physiological stress (e.g., biomarkers, bleaching)	2			√	√		√	√	√	√
	Factors controlling the success of year classes for species: Competition between key species	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Predator-prey relationships	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Habitat use at various life stages	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Recruitment	2	√	√	√		√	√		√	
EVENT RESPONSE	Develop or revise and validate appropriate ecological models to predict events	3							√		
	Event path tracking and identification of likely consequences	3							√		
	Relevant and appropriate data to identify and verify an event inside or adjacent to the sanctuary	3							√		
	Linkages between the causes of events	2							√		
	Identification of impacts at appropriate scales	2							√		
	Contingency plan for relevant events	2							√		
	Risk assessment: Probability of future events	2							√		
HARVESTING	Effects of fishing/harvest on predator-prey dynamics	3		√			√				
	Factors controlling year class strength of targeted species: Recruitment	3	√	√	√		√				
	Factors controlling year class strength of targeted species: Growth, reproduction, and mortality	3		√	√		√	√	√		
	Age of target organisms at time of harvest	3		√			√				
	Distribution and abundance of fish (target and non-target) at different life stages	3	√	√	√		√	√	√		
	Factors controlling year class strength of targeted species: Predator-prey relationships	2		√	√		√				
	Data on spatial and temporal habitat changes caused by fishing	2		√			√				
	Level of effort, spatial and temporal distribution, and density for recreational fishing/harvesting	2		√			√				
	Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting	2		√			√				
INDUSTRIAL USES	Identification of sources of invasive species	3									√
MAPPING CAPABILITIES	GIS compatible data: Shoreline	2	√			√					
OCEANOGRAPHIC REGIME	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Currents	3	√	√	√	√	√	√	√	√	√
RESTORATION	Valuation of sanctuary resources	3					√			√	√
	Assessment of appropriate technologies for restoration/rehabilitation in the following categories: Physical structure	3								√	
WATER QUALITY	Temporal and spatial dynamics influencing water quality: Inputs from non-point sources and selected human activities	3				√					
	Incidental contaminants from vessels (merchant, fishing, tourism, private)	2				√	√		√		√
	Temporal and spatial dynamics influencing water quality: Inputs from rivers and outfalls	2				√					
WILDLIFE DISTURBANCE	Susceptibility and response of species of concern to wildlife disturbance: Acute and chronic species response (e.g. behavioral, reproductive, physiological, physical injury)	3						√			
	Spatial and temporal variability in levels of wildlife disturbance	3						√			√
	Susceptibility and response of species of concern to wildlife disturbance: Verification of cause-and-effect relationships	2						√			√
	Susceptibility and response of species of concern to wildlife disturbance: Sensory capabilities, physiological tolerances, and thresholds	2						√			
	Threat assessment for sources of wildlife disturbance: Predict outcomes for various disturbance regimes	2						√			
	Threat assessment for sources of wildlife disturbance: Identification of sources	2						√			√
ZONE PERFORMANCE	Impacts of unrestricted human activities within zoned areas: Intensity	3		√							
	Impacts of unrestricted human activities within zoned areas: Spatial distribution	3		√							
	Impacts of unrestricted human activities within zoned areas: Types of impacts	3		√							
	Effectiveness of zoning regime	3		√			√	√		√	
	Endpoints related to management issue		8	19	13	7	18	16	12	12	9

* Note that endpoints are listed by topic category and not management issue. Endpoints may relate to more than one management issue.

Key Findings

- *The FKNMS had the lowest average recommended change for relevant endpoints among sites.*
- *The FKNMS had a comparatively low percentage of endpoints that require substantial increases in activity.*
- *Among management issues, the most appropriately addressed at the FKNMS appear to be Wildlife Disturbance, Industrial Uses, and Restoration/ Rehabilitation (though there remains the need for controlled research on the success of specific restoration actions).*
- *Potential surpluses may exist for several endpoints related to Habitat Delineation and Water Quality.*
- *Zoning, Living Marine Resources, and Fishing/Harvesting Effects appear to be the management issues warranting the greatest increases in science effort.*

Site Analysis
Florida Keys National Marine Sanctuary

All but one of the 150 endpoints were determined to be relevant to information needs for management at Florida Keys NMS. For these, the average recommended change in activity was 0.2, well below the Program mean of 0.9 and the lowest of all sites (Table 4). For moderate and high relevance endpoints, Florida Keys exceeds the Program average in the percentage being adequately addressed. Remarkably, little or no change was recommended for 73% of high relevance endpoints (Table FK-1), well above the Program average of 49% (Table 5) and the highest of any site.

Low relevance endpoints appear to be less appropriately addressed in the Florida Keys than at other sites. Little to no change was recommended for 77% (Table FK-1), compared to an average of 97% for all sites (Table 5). This reflects the recommendation of considerable decreases (-2 to –3) in activity for five endpoints judged to be of low relevance to the Florida Keys.

Table FK-1. The number and percentage of endpoints considered relevant at the Florida Keys NMS within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	***Number** of Total Endpoints with Recommended Change in Activity of*								***Percentage** of Total Endpoints with Recommended Change in Activity of*								*Percentage **Among** Relevance Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	1	4	1	14	2	na	na	22	1	3	1	9	1	na	na	15	23	**77**	na
3	1	1	15	3	10	4	na	34	1	1	10	2	7	3	na	23	6	82	12
4	na	3	3	58	7	19	3	93	na	2	2	39	5	13	2	62	3	**73**	24
Total	2	8	19	75	19	23	3	149	0	5	13	50	13	15	2	100	7	76	**17**

Are the information needs for management issues being appropriately addressed by science activities at Florida Keys NMS?

The Florida Keys NMS appears to be doing particularly well addressing endpoints related to Wildlife Disturbance, Restoration/ Rehabilitation, and Industrial Uses, with 83%, 82%, and 80% of endpoints warranting no change or slight adjustments in activity, respectively (Table FK-2). Interviews with sanctuary staff, however, suggest that there remains the need for controlled research on the success of specific restoration actions, as knowledge to date has been gained largely though trial and error.

The percentages of adequately addressed endpoints for all management issues are at or above the corresponding averages for the Program (Table 3). However, the percentages for Wildlife Disturbance and Restoration/Rehabilitation are particularly noteworthy because they are the highest values for an individual sanctuary.

For the Florida Keys, the highest percentages of endpoints potentially meriting substantial increases in activity (Table FK-1) were for Zoning, Fishing/Harvest Effects, and Living Marine Resources (28%, 26%, and 25%, respectively). However, all these fall well below their corresponding Program averages, with Zoning being particularly remarkable (Table 3). Zoning is the issue of greatest need for

the sanctuary, yet the percentage of endpoints that are appropriately addressed for this issue is 21 points higher than the Program average. This reflects the tremendous Program-wide need for increased science activity to support Zoning.

The fact that the Florida Keys NMS ranks well above the rest of the sanctuaries in addressing endpoints related to Zoning reflects considerable efforts over the last five years to establish zones and monitor their effectiveness. Despite these efforts, research on zoning remains a priority as it is required to evaluate this controversial approach to resource management.

Table FK-2. Percentage of endpoints within each level of recommended change in activity for each management issue in the Florida Keys NMS. Data of particular note are underlined and emphasized in bold.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	5	7	17	40	17	14	0	12	74	14
Zoning	0	2	7	47	16	28	0	2	70	**28**
Living Marine Resources	4	4	8	42	17	25	0	8	67	**25**
Water Quality	4	9	13	40	18	13	2	13	71	16
Fishing/Harvest Effects	4	5	9	44	12	25	2	9	65	**26**
Wildlife Disturbance	0	5	18	50	15	13	0	5	**83**	13
Event Response	0	3	3	59	14	21	0	3	76	21
Restoration/Rehabilitation	0	0	3	56	24	18	0	0	**82**	18
Industrial Uses	0	9	9	60	11	9	2	9	**80**	11

To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

Ten of the 149 relevant endpoints at Florida Keys NMS were recommended for decreased science activity (Table FK-1). In general, the surpluses occurred in endpoints that addressed basic research needs with broad applicability across management issues. Surpluses were evident in all levels of relevance, but they were particularly prominent for endpoints considered to be of low concern at the sanctuary. These included two endpoints regarding oceanographic data (oxygen and tides) and three related to cable laying (sediment types, impacts to habitat, and infauna/epifauna). Sanctuary staff may want to reconsider resource commitments to these particular areas of investigation.

At the Florida Keys, 17% of endpoints, or 26 endpoints, appear to warrant substantially greater science activity (Table FK-1). Twenty-two should be considered high priority, as they were rated as highly relevant by site staff (Table FK-3). Three management issues had comparatively high numbers of applicable endpoints in this category and may warrant the greatest attention: Fishing/ Harvest Effects, Living Marine Resources, and Zoning.

Endpoints in Table FK-3 that may warrant priority consideration for the targeting of science resources are those 1) with recommended increases in activity of three units, 2) that are broadly applicable across management issues, and 3) that are

To effectively manage resources in the Florida Keys National Marine Sanctuary, sanctuary managers require additional information on the life history characteristics of species targeted by recreational and commercial fishing activities.

both numerous and similar in nature. Three high relevance endpoints, each pertaining to only one management issue, were recommended for a +3 change in activity. The management issues and specific endpoints were: 1) Fishing/Harvest Effects: by-catch data; 2) Water Quality: socioeconomic effects of water quality on commercial and recreational uses and profits; and 3) Industrial Uses: ballast exchange requirements and protocols. [Note: Interviews with sanctuary staff following this evaluation indicate that, compared to other information needs, the latter two endpoints are not among the highest in priority.]

Two other endpoints are noteworthy because they are associated with at least six management issues: 1) Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Wave forces (referring at this site to the impact of storm events); and 2) Mechanistic linkages among geologic, biologic, oceanographic, and atmospheric processes as they influence habitat. Research to investigate various factors controlling year class strength for living resources should also be considered as an area to target resources. Six endpoints pertaining to this area were recommended for substantial increase in attention.

It should be noted that the Florida Keys NMS recently conducted an in-house evaluation of priority research and monitoring needs. The sanctuary relied on outside research and agency collaborators for input. A list of high priority needs was developed and a science plan has been drafted.

Table FK-3. High relevance endpoints with recommended changes in activity of +3 or +2 at the Florida Keys National Marine Sanctuary.

Endpoints		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
BIOLOGICAL RESOURCES*	Pertinent information on species of special interest: Keystone species (e.g. apex predators, critical herbivores)	2			√					√	
	Pertinent information on species of special interest: Ecological indicators	2		√	√	√				√	
	Factors controlling the success of year classes for species: Food requirements	2	√	√	√		√	√		√	
EVENT RESPONSE	Linkages between the causes of events	2							√		
HABITAT	Mechanistic linkages among geologic, biologic, oceanographic, and atmospheric processes as they influence habitat	2	√	√	√			√	√	√	
HARVESTING	By-catch data	3					√				
	Effects of fishing/harvest on predator-prey dynamics	2		√			√				
	Effects of natural events on harvested organisms and yields: Global warming	2					√				
	Factors controlling year class strength of targeted species: Competition between key species	2		√	√		√				
	Factors controlling year class strength of targeted species: Predator-prey relationships	2		√	√		√				
	Factors controlling year class strength of targeted species: Food requirements	2		√	√		√				
	Factors controlling year class strength of targeted species: Recruitment	2	√	√	√		√				
	Factors controlling year class strength of targeted species: Growth, reproduction, and mortality	2		√	√		√	√	√		
	Data on spatial and temporal habitat changes caused by fishing	2		√			√				
	Level of effort, spatial and temporal distribution, and density for recreational fishing/harvesting	2		√			√				
INDUSTRIAL USES	Characterization of vessel traffic: Ballast exchange requirements and protocols	3									√
MAPPING CAPABILITIES	GIS compatible data: Source areas for critical species	2	√	√	√		√			√	
OCEANOGRAPHIC REGIME	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Wave forces	2	√		√		√	√	√	√	√
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Upwelling	2	√		√	√	√		√		
WATER QUALITY	Socioeconomic effects of water quality on commercial and recreational uses and profits	3				√					
	Levels and mechanisms of sublethal stressors	2				√					
	Temporal changes in levels of pathogens and pathogenic indicators within: Biological samples	2				√					
	Endpoints related to management issue		6	12	12	5	14	4	5	6	2

* Note that endpoints are listed by topic category and not management issue. Endpoints may relate to more than one management issue.

Key Findings

- *Half of high priority endpoints at the Flower Gardens require substantial increases in activity.*
- *The sanctuary is adequately addressing Industrial Uses.*
- *No significant surpluses in activity are evident.*
- *Three management issues, Zoning, Fishing/Harvest Effects, and Restoration/Rehabilitation, require the greatest increase in scientific attention. The first two appear to warrant the most attention.*

Priority Endpoints

- *Recruitment*
- *Effects of fishing on predator-prey dynamics*
- *Harvest levels and impacts*
- *Recovery trajectories following various impacts*
- *Population dynamics of key species*
- *Community dynamics, including trophic structure and species interactions*

Site Analysis

Flower Garden Banks National Marine Sanctuary

For the Flower Garden Banks NMS, 138 of the 150 endpoints were considered relevant to management information needs. The average recommended change in activity at the Flower Gardens was 1.2, or 0.3 higher than the Program average (Table 4). All low relevance endpoints appear to be appropriately addressed at this site, as only one had a recommended slight reduction in activity (Table FG-1). Slight increases in activity, however, may be warranted for 17 of the 22 endpoints of low relevance. Endpoints of higher relevance are less adequately addressed. One third of the 46 moderate relevance endpoints and 49% of the 70 high relevance endpoints appear to warrant substantial increases in attention. These are slightly above the Program averages of 26% and 47%, respectively (Table 5).

Table FG-1. The number and percentage of endpoints considered relevant at the Flower Garden Banks within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	Number *of Endpoints with Recommended Change in Activity of*								***Percentage*** *of Endpoints with Recommended Change in Activity of*								*Percentage* ***Among*** *Relevance Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	0	0	1	4	**17**	na	na	22	0	0	1	3	12	na	na	16	0	100	na
3	0	0	4	5	22	15	na	46	0	0	3	4	16	11	na	33	0	67	**33**
4	na	0	0	13	23	27	7	70	na	0	0	9	17	20	5	51	0	51	**49**
Total	0	0	5	22	62	42	7	138	0	0	4	16	45	30	5	100	0	64	36

Are the information needs for management issues being appropriately addressed by science activities at Flower Garden Banks NMS?

The Flower Gardens appears to be doing particularly well addressing endpoints related to Industrial Uses. Eighty-one percent of the endpoints in Industrial Uses warranted no change or slight adjustments in activity (Table FG-2), compared to the Program average of 70% (Table 3).

Overall, 36% of management issue endpoints required an increase in activity of 2 or 3 (Table FG-1), close to the Program average of 34%. However, the percentages for Zoning, Fishing/Harvest Effects, and Restoration/Rehabilitation were 56%, 44%, and 47%, respectively (Table FG-2), slightly above corresponding Program averages and well above the percentages for other management issues at the Flower Gardens.

Table FG-2. Percentage of endpoints within each level of recommended change in activity for each management issue in the Flower Garden Banks NMS. Data of particular note are underlined and emphasized in bold.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	0	0	7	27	34	29	2	0	68	32
Zoning	0	0	0	12	33	47	9	0	44	**56**
Living Marine Resources	0	0	6	17	40	34	2	0	64	36
Water Quality	0	0	5	21	42	32	0	0	68	32
Fishing/Harvest Effects	0	0	4	15	37	37	7	0	56	**44**
Wildlife Disturbance	0	0	3	21	38	36	3	0	62	38
Event Response	0	0	0	28	38	31	3	0	66	34
Restoration/Rehabilitation	0	0	0	18	35	44	3	0	53	**47**
Industrial Uses	0	0	2	21	57	17	2	0	**81**	19

To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

No significant surpluses in activity were found for any management issues at the Flower Gardens, and no endpoints were recommended for substantial decreases in activity (Table FG-1). Furthermore, only five of the 138 endpoints rated as relevant by sanctuary staff appeared to warrant slight decreases (-1).

Overall, 36% of endpoints appear to warrant substantially greater science activity. Of the 34 high relevance endpoints with recommended changes in activity of 2 or above (Table FG-3), 23 apply to Zoning or Fishing/Harvest Effects, among other issues. Of the seven endpoints of high relevance that required an increase in activity of +3, four applied to each of these issues. Specific endpoints identified were assessments of recruitment as it relates to year/class strength; the effects of fishing on predator-prey dynamics; comparisons of impacts within areas of differing effort; and predicting trajectories of resource recovery.

Endpoints in Table FG-3 that may warrant priority consideration for the targeting of science resources are those 1) with recommended increases in activity of three units, 2) that are broadly applicable across management issues, and 3) that are both numerous and similar in nature. Seven endpoints listed in Table FG-3 were recommended for 3-unit enhancement in science activity. Several of these are rather specific areas of investigation pertaining to few management issues. Others are particularly noteworthy because they are broadly applicable or similar to other endpoints recommended for substantial increases. A number of endpoints with recommended changes of at least +2 pertain to several management issues. They include population dynamics of key species; community dynamics, including trophic structure and species interactions; predator-prey relationships; recruitment; mechanistic linkages among processes that influence habitat; and distribution and abundance of fish at different life stages. There also appears to be additional need for information regarding characterization of vessel traffic and the impacts of human activity. Each of these areas had three high relevance endpoints recommended for a change of +2 or +3.

Scientists have recently discovered that aggregations of species, such as this Marbled grouper, are associated with certain features at the Flower Garden Banks National Marine Sanctuary. The fact that the status of many commercially important species is still uncertain is a significant source of concern for sanctuary management.

Table FG-3. High relevance endpoints with recommended changes in activity of +3 or +2 at the Flower Garden Banks National Marine Sanctuary.

Endpoints		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
BIOLOGICAL RESOURCES*	Pertinent information on species of special interest: Potential invasive species	2		√	√						
	Factors controlling the success of year classes for species: Predator-prey relationships	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Recruitment	2	√	√	√		√	√		√	
	Information on key species and communities: Community dynamics (e.g., trophic structure, species interactions)	2		√	√	√	√	√		√	√
	Information on key species and communities: Population dynamics, including species and population level genetics, life history, and distribution	2		√	√	√	√	√	√	√	√
EVENT RESPONSE	Risk assessment: Probability of future events	3							√		
	Identification of impacts at appropriate scales	2							√		
HABITAT	Mechanistic linkages among geologic, biologic, oceanographic, and atmospheric processes as they influence habitat	2	√	√	√			√	√	√	
HARVESTING	Effects of fishing/harvest on predator-prey dynamics	3		√			√				
	Factors controlling year class strength of targeted species: Recruitment	3	√	√	√		√				
	Comparisons of impacts of fishing and harvest pressure in areas of high, low, and no activity	3		√			√				
	Assessments of harvested stocks (e.g., access to NMFS, FMC and tribal data)	2		√			√				
	Factors controlling year class strength of targeted species: Condition of critical habitat	2	√	√	√		√				
	Factors controlling year class strength of targeted species: Growth, reproduction, and mortality	2		√	√		√	√	√		
	Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting	2		√			√				
	Vessel types used for fishing and harvesting	2					√				
	Distribution and abundance of fish (target and non-target) at different life stages	2	√	√	√		√	√	√		
INDUSTRIAL USES	Characterization of vessel traffic: Ballast exchange requirements and protocols	3									√
	Characterization of vessel traffic: Distribution and abundance of vessels	2									√
	Characterization of vessel traffic: Vessel traffic patterns	2									√
MAPPING CAPABILITIES	GIS compatible data: Source areas for critical species	2	√	√	√		√			√	
OCEANOGRAPHIC REGIME	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Nutrient flux	2	√		√	√	√				
RECOVERY OF RESOURCES	Trajectories of probable population and community recovery within a likely range of anthropogenic and natural disturbances	3		√			√			√	
	Trajectories of probable habitat recovery within a likely range of anthropogenic and natural disturbances	2		√			√			√	
RESTORATION	Assessment of appropriate technologies for restoration/rehabilitation in the following categories: Biogeochemical processes	2								√	
WATER QUALITY	Levels and mechanisms of contaminants causing mortality	2				√					
	Temporal changes in levels of pathogens and pathogenic indicators within: Biological samples	2				√					
	Temporal changes in levels of relevant organics and metals within: Water column	2				√					
WILDLIFE DISTURBANCE	Threat assessment for sources of wildlife disturbance: Predict outcomes for various disturbance regimes	3						√			
	Susceptibility and response of species of concern to wildlife disturbance: Verification of cause-and-effect relationships	2						√			√
ZONE PERFORMANCE	Impacts of unrestricted human activities within zoned areas: Intensity	2		√							
	Impacts of unrestricted human activities within zoned areas: Spatial distribution	2		√							
	Impacts of unrestricted human activities within zoned areas: Types of impacts	2		√							
	Effectiveness of zoning regime	2		√			√	√		√	
	Endpoints related to management issue		8	21	12	6	18	10	6	10	6

* Note that endpoints are listed by topic category and not management issue. Endpoints may relate to more than one management issue.

Site Analysis
Gray's Reef National Marine Sanctuary

According to staff at Gray's Reef NMS, 128 of the 150 endpoints were relevant to the information needs of the sanctuary (Table GR-1). The average recommended change in activity for these endpoints was 1.3, which is 0.4 higher than the Program average (Table 4). Slight increases in activity may be warranted for all 36 endpoints of low relevance (Table GR-1). The higher relevance endpoints are less adequately addressed. Fifty-eight percent of moderate relevance endpoints and 64% of high relevance endpoints were recommended for a substantial increase in activity. Corresponding Program averages were 26% and 47%, respectively.

Table GR-1. The number and percentage of endpoints considered relevant at Gray's Reef NMS within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	***Number** of Endpoints with Recommended Change in Activity of*								***Percentage** of Endpoints with Recommended Change in Activity of*								*Percentage **Among** Relevance Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	0	0	0	0	36	na	na	36	0	0	0	0	28	na	na	28	0	100	na
3	0	0	7	3	12	31	na	53	0	0	5	2	9	24	na	41	0	42	**58**
4	na	2	0	9	3	10	15	39	na	2	0	7	2	8	12	30	5	31	**64**
Total	0	2	7	12	51	41	15	128	0	2	5	9	40	32	12	100	2	55	**44**

Are the information needs for management issues being appropriately addressed by science activities at Gray's Reef NMS?

Gray's Reef appears to require substantially more activity to address the information needs for all management issues. For all issues, percentages of endpoints warranting no change or only slight adjustments in activity (Table GR-2) are low compared to other sites, averaging nearly 20 percentage points below corresponding Program averages (Table 3).

Compared to other issues, endpoints associated with Habitat Delineation and Zoning appear to require the most additional attention at Gray's Reef, with substantial increases in activity recommended for 69% and 67% of endpoints, respectively (Table GR-2). Furthermore, the percentage of endpoints requiring substantial increases for Habitat Delineation, Living Marine Resources, and Water Quality were almost twice the corresponding Program averages (Table 3), suggesting these issues are particularly under-addressed compared to the rest of the Program. The values for Habitat Delineation and Water Quality represent the highest percentages for these issues for all the sanctuaries.

Key Findings

- *Nearly two-thirds of high priority endpoints require substantial increases in activity.*
- *All management issues require substantial increases in science activity.*
- *Surpluses in activity may exist in GIS compatible data for topography and for bathymetry.*
- *Five issues: Habitat Delineation, Zoning, Living Marine Resources, Water Quality, and Fishing/Harvest Effects appear to warrant the greatest increase in scientific activity.*

Priority Endpoints

- *Various types of oceanographic data*
- *Specific types of GIS compatible data*
- *Effects of fishing/harvest on predator-prey dynamics and levels*
- *Mechanisms of contaminants causing mortality*
- *Information on key species and communities: population trends, including rates of growth, mortality, and fecundity*

Rocky platforms at Gray's Reef National Marine Sanctuary are carpeted with a variety of invertebrates, such as hard and soft corals, sponges, and hydroids. The sanctuary has a critical need for additional habitat delineation to characterize these hard bottom habitats and the surrounding areas of soft sediment.

Table GR-2. Percentage of endpoints within each level of recommended change in activity for each management issue in Gray's Reef NMS. Data of particular note are underlined and emphasized in bold.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	0	6	0	9	17	31	37	6	26	**69**
Zoning	0	0	0	12	21	57	10	0	33	**67**
Living Marine Resources	0	0	2	17	19	40	23	0	38	**63**
Water Quality	0	3	0	17	19	33	28	3	36	**61**
Fishing/Harvest Effects	0	4	0	9	33	33	21	4	42	54
Wildlife Disturbance	0	0	3	13	38	38	8	0	54	46
Event Response	0	0	0	10	45	31	14	0	55	45
Restoration/Rehabilitation	0	0	0	9	35	44	12	0	44	56
Industrial Uses	0	0	20	10	20	33	17	0	50	50

To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

Only 2 of the 128 endpoints rated as relevant by the Gray's Reef merit consideration for a decrease in activity. The two endpoints, with a recommended change of –2, concerned the acquisition of GIS-compatible data for topography and bathymetry. These apparent surpluses may be a result of recent mapping activities in and around the sanctuary, reducing the need for continued data acquisition.

Overall, 56 endpoints warranted substantially greater science activity (Table GR-1). Twenty-five of these were also rated to be highly relevant to the needs of Gray's Reef (Table GR-3). Of these, four management issues had the greatest number of applicable endpoints: Fishing/Harvesting Effects, Habitat Delineation, Living Marine Resources, and Water Quality.

Of the endpoints listed in Table GR-3, several may warrant priority consideration as areas for targeting future scientific resources. There is a particular need for additional information regarding the oceanographic regime at Gray's Reef. Nine of the twelve endpoints related to oceanographic data were recommended for a 3-unit increase in activity. Three of these endpoints, specifically addressing data on currents, tides, and turbidity, have broad applicability across management issues. An increase of three units was also recommended for activities to secure several types of GIS-compatible data. Specific attention in this topic area should be directed toward critical habitat for species of concern, an endpoint applicable to eight management issues. Other endpoints recommended for a change of +3 include effects of fishing/harvest on predator-prey dynamics and levels and mechanisms of contaminants causing mortality. One endpoint recommended for a 2-unit increase also warrants consideration as a priority area of investigation due to its broad applicability across management issues. The endpoint is Information on key species and communities: population trends, including rates of growth, mortality, and fecundity.

Table GR-3. High relevance endpoints with recommended changes in activity of +3 or +2 at Gray's Reef National Marine Sanctuary.

Endpoints		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
BIOLOGICAL RESOURCES*	Pertinent information on species of special interest: Marine mammals	2		√	√			√			
	Information on key species and communities: Population trends, including rates of growth, mortality, and fecundity	2		√	√	√	√	√	√	√	√
HARVESTING	Effects of fishing/harvest on predator-prey dynamics	3		√			√				
	Assessments of harvested stocks (e.g., access to NMFS, FMC and tribal data)	2		√			√				
	Comparisons of impacts of fishing and harvest pressure in areas of high, low, and no activity	2		√			√				
MAPPING CAPABILITIES	GIS compatible data: Source areas for critical species	3	√	√	√		√			√	
	GIS compatible data: Critical habitat for species of concern	3	√	√	√		√	√	√	√	√
	GIS compatible data: Sediment types	3	√								
	GIS compatible data: Habitat types	3	√								
	GIS compatible data: Sampling locations	2				√					
OCEANOGRAPHIC REGIME	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Chlorophyll-a	3	√		√	√	√				
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Oxygen	3	√		√	√	√				
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Nutrient flux	3	√		√	√	√				
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Chemistry	3	√		√	√	√				√
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Light penetration/PAR	3	√		√	√	√				
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Turbidity	3	√		√	√	√		√	√	√
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Salinity	3	√		√	√	√				
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Tides	3	√		√	√	√	√	√		√
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Currents	3	√	√	√	√	√	√	√	√	√
WATER QUALITY	Levels and mechanisms of contaminants causing mortality	3				√					
	Levels and mechanisms of sublethal stressors	2				√					
ZONE PERFORMANCE	Impacts of unrestricted human activities within zoned areas: Intensity	2		√							
	Impacts of unrestricted human activities within zoned areas: Spatial distribution	2		√							
	Impacts of unrestricted human activities within zoned areas: Types of impacts	2		√							
	Effectiveness of zoning regime	2		√			√	√		√	
	Endpoints related to management issue		13	12	13	13	16	6	5	6	6

* Note that endpoints are listed by topic category and not management issue. Endpoints may relate to more than one management issue.

Key Findings

- *Compared to other sites, the Gulf of the Farallones NMS has a fairly low percentage of endpoints that require substantial increases in activity.*
- *Among management issues, the most appropriately addressed appears to be Water Quality, though non-point source pollution, harmful algal blooms, and agricultural runoff may require additional attention.*
- *Significant surpluses in activity are possible in two issues: Event Response and Restoration/Rehabilitation.*
- *Two issues, Fishing/Harvesting Effects and Zoning, appear to warrant the greatest increase in scientific activity.*

Priority Endpoints

- *Factors controlling year class strength of targeted species*
- *Factors controlling the success of year classes for species of concern*

Site Analysis

Gulf of the Farallones National Marine Sanctuary

Staff at Gulf of the Farallones considered 143 of the 150 endpoints to be relevant to information needs at the sanctuary. The average recommended change in activity at Gulf of the Farallones was 0.4, or 0.5 below the Program average (Table 4). All of the low relevance endpoints appear to be appropriately addressed at this site, although 5 of 18 were recommended for a slight reduction in activity (Table GF-1). Those of moderate and high relevance are well addressed compared to other sites (Table 5). No moderate relevance endpoints were judged to merit an increase in activity greater than +1. Only 34% percent of the 90 high relevance endpoints warrant substantially more attention, well below the Program average of 47%.

Table GF-1. The number and percentage of endpoints considered relevant at the Gulf of the Farallones NMS within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	***Number** of Endpoints with Recommended Change in Activity of*								***Percentage** of Endpoints with Recommended Change in Activity of*								*Percentage **Among** Relevance Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	0	0	5	13	0	na	na	18	0	0	3	9	0	na	na	13	0	100	na
3	0	1	7	3	24	0	na	35	0	1	5	2	17	0	na	24	3	**97**	0
4	na	**12**	7	27	13	31	0	90	0	8	5	19	9	22	0	63	13	52	**34**
Total	0	13	19	43	37	31	0	143	0	9	13	30	26	22	0	100	9	69	**22**

Are the information needs for management issues being appropriately addressed by science activities at the Gulf of the Farallones NMS?

The Gulf of the Farallones appears to be doing particularly well addressing endpoints related to Water Quality. Ninety-three percent of the endpoints in this management issue warranted no change or only slight adjustments in activity (Table GF-2). This value exceeds the Program average by 22% and equals Cordell Bank for the highest value of all the sanctuaries (Table 3). Despite these data, follow-up interviews with sanctuary staff indicate that certain water quality parameters, including non-point source pollution, harmful algal blooms, and agricultural runoff are not adequately addressed.

The percentage for Event Response (66%) only slightly exceed the Program average. However, 94% of the endpoints applicable to this issue were considered appropriately addressed or warranted decreased activity. This suggests that activity on this issue is nearly adequate to inform management needs. Furthermore, the percentages for eight of the nine management issues at Gulf of the Farallones exceed the corresponding Program averages.

Overall, Gulf of the Farallones appears to be doing very well at addressing management information needs. The issues with the highest percentages of endpoints requiring substantial increases in science activity at the site were Fishing/Harvest Effects and

Zoning (Table GF-2). Although these percentages were substantially higher than those for other issues at the sanctuary, only Fishing/Harvest Effects exceeded the Program average.

Table GF-2. Percentage of endpoints within each level of recommended change in activity for each management issue in Gulf of the Farallones NMS. Data of particular note are underlined and emphasized in bold.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	0	7	14	40	24	14	0	7	79	14
Zoning	0	5	16	19	16	44	0	5	51	**44**
Living Marine Resources	0	4	19	29	21	27	0	4	69	27
Water Quality	0	0	11	51	31	7	0	0	**93**	7
Fishing/Harvest Effects	0	5	11	27	13	45	0	5	50	**45**
Wildlife Disturbance	0	3	20	33	23	23	0	3	75	23
Event Response	0	**28**	7	34	24	7	0	28	66	7
Restoration/Rehabilitation	0	**15**	12	32	21	21	0	15	65	21
Industrial Uses	0	5	13	43	23	18	0	5	78	18

To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

Thirteen of the endpoints considered applicable to the Gulf of the Farallones may have a surplus in activity (Table GF-1). These endpoints are most applicable to two management issues, Event Response and Restoration/Rehabilitation (Table GF-2). Although surpluses were evident, all of these were also rated to be highly or moderately relevant to the sanctuary and recommended decreases did not exceed two units. The level of relevance of these endpoints suggests that any redirection of resources should be carefully considered before it is deemed appropriate.

Twenty-two percent of endpoints may warrant substantially greater science activity (Table GF-1). No high relevance endpoints required an increase of activity of 3 units, but 31 were recommended for an increase of 2 (Table GF-3). Two management issues had the most applicable endpoints in this category: Fishing/Harvest Effects and Zoning.

Of the endpoints listed in Table GF-3, one general area may warrant priority consideration for targeting future scientific resources, that being the factors controlling the success of year classes. Associated endpoints in the topic areas of Biological Resources and Harvesting include species of concern and targeted species. Nearly all of these endpoints warranted substantial increases in activity and are broadly applicable across management issues.

Sanctuary managers at Gulf of the Farallones National Marine Sanctuary would like to know more about the factors controlling year class strength of commercially and recreationally targeted species, such as these blue rockfish (Sebastes mystinus).

Table GF-3. High relevance endpoints with recommended changes in activity of +3 or +2 at the Gulf of the Farallones National Marine Sanctuary.

Endpoints		Recommended Change in Activity	Applicable Management Issue								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
BIOLOGICAL RESOURCES*	Pertinent information on species of special interest: Ecological indicators	2		√	√	√				√	
	Factors controlling the success of year classes for species: Condition and trends of critical habitat	2	√	√	√		√	√	√	√	√
	Factors controlling the success of year classes for species: Multi-species relationships	2			√		√	√		√	√
	Factors controlling the success of year classes for species: Competition between key species	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Predator-prey relationships	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Recruitment	2	√	√	√		√	√		√	
	Information on key species and communities: Community dynamics (e.g., trophic structure, species interactions)	2		√	√	√	√	√		√	√
HARVESTING	Assessments of harvested stocks (e.g., access to NMFS, FMC and tribal data)	2		√			√				
	Effects of fishing/harvest on predator-prey dynamics	2		√			√				
	Effects of natural events on harvested organisms and yields: Global warming	2					√				
	Effects of natural events on harvested organisms and yields: El Niños	2					√				
	Effects of natural events on harvested organisms and yields: Storm events	2					√				
	Effects of natural events on harvested organisms and yields: Currents	2					√				
	Factors controlling year class strength of targeted species: Competition between key species	2		√	√		√				
	Factors controlling year class strength of targeted species: Predator-prey relationships	2		√	√		√				
	Factors controlling year class strength of targeted species: Condition of critical habitat	2	√	√	√		√				
	Factors controlling year class strength of targeted species: Food requirements	2		√	√		√				
	Factors controlling year class strength of targeted species: Recruitment	2	√	√	√		√				
	Factors controlling year class strength of targeted species: Growth, reproduction, and mortality	2		√	√		√	√	√		
	By-catch data	2					√				
	Age of target organisms at time of harvest	2		√			√				
	Data on spatial and temporal habitat changes caused by fishing	2		√			√				
	Level of effort, spatial and temporal distribution, and density for recreational fishing/harvesting	2		√			√				
	Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting	2		√			√				
	Vessel types used for fishing and harvesting	2					√				
	Comparisons of impacts of fishing and harvest pressure in areas of high, low, and no activity	2		√			√				
INDUSTRIAL USES	Identification of sources of invasive species	2				√					√
	Characterization of vessel traffic: Ballast exchange requirements and protocols	2									√
	Characterization of vessel traffic: Proximity of major vessel traffic to sensitive resources	2									√
	Characterization of dredge and fill activities: Impact on localized flow dynamics	2						√			√
WILDLIFE DISTURBANCE	Threat assessment for sources of wildlife disturbance: Range of influence for potentially vulnerable species	2						√			
	Endpoints related to management issue		6	19	13	3	25	9	2	7	7

* Note that endpoints are listed by topic category and not management issue. Endpoints may relate to more than one management issue.

Site Analysis

Hawaiian Islands Humpback Whale National Marine Sanctuary

One hundred and twenty-eight of the 150 endpoints were considered to be relevant to information needs at Hawaiian Islands Humpback Whale NMS. For these endpoints, the average recommended change in activity was 1.4, the highest in the Program and 0.5 above the Program average (Table 4). No low or moderate relevance endpoints had a recommended reduction in activity (Table HI-1). Slight increases in activity, however, were recommended for 10 of the 12 endpoints of low relevance. Thirty percent of the moderate relevance endpoints were recommended for a substantial increase in activity. Seventy-one percent of the 86 high relevance endpoints appear to warrant a substantial increase in attention. This percentage is the highest for an individual site and is substantially higher than the Program average of 47% (Table 5).

Table HI-1. The number and percentage of endpoints considered relevant at the Hawaiian Islands Humpback Whale NMS within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	***Number** of Endpoints with Recommended Change in Activity of*								***Percentage** of Endpoints with Recommended Change in Activity of*								*Percentage **Among** Relevance Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	0	0	0	2	10	na	na	12	0	0	0	2	8	na	na	9	0	100	na
3	0	0	0	9	12	9	na	30	0	0	0	7	9	7	na	23	0	70	**30**
4	na	0	3	12	10	51	10	86	na	0	2	9	8	40	8	67	0	29	**71**
Total	0	0	3	23	32	60	10	128	0	0	2	18	25	47	8	100	0	45	55

Are the information needs for management issues being appropriately addressed by science activities at Hawaiian Islands Humpback Whale NMS?

The Hawaiian Islands Humpback Whale NMS appears to require substantially more activity to address all management issues. For all issues, the percentages of endpoints warranting no change or only slight adjustments in activity (Table HI-2) are below corresponding Program averages (Table 3), with most falling substantially below. The issues that appear to be best addressed at the site, Habitat Delineation and Industrial Uses, have averages that are only slightly below Program averages.

At this sanctuary, Zoning and Restoration/Rehabilitation have the highest percentages of endpoints requiring an increase of 2 or 3 units (Table HI-2). Five additional issues (i.e., Living Marine Resources, Water Quality, Fishing/Harvest Effects, Wildlife Disturbance, and Event Response) suggest particular need for science activity. For all seven of these, the percentage of endpoints requiring substantial increases in attention are nearly twice the corresponding Program average. In all but one case (i.e, Water Quality) the percentages are the highest of all sanctuaries.

Key Findings

- *Over two-thirds of high priority endpoints in the Hawaiian Islands Humpback Whale NMS require substantial increases in activity.*
- *All management issues appear to require substantial increases in science activity.*
- *No surpluses in activity are evident.*
- *Seven issues: Zoning, Living Marine Resources, Water Quality, Fishing/ Harvest Effects, Wildlife Disturbance, Event Response, and Restoration/ Rehabilitation seem to warrant the greatest increase in science attention.*

Priority Endpoints

- *Factors controlling the success of year classes for species*
- *Information on key species and communities*
- *Pertinent information on species of special interest*
- *GIS compatible data*

During their winter migration, humpback whales frequent the waters of the Hawaiian Islands Humback Whale National Marine Sanctuary. More information is needed to understand how this species responds to and is impacted by various types of disturbance.

Table HI-2. Percentage of endpoints within each level of recommended change in activity for each management issue in the Hawaiian Islands Humpback Whale NMS. Data of particular note are underlined and emphasized in bold.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	0	0	0	23	40	38	0	0	63	38
Zoning	0	0	0	10	13	61	16	0	23	77
Living Marine Resources	0	0	0	7	24	62	7	0	31	**69**
Water Quality	0	0	0	19	26	53	2	0	44	**56**
Fishing/Harvest Effects	0	0	0	15	21	54	10	0	36	64
Wildlife Disturbance	0	0	0	13	18	59	10	0	31	**69**
Event Response	0	0	0	11	25	61	4	0	36	**64**
Restoration/Rehabilitation	0	0	0	3	9	73	15	0	12	**88**
Industrial Uses	0	0	7	27	27	31	9	0	60	40

To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

All 128 endpoints relevant to the information needs of Hawaiian Islands Humpback Whale NMS are either being appropriately addressed or were recommended for increased activity. No surpluses were identified (table HI-1).

Seventy endpoints warranted substantially greater science activity (Table HI-1). For high relevance endpoints, 61 were recommended for an increase of +2 or +3 units (Table HI-3), the highest number of all sites. These endpoints are broadly applicable across management issues; however, two management issues have the most applicable endpoints: Wildlife Disturbance and Restoration/Rehabilitation.

Endpoints in Table HI-3 that may warrant priority consideration for the targeting of science resources are those 1) with recommended increases in activity of three units, 2) that are broadly applicable across management issues, and 3) that are both numerous and similar in nature. Most of the ten endpoints recommended for a 3-unit increase in activity pertain to fairly specific topics. All endpoints related to factors controlling the success of year classes for species, information on key species and communities, and GIS-compatible data should be considered priorities because they are broadly applicable across management issues. Finally, six endpoints relating to information on species of special interest were identified as requiring substantial increases in activity.

Table HI-3. High relevance endpoints with recommended changes in activity of +3 or +2 in the Hawaiian Islands Humpback Whale National Marine Sanctuary.

Endpoints		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
BIOLOGICAL RESOURCES*	Pertinent information on species of special interest: Potential invasive species	3		√	√						
	Pertinent information on species of special interest: Non-indigenous species	3		√	√						
	Factors controlling the success of year classes for species: Indicators of physiological stress (e.g., biomarkers, bleaching)	3			√	√		√	√	√	√
	Pertinent information on species of special interest: Keystone species (e.g. apex predators, critical herbivores)	2			√					√	
	Pertinent information on species of special interest: Ecological indicators	2		√	√	√				√	
	Pertinent information on species of special interest: Species of non-consumptive interest (e.g. tourism, scientific)	2			√			√			
	Pertinent information on species of special interest: Other specially protected species (international, national, local)	2			√			√			
	Factors controlling the success of year classes for species: Condition and trends of critical habitat	2	√	√	√		√	√	√	√	√
	Factors controlling the success of year classes for species: Multi-species relationships	2			√		√	√		√	√
	Factors controlling the success of year classes for species: Competition between key species	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Predator-prey relationships	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Habitat use at various life stages	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Food requirements	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Recruitment	2	√	√	√		√	√		√	
	Information on key species and communities: Population trends, including rates of growth, mortality, and fecundity	2		√	√	√	√	√	√	√	√
	Information on key species and communities: Incidence of deformities	2			√	√		√	√	√	√
	Information on key species and communities: Species' seasonal and spatial occurrence, distribution, and abundance	2		√	√	√	√	√	√	√	√
	Information on key species and communities: Habitat fidelity (strength of associations between species and habitats)	2		√	√		√			√	
	Information on key species and communities: Population dynamics, including species and population level genetics, life history, and distribution	2		√	√	√	√	√	√	√	√
	Information on key species and communities: Community dynamics (e.g., trophic structure, species interactions)	2		√	√	√	√	√		√	√
	Information on key species and communities: Incidence of disease	2			√	√		√	√	√	√
EVENT RESPONSE	Linkages between the causes of events	2							√		
	Develop or revise and validate appropriate ecological models to predict events	2							√		
	Mitigation alternatives	2							√		
	Identification of impacts at appropriate scales	2							√		
	Event path tracking and identification of likely consequences	2							√		
	Relevant and appropriate data to identify and verify an event inside or adjacent to the sanctuary	2							√		
	Contingency plan for relevant events	2							√		
	Risk assessment: Probability of future events	2							√		
INDUSTRIAL USES	Identification of sources of invasive species	3									√
MAPPING CAPABILITIES	GIS compatible data: Critical habitat for species of concern	2	√	√	√		√	√	√	√	√
	GIS compatible data: Source areas for critical species	2	√	√	√		√			√	

(Continued on next page)

Table HI-3 (continued).

Endpoints		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
RECOVERY OF RESOURCES	Trajectories of probable population and community recovery within a likely range of anthropogenic and natural disturbances	3		√			√			√	
	Trajectories of probable habitat recovery within a likely range of anthropogenic and natural disturbances	3		√			√			√	
RESTORATION	Valuation of sanctuary resources	3					√			√	√
	Assessment of appropriate technologies for restoration/rehabilitation in the following categories: Biological communities	2								√	
	Assessment of appropriate technologies for restoration/rehabilitation in the following categories: Key species	2								√	
	Assessment of appropriate technologies for restoration/rehabilitation in the following categories: Biogeochemical processes	2								√	
WATER QUALITY	Socioeconomic effects of water quality on commercial and recreational uses and profits	2				√					
	Human health implications of poor water quality (e.g., impacts of an algae bloom)	2				√					
	Levels and mechanisms of sublethal stressors	2				√					
	Levels and mechanisms of contaminants causing mortality	2				√					
	Temporal changes in levels of pathogens and pathogenic indicators within: Beach-cast organisms	2				√					
	Temporal changes in levels of pathogens and pathogenic indicators within: Biological samples	2				√					
	Temporal changes in levels of pathogens and pathogenic indicators within: Water column	2				√					
	Incidental contaminants from vessels (merchant, fishing, tourism, private)	2				√	√		√		√
	Temporal and spatial dynamics influencing water quality: Inputs from non-point sources and selected human activities	2				√					
	Temporal and spatial dynamics influencing water quality: Atmospheric deposition	2				√					
	Temporal and spatial dynamics influencing water quality: Inputs from rivers and outfalls	2				√					
WILDLIFE DISTURBANCE	Spatial and temporal variability in levels of wildlife disturbance	3						√			√
	Threat assessment for sources of wildlife disturbance: Predict outcomes for various disturbance regimes	3						√			
	Susceptibility and response of species of concern to wildlife disturbance: Verification of cause-and-effect relationships	2						√			√
	Susceptibility and response of species of concern to wildlife disturbance: Acute and chronic species response (e.g. behavioral, reproductive, physiological, physical injury)	2						√			
	Susceptibility and response of species of concern to wildlife disturbance: Sensory capabilities, physiological tolerances, and thresholds	2						√			
	Susceptibility and response of species of concern to wildlife disturbance: Behavioral variability	2						√			
	Threat assessment for sources of wildlife disturbance: Range of influence for potentially vulnerable species	2						√			
	Threat assessment for sources of wildlife disturbance: Identification of sources	2						√			√
ZONE PERFORMANCE	Effectiveness of zoning regime	3		√			√	√		√	
	Impacts of unrestricted human activities within zoned areas: Intensity	2		√							
	Impacts of unrestricted human activities within zoned areas: Spatial distribution	2		√							
	Impacts of unrestricted human activities within zoned areas: Types of impacts	2		√							
	Endpoints related to management issue		8	22	23	19	19	26	17	26	16

* Note that endpoints are listed by topic category and not management issue. Endpoints may relate to more than one management issue.

Site Analysis
Monterey Bay National Marine Sanctuary

Of the 150 endpoints, nearly all (148) were judged to be relevant to the information needs of Monterey Bay NMS. These endpoints had an average recommended change in activity of 1.3, or 0.4 higher than the Program average (Table 4). Low relevance endpoints appear to be appropriately addressed at this site, as all had little or no recommended change of activity (Table MB-1). Compared to other sites, endpoints of moderate and high relevance may not be as adequately addressed at Monterey Bay. Fifty-seven percent of moderate relevance endpoints and 44% of high relevance endpoints were recommended for little or no change in activity (Table MB-1) compared to the Program averages of 73% and 49%, respectively (Table 5).

Table MB-1. The number and percentage of endpoints considered relevant at the Monterey Bay NMS within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	Number *of Total Endpoints with Recommended Change in Activity of*								***Percentage*** *of Total Endpoints with Recommended Change in Activity of*								*Percentage* ***Among*** *Relevance Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	0	0	0	4	11	na	na	15	0	0	0	3	7	na	na	10	0	100	na
3	0	0	0	8	27	26	na	61	0	0	0	5	18	18	na	41	0	**57**	43
4	na	2	2	12	18	29	9	72	na	1	1	8	12	20	6	49	3	**44**	53
Total	0	2	2	24	56	55	9	148	0	1	1	16	38	37	6	100	1	55	**43**

Are the information needs for management issues being appropriately addressed by science activities at Monterey Bay NMS?

For all management issues, levels of recommended change in activity at Monterey Bay (Table MB-2) appear to be close to program averages (Table 3). Event Response appears to be the most appropriately addressed management issue at this sanctuary with 66% of endpoints recommended for little or no change in activity. This is slightly higher than the Program average (62%) for that issue. Living Marine Resources, Habitat Delineation, and Water Quality Protection are also relatively well addressed. However, the percentage of endpoints requiring little or no change in activity for Habitat Delineation and Water Quality Protection are slightly below corresponding Program averages.

Endpoints associated with Zoning and Wildlife Disturbance appear to require the greatest increase in activity compared to other issues at Monterey Bay, with substantial increases recommended for 50% and 53% of endpoints, respectively (Table MB-2). These percentages also exceed corresponding Program averages. While not particularly noteworthy with respect to the site, the percentage of endpoints associated with Industrial Uses recommended for substantial increase exceeds the Program average by 13 percent. For Industrial Uses, this is close to the highest percentage for an individual sanctuary.

Key Findings

- *Over half of high relevance endpoints at Monterey Bay may merit substantial increases in science activity.*
- *Event Response was identified as the management issue most appropriately addressed by the site.*
- *No major surpluses in scientific activity were evident.*
- *Zoning, Fishing/Harvest Effects, Wildlife Disturbance, and Industrial Issues appear to be the management issues warranting the greatest need for additional scientific attention.*

Priority Endpoints

- *Factors controlling the success of year classes for species*
- *Information on key species and communities*
- *Nature and sources of threats to wildlife*
- *Characterization and monitoring along potential cable routes*

Squid, shrimp, sardines, and salmon are just a few of the stocks that are fished commercially in Monterey Bay National Marine Sanctuary. Information on the impact of commercial and recreational harvesting is essential for effective sanctuary management.

Table MB-2. Percentage of endpoints within each level of recommended change in activity for each management issue in Monterey Bay NMS. Data of particular note are underlined and emphasized in bold.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	0	5	0	29	36	26	5	5	64	31
Zoning	0	0	0	14	33	47	7	0	47	**53**
Living Marine Resources	0	0	0	17	48	31	4	0	65	35
Water Quality	0	4	0	24	40	31	0	4	64	31
Fishing/Harvest Effects	0	0	4	13	41	36	7	0	57	43
Wildlife Disturbance	0	0	0	13	38	35	15	0	50	**50**
Event Response	0	0	0	28	38	31	3	0	**66**	34
Restoration/Rehabilitation	0	0	0	15	44	35	6	0	59	41
Industrial Uses	0	0	0	16	40	40	4	0	56	44

To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

Only 2 of the 148 relevant endpoints may merit decreases in activity at Monterey Bay. The endpoints are GIS-compatible data: Outfalls and GIS-compatible data: Shoreline.

Forty-three percent of endpoints (64 endpoints) appear to warrant substantially greater research activity (Table MB-1). Thirty-eight of these were rated as highly relevant. Of these, two management issues, Zoning and Fishing/Harvest Effects, had the highest number of applicable endpoints.

Endpoints in Table MB-3 that may warrant priority consideration for the targeting of science resources are those with recommended increases in activity of three units or those that are broadly applicable across management issues. Nine high relevance endpoints were recommended for an increase in activity of three units. Most of these were associated with only one or two management issues. Two endpoints were associated with eight of the nine management issues; four others were associated with six issues. These endpoints are related to 1) factors controlling the success of year classes for species and 2) information on key species and communities. Specific information needs are related to species and population level genetics, life history, competition, predation, recruitment, and habitat use, condition, and trends. Endpoints associated with Industrial Uses point to the need to characterize and monitor habitats relevant to cable laying.

Table MB-3. High relevance endpoints with recommended changes in activity of +3 or +2 at Monterey Bay National Marine Sanctuary.

Endpoints		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
BIOLOGICAL RESOURCES	Factors controlling the success of year classes for species: Competition between key species	3	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Recruitment	3	√	√	√		√	√		√	
	Pertinent information on species of special interest: Species of non-consumptive interest (e.g. tourism, scientific)	2			√			√			
	Factors controlling the success of year classes for species: Condition and trends of critical habitat	2	√	√	√		√	√	√	√	√
	Factors controlling the success of year classes for species: Predator-prey relationships	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Habitat use at various life stages	2	√	√	√		√	√		√	
	Information on key species and communities: Population dynamics, including species and population level genetics, life history, and distribution	2		√	√	√	√	√	√	√	√
	Information on key species and communities: Habitat fidelity (strength of associations between species and habitats)	2		√	√		√			√	
EVENT RESPONSE	Risk assessment: Consequences of events (including collateral consequences)	3							√		
	Identification of impacts at appropriate scales	2							√		
HABITAT	Processes that create and change seabed forms in the following contexts: Oceanographic (e.g., turbidity flows, erosion)	2	√								
	Predictive models to understand dynamics of habitat distribution and factors that influence it (e.g., substrate burial, gear impacts, climate change impacts)	2	√	√				√	√	√	
HARVESTING	By-catch data	3					√				
	Level of effort, spatial and temporal distribution, and density for recreational fishing/harvesting	3		√			√				
	Effects of fishing/harvest on predator-prey dynamics	2		√			√				
	Data on spatial and temporal habitat changes caused by fishing	2		√			√				
	Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting	2		√			√				
	Comparisons of impacts of fishing and harvest pressure in areas of high, low, and no activity	2		√			√				
INDUSTRIAL USES	Characterization of dredge and fill activities: Material texture, composition, and pore water chemistry	2				√					√
	Tourism profile: Activities (location, intensity) of tourists	2									√
	Characterization and monitoring of areas relevant to cable laying: Status of cable (burial)	2									√
	Characterization and monitoring of areas relevant to cable laying: Impacts of cable laying to habitat	2									√
	Characterization and monitoring of areas relevant to cable laying: Infauna and epifauna	2									√
	Characterization and monitoring of areas relevant to cable laying: Sediment types	2									√
MAPPING CAPABILITIES	GIS compatible data: Source areas for critical species	2	√	√	√		√			√	
	GIS compatible data: Sediment types	2	√								
OCEANOGRAPHIC REGIME	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Nutrient flux	2	√		√	√	√				
WATER QUALITY	Levels and mechanisms of sublethal stressors	2				√					
	Levels and mechanisms of contaminants causing mortality	2				√					
	Temporal changes in levels of pathogens and pathogenic indicators within: Water column	2				√					
	Temporal changes in levels of relevant organics and metals within: Beach-cast organisms	2				√					
	Temporal and spatial dynamics influencing water quality: Inputs from non-point sources and selected human activities	2				√					
WILDLIFE DISTURBANCE	Spatial and temporal variability in levels of wildlife disturbance	3						√			√
	Threat assessment for sources of wildlife disturbance: Predict outcomes for various disturbance regimes	3						√			
	Threat assessment for sources of wildlife disturbance: Range of influence for potentially vulnerable species	3						√			
	Threat assessment for sources of wildlife disturbance: Identification of sources	3						√			√
ZONE PERFORMANCE	Impacts of unrestricted human activities within zoned areas: Spatial distribution	2		√							
	Impacts of unrestricted human activities within zoned areas: Intensity	2		√							
	Endpoints related to management issue		10	16	10	8	15	12	5	9	10

* Note that endpoints are listed by topic category and not management issue. Endpoints may relate to more than one management issue.

Key Findings

- *Slightly more than a third of endpoints (54) at OCNMS require substantial increases in activity.*
- *Among management issues, the most appropriately addressed at Olympic Coast appear to be Water Quality Protection and Industrial Uses.*
- *Only one endpoint (tide data) may represent a surplus of effort.*
- *Fishing/Harvest Effects, Zoning, Living Marine Resources, and Restoration/Rehabilitation appear to be the management issues warranting the greatest increase in activity.*

Priority Endpoints

- *Factors controlling year class success*
- *Information on key species and communities*
- *Oceanographic data in and around areas of concern*
- *GIS data related to habitat and critical species*

Site Analysis
Olympic Coast National Marine Sanctuary

All but one of the 150 endpoints were judged to be relevant to management information needs at Olympic Coast. The average recommended change in activity was 1.0, just above the Program average of 0.9 (Table 4). Low relevance endpoints are appropriately addressed, with 95% recommended for little or no change and only one (Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Tides) recommended for a substantial decrease in activity. Moderate relevance endpoints also appear to be well addressed. All were recommended for little or no change in activity. Endpoints of high relevance appear to be less adequately addressed. Sixty-four percent had suggested increases in activity of two to three units (Table OC-1), substantially above the Program average of 47% (Table 5).

Table OC-1. The number and percentage of endpoints considered relevant at Olympic Coast NMS within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	Number *of Total Endpoints with Recommended Change in Activity of*								***Percentage*** *of Total Endpoints with Recommended Change in Activity of*								*Percentage* ***Among*** *Relevance Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	0	1	0	10	9	na	na	20	0	1	0	7	6	na	na	13	5	95	na
3	0	0	8	2	35	0	na	45	0	0	5	1	23	0	na	30	0	**100**	0
4	na	0	0	26	4	48	6	84	na	0	0	17	3	32	4	56	0	36	**64**
Total	0	1	8	38	48	48	6	149	0	1	5	26	32	32	4	100	1	63	36

Are the information needs for management issues being appropriately addressed by science activities at Olympic Coast NMS?

The Olympic Coast NMS appears to be doing particularly well addressing endpoints related to Water Quality Protection and Industrial Use. Seventy-three percent and 67%, respectively, of endpoints related to these management issues warranted no change or only slight adjustments in activity (Table OC-2). Although these are the highest averages for issues at Olympic Coast, they are similar to their corresponding averages for the Program (71% and 70%; Table 5).

For all other issues, the percentage of endpoints recommended for substantial increases in activity significantly exceeded Program averages by amounts ranging from 12% to 26% (Table 3). Zoning, Fishing/Harvest Effects, and Restoration/ Rehabilitation had the highest percentages (Table OC-2) of all management issues, suggesting that these may warrant the greatest attention.

Table OC-2. Percentage of endpoints within each level of recommended change in activity for each management issue in the Olympic Coast NMS. Data of particular note are underlined and emphasized in bold.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	0	2	7	10	26	48	7	2	43	55
Zoning	0	0	2	14	19	60	5	0	35	65
Living Marine Resources	0	2	0	16	27	49	6	2	43	55
Water Quality	0	2	7	22	44	20	4	2	**73**	24
Fishing/Harvest Effects	0	2	2	11	25	54	7	2	37	61
Wildlife Disturbance	0	2	2	20	27	44	5	2	49	49
Event Response	0	3	0	21	24	48	3	3	45	52
Restoration/Rehabilitation	0	0	0	12	32	53	3	0	44	56
Industrial Uses	0	2	4	24	38	24	7	2	**67**	31

To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

No significant surpluses in activity were found for any management issues. Only one of the 150 individual endpoints rated as relevant by the Olympic Coast warranted a considerable decrease in activity (-2). This endpoint was Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Tides.

Fifty-four endpoints (36%) appear to warrant substantially more science activity (Table OC-1). Significantly, all were also judged to be highly relevant. Three management issues, Fishing/Harvest Effects, Zoning, and Living Marine Resources, appear to warrant the greatest attention, with between 27 and 35 associated endpoints (Table OC-3).

Endpoints in Table OC-3 that may warrant priority consideration for the targeting of science resources are those 1) with recommended increases in activity of 3 units, 2) that are broadly applicable across management issues, and 3) that are both numerous and similar in nature. Six endpoints within four different topic areas had recommended increases in activity of +3. Two of these were related to oceanographic data. Four other endpoints in this area were recommended for substantial increases in activity, one of which is associated with all nine management issues: Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Currents. Endpoints with the broadest applicability across management issues were related to factors controlling the success of year classes and information on key species and communities. A number of endpoints also pointed to the need for GIS data related to habitat and critical species.

The sandy beaches, rocky intertidal, kelp forests, and open waters of the Olympic Coast National Marine Sanctuary provide a wide range of habitats for a tremendous variety of species. Learning more about the sanctuary's living marine resources is a critical information need for sanctuary management.

Table OC-3. High relevance endpoints with recommended changes in activity of +3 or +2 at Olympic Coast National Marine Sanctuary.

Endpoints		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
BIOLOGICAL RESOURCES*	Pertinent information on species of special interest: Non-indigenous species	2		√	√						
	Pertinent information on species of special interest: Species harvested under special exemptions (cultural activities)	2			√		√	√			
	Pertinent information on species of special interest: Migratory bird species	2			√			√			
	Factors controlling the success of year classes for species: Condition and trends of critical habitat	2	√	√	√		√	√	√	√	√
	Factors controlling the success of year classes for species: Predator-prey relationships	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Habitat use at various life stages	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Food requirements	2	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Recruitment	2	√	√	√		√	√		√	
	Information on key species and communities: Population trends, including rates of growth, mortality, and fecundity	2		√	√	√	√	√	√	√	√
	Information on key species and communities: Community dynamics (e.g., trophic structure, species interactions)	2		√	√	√	√	√		√	√
	Information on key species and communities: Population dynamics, including species and population level genetics, life history, and distribution	2		√	√	√	√	√	√	√	√
	Information on key species and communities: Habitat fidelity (strength of associations between species and habitats)	2		√	√		√			√	
	Information on key species and communities: Species' seasonal and spatial occurrence, distribution, and abundance	2		√	√	√	√	√	√	√	√
EVENT RESPONSE	Mitigation alternatives	2							√		
	Identification of impacts at appropriate scales	2							√		
	Event path tracking and identification of likely consequences	2							√		
	Risk assessment: Probability of future events	2							√		
HABITAT	Processes that create and change seabed forms in the following contexts: Oceanographic (e.g., turbidity flows, erosion)	2	√								
	Sediment characterization within areas of concern	2	√				√				√
	Predictive models to understand dynamics of habitat distribution and factors that influence it (e.g., substrate burial, gear impacts, climate change impacts)	2	√	√				√	√	√	
	Mechanistic linkages among geologic, biologic, oceanographic, and atmospheric processes as they influence habitat	2	√	√	√			√	√	√	
HARVESTING	Factors controlling year class strength of targeted species: Condition of critical habitat	3	√	√	√		√				
	Comparisons of impacts of fishing and harvest pressure in areas of high, low, and no activity	3		√			√				
	Effects of fishing/harvest on predator-prey dynamics	2		√			√				
	Factors controlling year class strength of targeted species: Predator-prey relationships	2		√	√		√				
	Factors controlling year class strength of targeted species: Food requirements	2		√	√		√				
	Factors controlling year class strength of targeted species: Recruitment	2	√	√	√		√				
	By-catch data	2					√				
	Data on spatial and temporal habitat changes caused by fishing	2		√			√				
	Level of effort, spatial and temporal distribution, and density for recreational fishing/harvesting	2		√			√				
	Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting	2		√			√				
	Gear types used for fishing and harvesting	2					√				
	Distribution and abundance of fish (target and non-target) at different life stages	2	√	√	√		√	√	√		
INDUSTRIAL USES	Characterization of vessel traffic: Acoustic signatures of vessel traffic	3						√			√
	Identification of sources of invasive species	2									√
	Characterization of vessel traffic: Ballast exchange requirements and protocols	2									√

(Continued on next page)

Table OC-3 (continued).

Endpoints		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
MAPPING CAPABILITIES	GIS compatible data: Source areas for critical species	2	√	√	√		√			√	
	GIS compatible data: Critical habitat for species of concern	2	√	√	√		√	√	√	√	√
	GIS compatible data: Sediment types	2	√								
	GIS compatible data: Habitat types	2	√								
	GIS compatible data: Topography	2	√				√				
OCEANOGRAPHIC REGIME	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Light penetration/PAR	3	√		√	√	√				
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Turbidity	3	√		√	√	√		√	√	√
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Chlorophyll-a	2	√		√	√	√				
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Nutrient flux	2	√		√	√	√				
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Upwelling	2	√		√	√	√		√		
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Currents	2	√	√	√	√	√	√	√	√	√
RECOVERY OF RESOURCES	Trajectories of probable population and community recovery within a likely range of anthropogenic and natural disturbances	2		√			√			√	
	Trajectories of probable habitat recovery within a likely range of anthropogenic and natural disturbances	2		√			√			√	
RESTORATION	Assessment of appropriate technologies for restoration/rehabilitation in the following categories: Biological communities	2								√	
WATER QUALITY	Socioeconomic effects of water quality on commercial and recreational uses and profits	2				√					
WILDLIFE DISTURBANCE	Susceptibility and response of species of concern to wildlife disturbance: Verification of cause-and-effect relationships	3						√			√
	Susceptibility and response of species of concern to wildlife disturbance: Acute and chronic species response (e.g. behavioral, reproductive, physiological, physical injury)	2						√			
	Threat assessment for sources of wildlife disturbance: Identification of sources	2						√			√
	Endpoints related to mangement issue		23	28	27	11	35	20	15	19	14

* Note that endpoints are listed by topic category and not management issue. Endpoints may relate to more than one management issue.

Key Findings

- *Among management issues, the most appropriately addressed at Stellwagen Bank appear to be Industrial Uses.*
- *The issues of Water Quality and Habitat Delineation appear to be well addressed, but both issues may have some surplus activity.*
- *Endpoints related to Zoning may warrant the greatest increase in scientific effort, followed closely by Living Marine Resources, Fishing/Harvest Effects, and Wildlife Disturbance.*

Priority Endpoints

- *Factors controlling the success of year classes for species (target species and those of special concern)*
- *Oceanographic data, specifically tides*
- *Tourism profiles*
- *Information on species of special interest*
- *Susceptibility of species to disturbance*
- *Impacts of human activities within zoned areas*

Site Analysis

Stellwagen Bank National Marine Sanctuary

For Stellwagen Bank NMS, 137 of the 150 endpoints were considered relevant to management information needs. The average recommended change in activity for these was 0.9, equal to the Program average (Table 4). All low relevance endpoints appear to be appropriately addressed at this site, with 100% recommended for little or no change (Table SB-1). Slight increases in activity, however, may be warranted for 16 of the 25 low relevance endpoints. Higher relevance endpoints are less adequately addressed. Half those of moderate relevance may require substantial increases in activity. This is well above the Program average of 26% (Table 5). Among the high relevance endpoints, 37% were recommended for considerably more attention, 10% below the Program average.

Table SB-1. The number and percentage of endpoints considered relevant at Stellwagen Bank NMS within each of the "recommended change in activity" categories. Data of particular note are underlined and emphasized in bold.

	Number *of Total Endpoints with Recommended Change in Activity of*								***Percentage*** *of Total Endpoints with Recommended Change in Activity of*								*Percentage* ***Among*** *Relevance Levels*		
Relevance	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*Total*	*-3 to -2*	*-1 to 1*	*2 to 3*
2	0	0	1	8	16	na	na	25	0	0	1	6	12	na	na	18	0	100	na
3	0	0	0	2	11	13	na	26	0	0	0	1	8	9	na	19	0	**50**	50
4	na	**7**	10	18	19	23	9	86	na	5	7	13	14	17	7	63	**8**	55	37
Total	0	7	11	28	46	36	9	137	0	5	8	20	34	26	7	100	5	62	33

Are the information needs for management issues being appropriately addressed by science activities at the Stellwagen Bank NMS?

At Stellwagen Bank NMS, Industrial Uses and Water Quality appear to be the best addressed management issues, with the highest percentages of endpoints requiring little or no adjustments in activity. These are followed closely by Restoration/Rehabilitation. Compared to the Program, Stellwagen Bank is doing relatively well addressing these issues as well as five other issues with corresponding percentages above the Program average (Table 3).

Zoning and Fishing/Harvest Effects may warrant greater attention than other issues at Stellwagen Bank, as they have the highest percentage of endpoints recommended for substantial increases in activity (Table SB-2). However, the percentages of endpoints requiring substantial increases in activity for all issues at the sanctuary are lower than corresponding Program averages.

Table SB-2. Percentage of endpoints with each level of recommended change in activity for each management issue in Stellwagen Bank NMS. Data of particular note are underlined and emphasized in bold.

	Recommended Change in Activity									
Management Issue	*-3*	*-2*	*-1*	*0*	*1*	*2*	*3*	*-3 to -2*	*-1 to 1*	*2 to 3*
Habitat Delineation	0	15	18	23	28	10	8	**15**	68	18
Zoning	0	2	9	23	23	23	19	2	56	**42**
Living Marine Resources	0	0	8	23	35	25	8	0	67	33
Water Quality	0	10	3	20	55	13	0	**10**	**78**	13
Fishing/Harvest Effects	0	5	5	20	34	27	9	5	59	**36**
Wildlife Disturbance	0	0	10	28	28	30	5	0	65	**35**
Event Response	0	0	10	17	41	31	0	0	69	31
Restoration/Rehabilitation	0	0	11	29	36	18	7	0	75	25
Industrial Uses	0	2	14	29	38	14	2	2	**81**	17

To best provide for the information needs for management, which endpoints should be considered for increased or decreased science activity?

Seven of the endpoints considered applicable to the Stellwagen Bank may have a surplus in activity (Table SB-1). These endpoints applied primarily to two issues: Habitat Delineation and Water Quality (Table SB-2). Surpluses were identified in the following areas: GIS-compatible data (including sampling locations, special use or management areas, outfalls, topography, and bathymetry); sediment characterization within areas of concern; and geological characterization. All of these areas were also rated to be highly relevant to the sanctuary and recommended decreases did not exceed two units. The level of relevance of these endpoints suggests that any redirection of resources should be carefully considered before it is deemed appropriate. It is likely that such surpluses result from extensive efforts of NOAA and other agencies conducting mapping activities and monitoring in and near the sanctuary.

Thirty-three percent of endpoints appear to warrant substantially greater science activity (Table SB-1). For the 32 high relevance endpoints with recommended increases of +2 or +3 (Table SB-3), four management issues appear to warrant the greatest attention: Zoning, Fishing/Harvest Effects, Living Marine Resources, and Wildlife Disturbance.

Endpoints in Table SB-3 that may warrant priority consideration for the targeting of science resources are those 1) with recommended increases in activity of 3 units, 2) that are broadly applicable across management issues, and 3) that are both numerous and similar in nature. Nine high relevance endpoints were recommended for a +3 change in activity. Two were associated with six management issues. These endpoints were 1) Factors controlling the success of year classes for species: Competition between key species, and 2) Factors controlling the success of year classes for species: Food requirements. Other endpoints that had broad application to management issues were related to oceanographic data (specifically tides) and recruitment success. Finally, several groupings of endpoints were related to factors controlling year class success, tourism profiles, information on species of special interest, susceptibility of species to disturbance, and impacts of human activities within zoned areas.

The productive waters of Stellwagen Bank National Marine Sanctuary provide habitat for a variety of species including endangered marine mammals and seaturtles, seabirds, and commercially important fish stocks. Management of these resources requires additional information on factors affecting these species, including food requirements and human disturbance.

Table SB-3. High relevance endpoints with recommended changes in activity of +3 or +2 at Stellwagen Bank National Marine Sanctuary.

Endpoints		Recommended Change in Activity	Applicable Management Issues								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
BIOLOGICAL RESOURCES*	Factors controlling the success of year classes for species: Competition between key species	3	√	√	√		√	√		√	
	Factors controlling the success of year classes for species: Food requirements	3	√	√	√		√	√		√	
	Pertinent information on species of special interest: Keystone species (e.g. apex predators, critical herbivores)	2			√					√	
	Pertinent information on species of special interest: Ecological indicators	2		√	√	√				√	
	Pertinent information on species of special interest: Species of non-consumptive interest (e.g. tourism, scientific)	2			√			√			
	Pertinent information on species of special interest: Other specially protected species (international, national, local)	2			√			√			
	Factors controlling the success of year classes for species: Recruitment	2	√	√	√		√	√		√	
HARVESTING	Factors controlling year class strength of targeted species: Food requirements	3		√	√		√				
	Factors controlling year class strength of targeted species: Recruitment	3	√	√	√		√				
	Level of effort, spatial and temporal distribution, and density for recreational fishing/harvesting	3		√			√				
	Assessments of harvested stocks (e.g., access to NMFS, FMC and tribal data)	2		√			√				
	Effects of fishing/harvest on predator-prey dynamics	2		√			√				
	Factors controlling year class strength of targeted species: Competition between key species	2		√	√		√				
	Factors controlling year class strength of targeted species: Predator-prey relationships	2		√	√		√				
	Factors controlling year class strength of targeted species: Growth, reproduction, and mortality	2		√	√		√	√	√		
	Age of target organisms at time of harvest	2		√			√				
	Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting	2		√			√				
INDUSTRIAL USES	Tourism profile: Activities of vendors	3									√
	Tourism profile: Activities (location, intensity) of tourists	2									√
	Tourism profile: Proximity of sanctuary resources to populated areas	2									√
	Characterization of vessel traffic: Acoustic signatures of vessel traffic	2						√			√
MAPPING CAPABILITIES	GIS compatible data: Source areas for critical species	2	√	√	√		√			√	
OCEANOGRAPHIC REGIME	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Upwelling	2	√		√	√	√		√		
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Tides	2	√		√	√	√	√	√		√
WILDLIFE DISTURBANCE	Susceptibility and response of species of concern to wildlife disturbance: Verification of cause-and-effect relationships	2						√			√
	Susceptibility and response of species of concern to wildlife disturbance: Acute and chronic species response (e.g. behavioral, reproductive, physiological, physical injury)	2						√			
	Susceptibility and response of species of concern to wildlife disturbance: Sensory capabilities, physiological tolerances, and thresholds	2						√			
	Susceptibility and response of species of concern to wildlife disturbance: Behavioral variability	2						√			
	Threat assessment for sources of wildlife disturbance: Range of influence for potentially vulnerable species	2						√			
ZONE PERFORMANCE	Impacts of unrestricted human activities within zoned areas: Intensity	3		√							
	Impacts of unrestricted human activities within zoned areas: Spatial distribution	3		√							
	Impacts of unrestricted human activities within zoned areas: Types of impacts	3		√							
	Endpoints related to management issue		7	18	15	3	16	13	3	6	6

* Note that endpoints are listed by topic category and not management issue. Endpoints may relate to more than one management issue.

Program Information Needs

Of the 150 endpoints identified during the workshop that preceded this evaluation, 136 were recognized as requiring substantially more attention by at least one site. A complete list of these endpoints can be found in Appendix 3. Twelve endpoints were identified by at least eight of the eleven participating sites as requiring substantial increases, suggesting a particular need to address these endpoints. They are

- Biological Resources: Factors controlling the success of year classes for species: Competition between key species
- Biological Resources: Factors controlling the success of year classes for species: Predator-prey relationships
- Biological Resources: Factors controlling the success of year classes for species: Recruitment
- Biological Resources: Pertinent information on species of special interest: Ecological indicators
- Harvesting: Data on spatial and temporal habitat changes caused by fishing
- Harvesting: Effects of fishing/harvest on predator-prey dynamics
- Harvesting: Factors controlling year class strength of targeted species: Competition between species
- Harvesting: Factors controlling year class strength of targeted species: Growth, reproduction, and mortality
- Harvesting: Factors controlling year class strength of targeted species: Recruitment
- Harvesting: Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting
- Industrial Uses: Identification of sources of invasive species
- Mapping Capabilities: GIS compatible data: Source areas for critical species

Individual site analyses demonstrate the considerable variation in information needs throughout the National Marine Sanctuary Program. Nevertheless, Table 9 summarizes the site analyses and shows the near-consensus opinion of the need for research on Zoning and Fishing/Harvest Effects in the marine sanctuaries. Data from almost all sites substantiate these needs. Water Quality and Industrial Uses are the management issues that require the least additional activity. Potential surpluses in activity may exist among four of the issues at certain sites.

Twelve of the 150 endpoints were judged by at least eight of the 11 marine sanctuaries to require substantial increases in scientfic effort. Most related to factors affecting the survival of key species or the effects of fishing.

Invasive species, like this kelp (Undaria pinnatifida) *removed from Monterey Bay, pose a potential threat to the resources in all of the national marine sanctuaries. Management at a majority of the sanctuaries demonstrated the need for additional information on the sources of invasives.*

Table 9. Summary of individual site assessments, indicating management issues that appear to be best addressed by the sites (√), those requiring the greatest increase in attention (●), those requiring substantial increases in attention, but secondary to others (❍), and those for which there may be a surplus in activity (–).

Attributes and Significant Resources		Marine Sanctuary	Management Issue								
			Habitat Delineation	Zoning	Living Marine Resources	Water Quality	Fishing/Harvest Effects	Wildlife Disturbance	Event Response	Restoration/Rehabilitation	Industrial Uses
Marine Mammals	West Coast	OC		●	●	√	●			●	√
		CB		●		√	●		√–		❍
		GF		●		√	●		–	–	
		MB		●			●	●	√		●
		CI	√	❍	√		●	❍			●
		SB	–	●	❍	√–	❍	❍			√
	Coral Resources	HI		●	●			●		●	
		FB	√	●		√			●	●	√
		FG		●			●			❍	√
		FK	–	●	●	–	●	√		√	√
		GR	●	●	●	●	●				
		Increase (● or ❍)	1	**11**	5	1	**9**	4	1	4	3
		Best Addressed (√)	2	0	1	**5**	0	1	2	1	**5**
		Surplus (–)	2	0	0	2	0	0	2	1	0

Coral Reef Information Needs

A number of other endpoints consistently appeared among sites with similar attributes, demonstrating unique needs dictated by the nature of the resources protected. In addition to the needs listed above, 12 endpoints with suggested substantial increases in activity were identified at four of the five sites containing coral reefs or coral habitats:

- Biological Resources: Factors controlling the success of year classes for species: Habitat use at various life stages
- Biological Resources: Pertinent information on species of special interest: Keystone species (e.g., apex predators, critical herbivores)
- Event Response: Linkages between causes of events
- Event Response: Risk assessment: Probability of future events
- Water Quality: Incidental contaminants from vessels (merchant, fishing, tourism, private)
- Water Quality: Levels and mechanisms of contaminants causing mortality
- Water Quality: Levels and mechanisms of sublethal stressors
- Water Quality: Temporal changes in levels of pathogens and pathogenic indicators within: Biological samples
- Zone Performance: Effectiveness of zoning regime
- Zone Performance: Impacts of unrestricted human activities within zoned areas: Intensity
- Zone Performance: Impacts of unrestricted human activities within zoned areas: Spatial distribution
- Zone Performance: Impacts of unrestricted human activities within zoned areas: Types of impacts

Marine Mammal Information Needs

Five endpoints with recommended substantial increases in activity appeared particularly relevant among sites that protect marine mammals:

- Biological Resources: Pertinent information on species of special interest: Ecological indicators
- Restoration: Valuation of sanctuary resources
- Wildlife Disturbance: Susceptibility and response of species of concern: Acute and chronic response (e.g., behavioral, reproductive, physiological, physical injury)
- Wildlife Disturbance: Susceptibility and response of species of concern: Verification of cause-and-effect relationships
- Wildlife Disturbance: Threat assessment for sources of wildlife disturbance: Range of influence for potentially vulnerable species

A marine reserve in the Florida Keys National Marine Sanctuary with boundaries clearly delineated by vessels fishing along the edge. Sanctuaries share a common need for information on zone performance. (Credit: David B. McClellan and James L. Tobias, National Marine Fisheries Service, Miami, FL.)

Results from the sanctuaries with marine mammal species note a particular need for information on the sources of and susceptibility and response to wildlife disturbance.

Trawlers and other vessels harvest a variety of marine resources including kelp. At the west coast sanctuaries, there is a general need to better understand the impacts of harvesting activities.

West Coast Information Needs

Finally, for sites along the west coast of the U.S., six additional high priority endpoints were identified at four of the five sites, suggesting unique regional needs:

- Biological Resources: Factors controlling the success of year classes for species: Condition and trends of critical habitat
- Harvesting: By-catch data
- Harvesting: Comparisons of impacts of fishing and harvest pressure in areas of high, low, and no activity
- Harvesting: Factors controlling year class strength of targeted species: food requirements
- Harvesting: Level of effort, spatial and temporal distribution, and density for recreational fishing/harvesting
- Industrial Uses: Characterization of vessel traffic: Ballast exchange requirements and protocols

Next Steps

This report used information gathered from science experts in a number of fields relevant to marine sanctuary management, as well as input from professionals actively participating in natural resource protection and management. The analysis of data from site-specific evaluations is intended to provide guidance for planning by sanctuary program staff and other individuals and agencies conducting research and monitoring in the marine sanctuaries. The changes in activity recommended in this report are meant to stimulate critical review among program staff regarding the allocation of financial resources, personnel, and effort. Recognition of the areas of greatest need, combined with the redistribution of assets, where appropriate, will increase efficiency and effectiveness and improve our ability to prioritize among the many and diverse information needs of the National Marine Sanctuary Program.

The next phase of the plan to strengthen science for the management of the National Marine Sanctuaries will involve the implementation of programs and projects to address the information needs identified in this report (see Figure 1). The findings presented here will determine what partnerships and mechanisms will be required to accomplish this. Implementation plans will be developed to propose the focus areas, priority partnerships, and suggested mechanisms, which are likely to include planning workshops and targeted agreements.

This report, as well as future plans resulting from it, will be provided as science guidance for various other programs and agencies. The National Marine Sanctuary Program is frequently asked to provide such information to assist the planning efforts of these organizations. Some use it to improve Requests for Proposals issued to the scientific community. Others use it to assist agency scientists in the development of annual work plans. Examples include several NOAA Programs, such as the National Centers for Coastal Ocean Science, the National Undersea Research Program and its associated Centers across the country, and the Office of Ocean Exploration. Another Federal agency likely to use this information for internal planning and partnership building is the U.S. Geological Survey.

The report will also be used to respond to administration and Congressional queries about program information and funding needs. Identifying the funding requirements for the projects and programs developed during the Implementation Phase will be necessary to generate both internal and external support for the work.

Appendix 1 - Survey Form

Survey instrument used to obtain information from marine sanctuaries on the extent to which information needs have been or are being met by the scientific community.

How effectively does the science conducted in the National Marine Sanctuaries support management information needs?

To answer this question, the National Marine Sanctuary System has initiated a multi-step process. The first step was to inventory science activities. A database was developed and populated with general information about recent, current, and planned activites/projects, the management applications of each project, and cost information among other data. The second step was to hold a workshop that included sanctuary research staff and invited guests representing academia, government, and non-governmental organizations. Workshop participants provided expert input on the scientific information (endpoints) necessary to address priority management issues within the National Marine Sanctuaries.

The next step is to use the information gathered in the first two steps to conduct the following assessment of the status of science in the National Marine Sanctuaries. This assessment will evaluate: the extent to which current activities address the endpoints identified in the workshop; and the availability of quality information/data pertaining to the endpoints and its utility in decision-making. It has been designed to elucidate:

*the overall status of NMS scientific efforts and knowledge

*the extent to which science efforts are targeting management issues;

*duplications in research and monitoring efforts; and

*gaps in the data and information necessary to address priority management issues.

Following the Science Workshop, the endpoints were reviewed by the Science Team for consistency and clarity. Numerous overlaps were identified among the endpoints determined by breakout groups. For purposes of this assessment, similar endpoints were grouped in topical categories and duplications were removed. Topical categories should not be confused with the management issues used to structure breakout groups.

Instructions for the Assessment of the Status of Science in the National Marine Sanctuaries

In the following sections, endpoints are listed in topical categories. The management issues relevant to each endpoint are indicated on the right by a checkmark. The first three columns following the endpoints are for the assessment. Please consider each endpoint as it pertains to your sanctuary and provide a rating for the following three categories:

A) Rate the level of concern/relevance your site ascribes to the endpoints (1=N/A, 2=low, 3=medium, 4=high)

B) Rate the extent to which recent, planned, or current science efforts (i.e., those projects cataloged in the NMS science database) address the endpoints identified in the workshop (1=not addressed, 2=somewhat addressed, 3=moderately addressed, 4=well addressed).

C) Rate the availability, from all sources, of quality information/data pertaining to the endpoints and the utility of this information in decision-making (1=not available, 2=limited availability/utility, 3=moderate availability/utility, 4=fully available/useful).

A comments column is also provide for purposes of clarification.

Assessment of the Status of Science in the National Marine Sanctuaries	A) Concern/Relevance	B) Current Activities	C) State of Knowledge	1) Habitat Charact.	2) Zoning	3) Living Marine Res.	4) WQ Protection	5) Fishing/Harvest	6) Wildlife Disturbance	7) Event Response	8) Restoration/Rehab.	9) Industrial Uses	Comments
I. OCEANOGRAPHIC REGIME													
Oceanographic data, including temporal variation, in and around areas of concern or particular interest:													
Currents				√	√	√	√	√	√	√	√	√	
Tides				√		√	√	√	√	√		√	
Upwelling				√		√	√	√		√			
Salinity				√		√	√	√					
Temperature				√		√	√	√	√				
Turbidity				√		√	√	√		√	√	√	
Light penetration/PAR				√		√	√	√					
Chemistry				√		√	√	√				√	
Nutrient Flux				√		√	√	√					
Oxygen				√		√	√	√					
Wave forces				√		√		√	√	√	√	√	
Chlorophyll-a				√		√	√	√					
II. HABITAT													
Mechanistic linkages among geologic, biologic, oceanographic, and atmospheric processes as they influence habitat				√	√	√			√	√	√		
Predictive models to understand dynamics of habitat distribution and factors that influence it (e.g., substrate burial, gear impacts, climate change impacts)				√	√				√	√	√		
Identification of anthropogenic habitats (e.g., shipwrecks, artificial reefs, oil platforms, piers, dumps, bottom fishing gear scars)				√	√	√		√				√	
Geological characterization (including tectonism and diapirism)				√									
Sediment characterization within areas of concern				√				√				√	
Processes that create and change seabed forms in the following contexts:													
Atmospheric (e.g., precipitation, atmospheric deposition, air/sea exchange, atmospheric loading)				√									
Oceanographic (e.g., turbidity flows, erosion)				√									

Assessment of the Status of Science in the National Marine Sanctuaries	A) Concern/Relevance	B) Current Activities	C) State of Knowledge	1) Habitat Charact.	2) Zoning	3) Living Marine Res.	4) WQ Protection	5) Fishing/Harvest	6) Wildlife Disturbance	7) Event Response	8) Restoration/Rehab.	9) Industrial Uses	Comments
III. MAPPING CAPABILITIES													
GIS compatible data:													
Bathymetry				√			√	√					
Topography				√				√					
Shoreline				√			√						
Rivers				√			√						
Outfalls				√			√						
Special use or management areas				√	√		√						
Sampling locations							√						
Watersheds				√			√						
Land uses				√			√						
Habitat types				√									
Sediment types				√									
III. MAPPING CAPABILITIES (continued)													
Extractable minerals				√								√	
Critical habitat for species of concern				√	√	√		√	√	√	√	√	
Source areas for critical species				√	√	√		√			√		
IV. BIOLOGICAL RESOURCES													
Information on key species and communities													
Species' seasonal and spatial occurrence, distribution, and abundance					√	√	√	√	√	√	√	√	
Habitat fidelity (strength of associations between species and habitats)					√	√		√			√		
Population dynamics, including species and population level genetics, life history, and distribution					√	√	√	√	√	√	√	√	
Community dynamics (e.g., trophic structure, species interactions)					√	√	√	√	√		√	√	
Incidence of disease						√	√		√	√	√	√	
Incidence of deformities						√	√		√	√	√	√	

Assessment of the Status of Science in the National Marine Sanctuaries	A) Concern/Relevance	B) Current Activities	C) State of Knowledge	1) Habitat Charact.	2) Zoning	3) Living Marine Res.	4) WQ Protection	5) Fishing/Harvest	6) Wildlife Disturbance	7) Event Response	8) Restoration/Rehab.	9) Industrial Uses	Comments
IV. BIOLOGICAL RESOURCES (continued)													
Information on key species and communities (continued)													
Population trends, including rates of growth, mortality, and fecundity					√	√	√	√	√	√	√	√	
Factors controlling the success of year classes for species													
Recruitment				√	√	√		√	√		√		
Food requirements				√	√	√		√	√		√		
Habitat use at various life stages				√	√	√		√	√		√		
Predator-prey relationships				√	√	√		√	√		√		
Competition between key species				√	√	√		√	√		√		
Multi-species relationships						√		√	√		√	√	
Condition and trends of critical habitat				√	√	√		√	√	√	√	√	
Indicators of physiological stress (e.g., biomarkers, bleaching)						√	√		√	√	√	√	
Pertinent information on species of special interest													
Federal or state endangered or threatened species						√			√				
Marine mammals					√	√			√				
Migratory bird species						√			√				
Other specially protected species (international, national, local)						√			√				
Species harvested under special exemptions (cultural activities)						√		√	√				
Species of non-consumptive interest (e.g. tourism, scientific)						√			√				
Ecological indicators					√	√	√				√		
Keystone species (e.g. apex predators, critical herbivores)						√					√		
Habitat providers (e.g. seagrasses, mangroves, kelp, coral)				√	√	√			√				
Non-indigenous species					√	√							
Potential invasive species					√	√							

Assessment of the Status of Science in the National Marine Sanctuaries

	A) Concern/Relevance	B) Current Activities	C) State of Knowledge	1) Habitat Charact.	2) Zoning	3) Living Marine Res.	4) WQ Protection	5) Fishing/Harvest	6) Wildlife Disturbance	7) Event Response	8) Restoration/Rehab.	9) Industrial Uses	Comments
V. HARVESTING													
Distribution and abundance of fish (target and non-target) at different life stages				√	√	√		√	√	√			
Comparisons of impacts of fishing and harvest pressure in areas of high, low, and no activity					√			√					
Vessel types used for fishing and harvesting								√					
Gear types used for fishing and harvesting								√					
Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting					√			√					
Level of effort, spatial and temporal distribution, and density for recreational fishing/harvesting					√			√					
Data on spatial and temporal habitat changes caused by fishing					√			√					
Age of target organisms at time of harvest					√			√					
By-catch data								√					
Factors controlling year class strength of targeted species													
Growth, reproduction, and mortality					√	√		√	√	√			
Recruitment				√	√	√		√					
Food requirements					√	√		√					
Condition of critical habitat				√	√	√		√					
Predator-prey relationships					√	√		√					
Competition between key species					√	√		√					
Effects of natural events on harvested organisms and yields:													
Currents								√					
Storm events								√					
Hurricanes								√					
El Niños								√					
Global warming								√					
Effects of fishing/harvest on predator-prey dynamics					√			√					
Assessments of harvested stocks (e.g., access to NMFS, FMC and tribal data)					√			√					

Assessment of the Status of Science in the National Marine Sanctuaries

	A) Concern/Relevance	B) Current Activities	C) State of Knowledge	1) Habitat Charact.	2) Zoning	3) Living Marine Res.	4) WQ Protection	5) Fishing/Harvest	6) Wildlife Disturbance	7) Event Response	8) Restoration/Rehab.	9) Industrial Uses	Comments
VI. WILDLIFE DISTURBANCE													
Threat assessment for sources of wildlife disturbance:													
Identification of sources									√			√	
Range of influence for potentially vulnerable species									√				
Predict outcomes for various disturbance regimes									√				
Spatial and temporal variability in levels of wildlife disturbance									√			√	
Susceptibility and response of species of concern to wildlife disturbance:													
Behavioral variability									√				
Sensory capabilities, physiological tolerances, and thresholds									√				
Acute and chronic species response (e.g. behavioral, reproductive, physiological, physical injury)									√				
Verification of cause-and-effect relationships									√			√	
VII. WATER QUALITY													
Temporal and spatial dynamics influencing water quality:													
Inputs from rivers and outfalls							√						
Atmospheric deposition							√						
Inputs from non-point sources and selected human activities							√						
Incidental contaminants from vessels (merchant, fishing, tourism, private)							√	√		√		√	
Temporal changes in levels of relevant organics and metals within:													
Sentinal organisms							√						
Water column							√						
Sediments							√						
Beach-cast organisms							√						
Temporal changes in levels of pathogens and pathogenic indicators within:													
Water column							√						
Biological samples							√						
Beach-cast organisms							√						
Levels and mechanisms of contaminants causing mortality							√						
Levels and mechanisms of sublethal stressors							√						

Assessment of the Status of Science in the National Marine Sanctuaries	A) Concern/ Relevance	B) Current Activities	C) State of Knowledge	1) Habitat Charact.	2) Zoning	3) Living Marine Res.	4) WQ Protection	5) Fishing/Harvest	6) Wildlife Disturbance	7) Event Response	8) Restoration/Rehab.	9) Industrial Uses	Comments
VII. WATER QUALITY (continued)													
Human health implications of poor water quality (e.g., impacts of an algae bloom)							√						
Socioeconomic effects of water quality on commercial and recreational uses and profits							√						
VIII. INDUSTRIAL USES													
Characterization and monitoring of areas relevant to cable laying:													
Sediment types												√	
Sediment chemistry												√	
Infauna and epifauna												√	
Impacts of cable laying to habitat												√	
Status of cable (burial)												√	
Characterization of vessel traffic:													
Vessel traffic patterns												√	
Proximity of major vessel traffic to sensitive resources									√			√	
Acoustic signatures of vessel traffic									√			√	
Distribution and abundance of vessels												√	
Vessel class information: type, quantity, speed, length, tonnage, age, draft, nationality												√	
Cargo: type, quantity, value, classification												√	
Economics of alternate ship routes												√	
Ballast exchange requirements and protocols												√	
Identification of sources of invasive species												√	
Tourism profile:													
Origin and number of visitors												√	
Proximity of sanctuary resources to populated areas												√	
Activities (location, intensity) of tourists												√	
Expenditures by tourists												√	
Activities of vendors												√	

Assessment of the Status of Science in the National Marine Sanctuaries	A) Concern/Relevance	B) Current Activities	C) State of Knowledge	1) Habitat Charact.	2) Zoning	3) Living Marine Res.	4) WQ Protection	5) Fishing/Harvest	6) Wildlife Disturbance	7) Event Response	8) Restoration/Rehab.	9) Industrial Uses	Comments
VIII. INDUSTRIAL USES (continued)													
Characterization of dredge and fill activities:													
Material texture, composition, and pore water chemistry							√					√	
Impact on localized flow dynamics							√					√	
Resuspension of sediment contaminants							√					√	
IX. EVENT RESPONSE													
Risk assessment:													
Data/statistics on the occurrence of past events (for each type of event)										√			
Consequences of events (including collateral consequences)										√			
Current status/trends of causal factors (e.g., vessel traffic patterns, status of drilling and production platforms, regional occurrence of disease outbreaks)										√			
Probability of future events										√			
Contingency plan for relevant events										√			
Relevant and appropriate data to identify and verify an event inside or adjacent to the sanctuary										√			
Event path tracking and identification of likely consequences										√			
Identification of impacts at appropriate scales										√			
Mitigation alternatives										√			
Develop or revise and validate appropriate ecological models to predict events										√			
Linkages between the causes of events										√			
X. ZONE PERFORMANCE													
Effectiveness of zoning regime					√			√	√		√		
Impacts of unrestricted human activities within zoned areas:													
Types of impacts					√								
Spatial distribution					√								
Intensity					√								

Assessment of the Status of Science in the National Marine Sanctuaries	A) Concern/Relevance	B) Current Activities	C) State of Knowledge	1) Habitat Charact.	2) Zoning	3) Living Marine Res.	4) WQ Protection	5) Fishing/Harvest	6) Wildlife Disturbance	7) Event Response	8) Restoration/Rehab.	9) Industrial Uses	Comments
XI. RESTORATION													
Assessment of appropriate technologies for restoration/rehabilitation in the following categories:													
Physical structure											M		
Biogeochemical processes											M		
Key species											M		
Biological communities											M		
Cost/benefit analysis, including temporal threshold, for implementing primary restoration activities											M		
Criteria to evaluate effectiveness of restoration actions (e.g., physical stability, bioindicators)											M		
Valuation of sanctuary resources								M			M	M	
XII. RECOVERY OF RESOURCES													
Trajectories of probable *habitat* recovery within a likely range of anthropogenic and natural disturbances					M			M			M		
Trajectories of probable *population and community* recovery within a likely range of anthropogenic and natural disturbances					M			M			M		

Appendix 2 - Survey Participants

List of evaluators for each national marine sanctuary.
The key science contact for each sanctuary is emphasized by bold and italics.

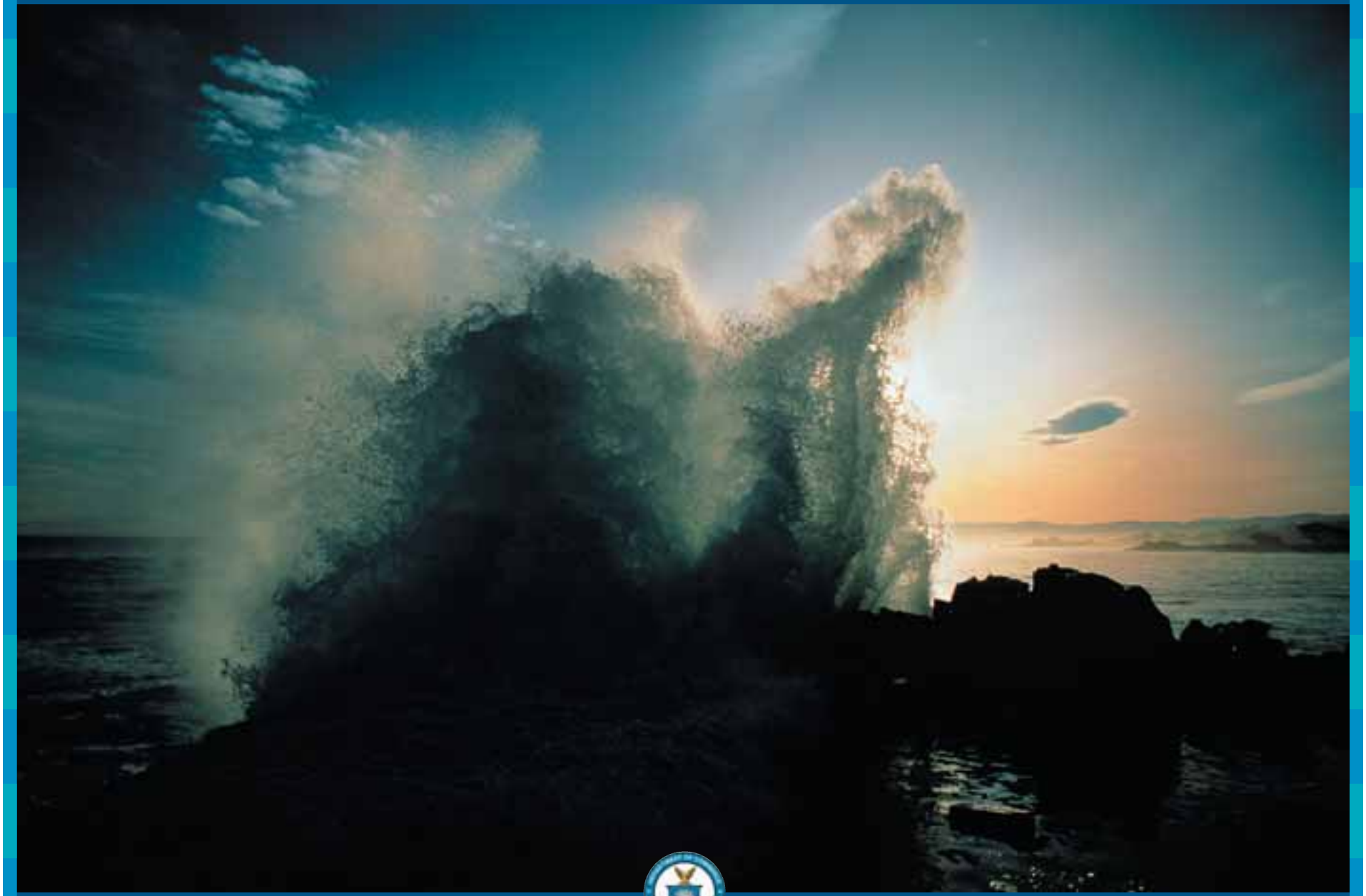
Site	*Evaluator*
Channel Islands	***Sarah Fangman*** Ben Waltenberger
Cordell Bank	***Jan Roletto*** Dan Howard
Fagatele Bay	***Nancy Daschbach***
Florida Keys	***Brian Keller*** Joanne Delaney
Flower Garden Banks	***Emma Hickerson*** Steve Gittings
Gray's Reef	***Greg McFall*** Reed Bohne
Gulf of the Farallones	***Jan Roletto*** Dan Howard
Hawaiian Island Humpback Whale	***Claire Cappelle*** Naomi McIntosh Jeff Walters
Monterey Bay	***Andrew DeVogelaere*** Mario Tamburri Bill Douros
Olympic Coast	***Ed Bowlby***
Stellwagen Bank	***James Lindholm***

Appendix 3 - Endpoints Recommended for Substantial Increase in Activity

List of all endpoints recommended for substantial increase in activity (+2 or +3) in at least one national marine sanctuary.
Sanctuaries are organized into categories to allow comparison among sanctuaries with common resources or in geographic proximity.

Endpoints		Marine Mammal											Number of Sites
		West Coast						Coral Resource					
		OCNMS	CBNMS	GFNMS	MBNMS	CINMS	SBNMS	HIHWNMS	FBNMS	FGBNMS	FKNMS	GRNMS	
BIOLOGICAL RESOURCES	Factors controlling the success of year classes for species: Competition between key species		2	2	3		3	2	2	2	2		8
	Factors controlling the success of year classes for species: Condition and trends of critical habitat	2	2	2	2			2		2			6
	Factors controlling the success of year classes for species: Food requirements	2					3	2		2		2	5
	Factors controlling the success of year classes for species: Habitat use at various life stages	2			2			2	2	2	2		6
	Factors controlling the success of year classes for species: Indicators of physiological stress (e.g., biomarkers, bleaching)							3	2				2
	Factors controlling the success of year classes for species: Multi-species relationships		2	2				2	3	2			5
	Factors controlling the success of year classes for species: Predator-prey relationships	2	2	2	2			2	2	2	2		8
	Factors controlling the success of year classes for species: Recruitment	2	2	2	3		2	2	2		2		8
	Information on key species and communities: Community dynamics (e.g., trophic structure, species interactions)	2	2	2				2		2	2		6
	Information on key species and communities: Habitat fidelity (strength of associations between species and habitats)	2			2			2	2				4
	Information on key species and communities: Incidence of deformities				2			2		2	2		4
	Information on key species and communities: Incidence of disease							2		2			2
	Information on key species and communities: Population dynamics, including species and population level genetics, life history, and distribution	2			2			2			2		4
	Information on key species and communities: Population trends, including rates of growth, mortality, and fecundity	2						2		2			3
	Information on key species and communities: Species' seasonal and spatial occurrence, distribution, and abundance	2						2					2
	Pertinent information on species of special interest: Ecological indicators		2	2		2	2	2	3	2		2	8
	Pertinent information on species of special interest: Keystone species (e.g. apex predators, critical herbivores)						2	2	2	2		2	5
	Pertinent information on species of special interest: Marine mammals									2			1
	Pertinent information on species of special interest: Migratory bird species	2					2						2
	Pertinent information on species of special interest: Non-indigenous species	2						3					2
	Pertinent information on species of special interest: Other specially protected species (international, national, local)						2	2					2
	Pertinent information on species of special interest: Potential invasive species				2			3			2		3
	Pertinent information on species of special interest: Species harvested under special exemptions (cultural activities)	2											1
	Pertinent information on species of special interest: Species of non-consumptive interest (e.g. tourism, scientific)				2		2	2					3

Endpoints		Marine Mammal											Number of Sites
		West Coast						Coral Resource					
		OCNMS	CBNMS	GFNMS	MBNMS	CINMS	SBNMS	HIHWNMS	FBNMS	FGBNMS	FKNMS	GRNMS	
EVENT RESPONSE	Contingency plan for relevant events							2	2				2
	Develop or revise and validate appropriate ecological models to predict events						2	2	3				3
	Event path tracking and identification of likely consequences	2			2			2	3				4
	Identification of impacts at appropriate scales	2			2	2		2	2		2		6
	Linkages between the causes of events						2	2	2		2	2	5
	Mitigation alternatives	2					2	2	2				4
	Relevant and appropriate data to identify and verify an event inside or adjacent to the sanctuary							2	3	2			3
	Risk assessment: Consequences of events (including collateral consequences)				3	2	2						3
	Risk assessment: Data/statistics on the occurrence of past events (for each type of event)					2	2						2
	Risk assessment: Probability of future events	2					2	2	2	2	3		6
HABITAT	Geological characterization (including tectonism and diapirism)									2			1
	Identification of anthropogenic habitats (e.g., shipwrecks, artificial reefs, oil platforms, piers, dumps, bottom fishing gear scars)							2		2			2
	Mechanistic linkages among geologic, biologic, oceanographic, and atmospheric processes as they influence habitat	2								2	2	2	4
	Predictive models to understand dynamics of habitat distribution and factors that influence it (e.g., substrate burial, gear impacts, climate change impacts)	2			2	2		2		2			5
	Processes that create and change seabed forms in the following contexts: Atmospheric (e.g., precipitation, atmospheric deposition, air/sea exchange, atmospheric loading)				2	2							2
	Processes that create and change seabed forms in the following contexts: Oceanographic (e.g., turbidity flows, erosion)	2			2	2				2			4
	Sediment characterization within areas of concern	2											1
HARVESTING	Age of target organisms at time of harvest		2	2	2		2		3	2	2		7
	Assessments of harvested stocks (e.g., access to NMFS, FMC and tribal data)			2			2			2	2		4
	By-catch data	2	2	2	3						2	3	6
	Comparisons of impacts of fishing and harvest pressure in areas of high, low, and no activity	3	2	2	2					2	3		6
	Data on spatial and temporal habitat changes caused by fishing	2	2	2	2	2			2	2		2	8
	Distribution and abundance of fish (target and non-target) at different life stages	2							3		2		3
	Effects of fishing/harvest on predator-prey dynamics	2	2	2	2	2	2		3	3	3	2	10
	Effects of natural events on harvested organisms and yields: Currents		2	2		2	2						4
	Effects of natural events on harvested organisms and yields: El Niños		2	2									2
	Effects of natural events on harvested organisms and yields: Global warming		2	2		2						2	4
	Effects of natural events on harvested organisms and yields: Hurricanes		2				2						2
	Effects of natural events on harvested organisms and yields: Storm events			2			2						2
	Factors controlling year class strength of targeted species: Competition between key species		2	2	2	2	2		2	2		2	8
	Factors controlling year class strength of targeted species: Condition of critical habitat	3	2	2						2	2		5
	Factors controlling year class strength of targeted species: Food requirements	2	2	2	2		3			2		2	7
	Factors controlling year class strength of targeted species: Growth, reproduction, and mortality		2	2	2	2	2		3		2	2	8
	Factors controlling year class strength of targeted species: Predator-prey relationships	2	2	2			2		2	2		2	7
	Factors controlling year class strength of targeted species: Recruitment	2	2	2	2		3		3		3	2	8
	Gear types used for fishing and harvesting	2											1
	Level of effort, spatial and temporal distribution, and density for commercial fishing/harvesting	2	2	2	2	2	2		2		2		8
	Level of effort, spatial and temporal distribution, and density for recreational fishing/harvesting	2	2	2	3		3		2			2	7
	Vessel types used for fishing and harvesting		2	2							2		3

Endpoints		Marine Mammal											Number of Sites
		West Coast						Coral Resource					
		OCNMS	CBNMS	GFNMS	MBNMS	CINMS	SBNMS	HIHWNMS	FBNMS	FGBNMS	FKNMS	GRNMS	
INDUSTRIAL USES	Characterization and monitoring of areas relevant to cable laying: Impacts of cable laying to habitat				2								1
	Characterization and monitoring of areas relevant to cable laying: Infauna and epifauna				2								1
	Characterization and monitoring of areas relevant to cable laying: Sediment types				2								1
	Characterization and monitoring of areas relevant to cable laying: Status of cable (burial)				2								1
	Characterization of dredge and fill activities: Impact on localized flow dynamics		2	2									2
	Characterization of dredge and fill activities: Material texture, composition, and pore water chemistry				2								1
	Characterization of dredge and fill activities: Resuspension of sediment contaminants				2								1
	Characterization of vessel traffic: Acoustic signatures of vessel traffic	3				3	2			2		2	5
	Characterization of vessel traffic: Ballast exchange requirements and protocols	2		2	2	3					3	3	6
	Characterization of vessel traffic: Cargo: type, quantity, value, classification					2							1
	Characterization of vessel traffic: Distribution and abundance of vessels										2		1
	Characterization of vessel traffic: Economics of alternate ship routes					2							1
	Characterization of vessel traffic: Proximity of major vessel traffic to sensitive resources		2	2	2								3
	Characterization of vessel traffic: Vessel traffic patterns					2				2	2		3
	Identification of sources of invasive species	2	2	2	2	2		3	3			2	8
	Tourism profile: Activities (location, intensity) of tourists		2		2		2						3
	Tourism profile: Activities of vendors				2	2	3						3
	Tourism profile: Proximity of sanctuary resources to populated areas		2				2						2
MAPPING CAPABILITIES	GIS compatible data: Critical habitat for species of concern	2	2					2		3			4
	GIS compatible data: Habitat types	2								3			2
	GIS compatible data: Sampling locations									2			1
	GIS compatible data: Sediment types	2	2		2					3			4
	GIS compatible data: Shoreline					2			2				2
	GIS compatible data: Source areas for critical species	2			2		2	2	2	3	2	2	8
	GIS compatible data: Topography	2											1
	GIS compatible data: Watersheds										2		1
OCEANOGRAPHIC REGIME	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Chemistry							2		3			2
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Chlorophyll-a	2						2		3			3
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Currents	2							3	3			3
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Light penetration/PAR	3								3			2
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Nutrient Flux	2			2			2		3	2		5
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Oxygen							2		3			2
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Salinity							2		3			2
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Tides						2			3			2
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Turbidity	3								3	2		3
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Upwelling	2					2				2	2	4
	Oceanographic data, including temporal variation, in and around areas of concern or particular interest: Wave forces				2							2	2

Endpoints		Marine Mammal											Number of Sites
		West Coast						Coral Resource					
		OCNMS	CBNMS	GFNMS	MBNMS	CINMS	SBNMS	HIHWNMS	FBNMS	FGBNMS	FKNMS	GRNMS	
RECOVERY OF RESOURCES	Trajectories of probable habitat recovery within a likely range of anthropogenic and natural disturbances	2						3			2		3
	Trajectories of probable population and community recovery within a likely range of anthropogenic and natural disturbances	2			2			3			3		4
RESTORATION	Assessment of appropriate technologies for restoration/rehabilitation in the following categories: Biogeochemical processes					2		2	2		2		4
	Assessment of appropriate technologies for restoration/rehabilitation in the following categories: Biological communities	2				2		2	2				4
	Assessment of appropriate technologies for restoration/rehabilitation in the following categories: Key species				2	2		2					3
	Assessment of appropriate technologies for restoration/rehabilitation in the following categories: Physical structure					2			3				2
	Cost/benefit analysis, including temporal threshold, for implementing primary restoration activities					2		2			2		3
	Criteria to evaluate effectiveness of restoration actions (e.g., physical stability, bioindicators)					2		2	2		2		4
	Valuation of sanctuary resources				2	2	2	3	3				5
WATER QUALITY	Human health implications of poor water quality (e.g., impacts of an algae bloom)							2					1
	Incidental contaminants from vessels (merchant, fishing, tourism, private)				2	3		2	2	2		2	6
	Levels and mechanisms of contaminants causing mortality				2			2		3	2	2	5
	Levels and mechanisms of sublethal stressors				2			2	2	2		2	5
	Socioeconomic effects of water quality on commercial and recreational uses and profits	2			2		2	2				3	5
	Temporal and spatial dynamics influencing water quality: Atmospheric deposition							2					1
	Temporal and spatial dynamics influencing water quality: Inputs from non-point sources and selected human activities				2			2	3	2			4
	Temporal and spatial dynamics influencing water quality: Inputs from rivers and outfalls							2	2				2
	Temporal changes in levels of pathogens and pathogenic indicators within: Beach-cast organisms							2		2			2
	Temporal changes in levels of pathogens and pathogenic indicators within: Biological samples							2		2	2	2	4
	Temporal changes in levels of pathogens and pathogenic indicators within: Water column				2	2		2		2			4
	Temporal changes in levels of relevant organics and metals within: Beach-cast organisms				2								1
	Temporal changes in levels of relevant organics and metals within: Sediments				2				2		2		3
	Temporal changes in levels of relevant organics and metals within: Sentinal organisms						2				2		2
	Temporal changes in levels of relevant organics and metals within: Water column				2	2			2		2		4
WILDLIFE DISTURBANCE	Spatial and temporal variability in levels of wildlife disturbance				3	2		3	3				4
	Susceptibility and response of species of concern to wildlife disturbance: Acute and chronic species response (e.g. behavioral, reproductive, physiological, physical injury)	2			2	2	2	2	3		2		7
	Susceptibility and response of species of concern to wildlife disturbance: Behavioral variability				2		2	2	2				4
	Susceptibility and response of species of concern to wildlife disturbance: Sensory capabilities, physiological tolerances, and thresholds				2	2	2	2	2		2		6
	Susceptibility and response of species of concern to wildlife disturbance: Verification of cause-and-effect relationships	3			2	2	2	2	2		2		7
	Threat assessment for sources of wildlife disturbance: Identification of sources	2			3			2	2				4
	Threat assessment for sources of wildlife disturbance: Predict outcomes for various disturbance regimes				3			3	2		3		4
	Threat assessment for sources of wildlife disturbance: Range of influence for potentially vulnerable species		2	2	3		2	2					5
ZONE PERFORMANCE	Effectiveness of zoning regime		3					3	3	2	2		5
	Impacts of unrestricted human activities within zoned areas: Intensity				2		3	2	3	2	2		6
	Impacts of unrestricted human activities within zoned areas: Spatial distribution				2		3	2	3	2	2		6
	Impacts of unrestricted human activities within zoned areas: Types of impacts						3	2	3	2	2		5