



## The Application Of Observing System Data In California Current Ecosystem Assessments

**U.S. Department of Commerce**  
National Oceanic and Atmospheric Administration  
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# **The Application Of Observing System Data In California Current Ecosystem Assessments**

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NOAA Office of National Marine Sanctuaries, Monterey Bay National Marine Sanctuary  
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## **COVER**

Divers prepare to descend on a mooring to replace data loggers. This mooring is part of the NMSP West Coast Observatory project and collects data on ocean temperature and currents. For more information see:

[http://www.mbnms-simon.org/sections/obs/nmsp\\_wco.php](http://www.mbnms-simon.org/sections/obs/nmsp_wco.php). Credit Josh Pederson, NOAA/MBNMS/SIMoN

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## ABSTRACT

Ecosystem-based management requires comprehensive assessments of the ecosystem to establish a feedback loop on the conditions in the systems under management. These assessments require observing data that reflect the pressures and ecosystem indicators of concern to managers. This report examines ongoing ecosystem assessment and modeling efforts in the California Current Ecosystem (hereafter referred to as ‘ecosystem assessments’) in the context of NOAA’s model for Integrated Ecosystem Assessment (IEA) development. The goals of this effort are to 1) examine the ecosystem assessments in the context of a DPSIR (Driver, Pressure, State, Impact, Response) approach; and 2) identify ocean observing datasets in use by current assessments to identify gaps in the data and services available to support future assessments.

The purpose, scale, and drivers for 10 selected assessments were compared with the ocean observing data sources used in their development. These 10 assessments vary in the spatial scope of the assessment from the California Current Ecosystem scale to the local scale. A more detailed comparison of the California Current IEA, Module 1 and Northern California Current Ecosystem, Atlantis model was then undertaken to highlight their use of drivers, pressures, and indicators.

Five Sanctuary condition reports, assessments for individual sanctuaries, were examined in depth to understand the relationship between drivers, pressures and responses in the context of management requirements. The sources of data used to evaluate indicators of those responses were then identified. This provided a link between a pressure-state-response model of IEA development and ocean observing data sets. The final step was to examine observing datasets being used by one or more assessment efforts in the California Current Ecosystem. This work provides an assessment of how existing ocean observing efforts are informing assessments efforts in the California Current Ecosystem and where gaps exist.

We identified four datasets available through the Pacific Coast Ocean Observing System that are being used by both large and small-scale assessment efforts. However, the overwhelming majority of the datasets identified in this analysis were used by either small or large-spatial scale assessment efforts but not both. A very large gap exists for data describing the level of human activities that impact the marine environment. In addition, the authors identify a need for more data collected at the sub-regional and local level. Currently, in no single sub-region are data available for all the physical, chemical, and especially biological indicators required for comprehensive analyses.

This review recognized four key barriers to fully exploiting ocean-observing data for ecosystem-based management: data discovery, data access, integrating disparate data, and closing the gap between data needs and data collection. One of the key challenges to IEA application in ecosystem-based management is the lack of available data. Even if there

were no barriers to discovering, accessing, and integrating existing data, effectively developing management alternatives and monitoring effectiveness requires investments in data collection and analysis. In many cases, the necessary data are not available, significantly hampering our ability for taking ecosystem-relevant management actions and increasing uncertainty in outcomes. Resource managers must make the best decisions possible with available information. This requirement to move forward, even with data gaps highlights the importance of maximizing the use of what we do have through data management, improved accessibility, improved integration and compatibility, and more comprehensive analysis.

### **KEY WORDS**

Pacific Coast Ocean Observing System, PaCOOS, Integrated Ocean Observing System, IOOS, Integrated Ecosystem Assessment, IEA, Ecosystem Based Management, EBM, National Marine Sanctuaries, Channel Islands, Monterey Bay, Gulf of The Farallones, Cordell Bank, Olympic Coast, DPSIR, California Current, Atlantis Model, Condition Report

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## INTRODUCTION

Incorporating ecosystem principles into resource management is a strategic goal of NOAA (NOAA 2009). This goal requires an ecosystem-based management (EBM) approach that moves beyond individual species or single-issue management to consider a range of relevant ecological, environmental, and human factors (Murawski and Matlock 2006). Integrated Ecosystem Assessments (IEAs) are an EBM approach that helps to overcome barriers to implementation. NOAA defines an IEA as “a synthesis and quantitative analysis of information on relevant physical, chemical, ecological and human processes in relation to specified ecosystem management objectives (Levin et al. 2009). IEAs can help improve our understanding of interactions among climate, water, habitat, living resources and human activities. Collaborative ecosystem-based management requires mobilizing contemporary and historical data from NOAA and other organizations to create a comprehensive picture of the ocean ecosystems and how they are changing. Creating this picture requires alliances among researchers and the professionals entrusted with managing marine resources and a deep understanding of the linkages between management needs and ecosystem observations.

Achieving NOAA’s goal of moving to ecosystem-based management entails access to high quality data to develop IEAs that support resource manager’s requirements for adaptive management. Levin et al. (2009) have outlined a framework for the development of IEAs that consists of five key steps (Figure 1). This framework begins with a scoping process to identify key threats, management objectives and constraints, and appropriate indicators<sup>1</sup> of ecosystem change. Risk assessments of individual indicators are combined into a determination of overall ecosystem status. The potential of different management strategies to alter ecosystem status is evaluated, and then management actions are implemented and their effectiveness monitored. The cycle is repeated in an adaptive manner. An assessment of stressors on the ecosystem identifies the “drivers” and “pressures”. Key relevant datasets are selected to assess the “state” of key indicators of ecosystem baseline conditions. An evaluation of the ecological and economic “impacts” of alternative management options help to identify the management “response” (Levin et al. 2008). The approaches Levin et al. describe provide a framework for understanding how to develop links that extend from observing data through adaptive management.

For IEAs to be useful they must be relevant to the management priorities of organizations with ocean stewardship responsibilities (deReynier et al. 2009). Because management actions can only be implemented by those agencies with management authority, agency management processes must be synchronized with the IEA process. National marine sanctuaries bring together the scientific community, stakeholders, and the public to clearly define goals, protocols, and decision points for applying marine ecosystem-based management principles in order to manage ocean resources. Each sanctuary in the National Marine Sanctuary System has a management plan. In general, management

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<sup>1</sup> Following the definition in EPA (2000), “An ecological indicator is defined here as a measure, an index of measures, or a model that characterizes an ecosystem or one of its critical components. An indicator may reflect biological, chemical or physical attributes of ecological condition.”

plans are used to inform decision making and project planning, while articulating goals, objectives, and priorities. Management plans are organized into action plans that link to management issues. Actions plans have common themes among sanctuaries based on the general goals of the Office of National Marine Sanctuaries (ONMS). One of these goals is to better characterize sanctuary resources, such as water quality, habitat, and living marine resources. Characterizing the condition of natural resources and ecosystem processes is the principal means by which the ONMS improves its understanding of the marine environment. A second major goal of the ONMS is to identify management actions needed to protect and conserve sanctuary resources. Examples of management actions include detecting the impacts of human activities or implementing new marine zones to protect vulnerable resources.

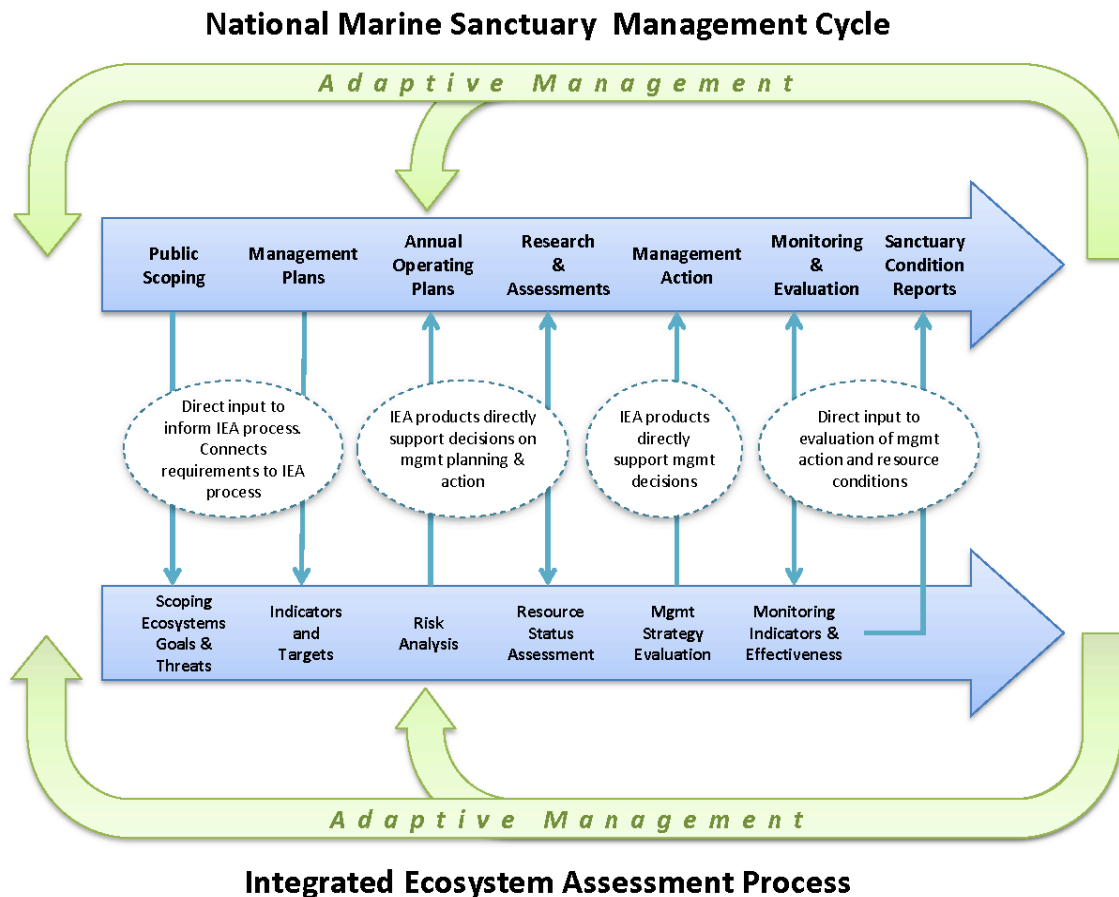


Figure 1 – Interaction between sanctuary management cycle and integrated ecosystem assessment process. The lower blue arrow shows the process of integrated ecosystem assessment (adapted from Levin et al. 2009). The ovals illustrate how a management unit’s actions, in this case a sanctuary, both contribute to and depend on results from IEAs.

The connection between National Marine Sanctuary management and the IEA process is one that illustrates the interdependency of sound science and resource management. It is based in connecting science capabilities with management requirements and must consider science, analysis, policy, socioeconomics, and programmatic processes to allow

effective implementation, beginning with public scoping sessions to inform managers on the range of issues that management should consider (Figure 1). A Sanctuary management plan provides the overarching connection between threats to managed resources, social and economic trends, and planned programmatic ecosystem-based management actions (see: <http://sanctuaries.noaa.gov/jointplan/welcome.html>). Sanctuary management plans, including their associated public scoping process can inform IEA scoping, threat identification, and indicator development. Based on these inputs, managers develop annual operating plans to allocate resources and address the identified threats. IEA risk analysis supports this program planning and investment by identifying high risk and high priority resources, processes, and issues. Each of the elements on the blue arrows in Figure 1 is an integral component of the adaptive management cycle central to EBM.

Monitoring allows managers to assess the effectiveness of specific strategies and overall effectiveness. Sanctuary condition reports provide the assessment and analysis of conditions and trends of sanctuary resources in the context of management plan goals (see: <http://sanctuaries.noaa.gov/science/condition>). Research and assessment activities provide the information necessary to develop targeted, effective management options. In the sanctuary system, such options can include regulations, permits, non-regulatory actions, and other tools for implementing strategies to address the identified pressures and threats on sanctuary resources. IEA tools (like simulation models) support these options by helping managers evaluate alternative management actions.

Creating a more comprehensive understanding of ecosystem status or health is a goal of many research, modeling, and assessment efforts recently undertaken in the California Current Ecosystem<sup>2</sup>. In this report we compare a number of these efforts in the context of NOAA's DPSIR (Driver, Pressure, State, Impact, Response) and IEA approaches. DPSIR is closely intertwined with IEAs (Koshel and Mcallister 2008; Levin et al. 2008; van Woerden et al. 2007) so it provides a useful comparison tool. The application of an IEA framework for EBM is a relatively new approach with few comprehensive examples. This report reviews assessments that while not meeting all requirements of a complete IEA, go beyond the individual species or single-issue assessment upon which managers have often relied in the past. These assessments meet one or several of the key IEA components shown in Figure 1 and can provide insight into the kinds of ocean observing data that fully developed IEAs will require. This report refers to these efforts as ecosystem assessments to indicate that they do not necessarily meet all the characteristics of an IEA but do provide managers with insights into the conditions of ecological resources and functions beyond those possible with single sector assessments.

Tallis identifies data acquisition, quality, and utility as a key factor in manager's ability to apply IEA approaches in EBM (Tallis et al. 2009). The goal of this report is to: 1) examine ecosystem assessments in the context of a DPSIR approach; and 2) identify ocean observing datasets in use by current assessments in order to understand the data

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<sup>2</sup> The CCE extend from approximately La Paz Mexico to the U.S.-Canadian border ([www.lme.noaa.gov/](http://www.lme.noaa.gov/) (accessed 12/12/2009)).

and services available to support future assessments. This report compares the purpose, scale, and drivers for 10 selected ecosystem assessments with the data sources used in their development. The CCE includes a wide range of spatial scales that are relevant to ecosystem-based management. Different geographies within the CCE can be described by physical processes (Hickey and Banas 2008), biogeography (Pacific Fisheries Management Council 2008), or by governance (Ekstrom 2009). The 10 assessments in this report represent different scales of investigation including the entire CCE, regions within the CCE, specific management units such as National Marine Sanctuaries, and local areas such as Monterey Bay.

A more detailed comparison of two ecosystem assessments efforts - the California Current IEA, Module I and Northern California Current Ecosystem Atlantis model - was undertaken to highlight their use of drivers, pressures, and indicators. Five Sanctuary condition reports, a component of IEAs for individual sanctuaries, were examined in depth to understand the relationship between drivers, pressures and indicators in the context of management requirements. The sources of data used to evaluate the state of sanctuary resources were then identified. This approach provided the link between the DPSIR model, the IEA framework, and data sources, some of which are IOOS data sets. The final step was to examine which of the observing datasets hosted by PaCOOS were being used by one or more ecosystem assessment efforts in the CCE. This work provides an assessment of how existing IOOS efforts are informing IEA efforts and where gaps exist in data availability.

This report identifies how the resource characterization (Table 1) and management action (Table 2) needs of the five west coast sanctuaries could be addressed, at least in part, by ocean observing data. The management plans for three sites in central California – Monterey Bay NMS, Cordell Bank NMS, and Gulf of the Farallones NMS, were reviewed and updated in 2008 in a process called the Joint Management Plan Review (NOAA 2008a, 2008b, 2008c). Similarly, the management plan for the Channel Islands NMS was recently completed in 2009 (NOAA 2009). The management plan review process at the Olympic Coast NMS began in 2008 and information from issue identification workshops was used to identify site management needs.

The strategies and activities highlighted in action plans help define the specific research topics or questions that need to be answered at each site and the sites' need for monitoring data. Many resource characterizations and management action needs are shared by most or all sanctuaries on the west coast (Tables 1, 2). For example, all five sites have a need for better subtidal benthic habitat characterization and a need to detect natural and human-induced changes to rocky intertidal habitat. However, some needs are more sanctuary specific. For example, the Monterey Bay NMS highlighted the need to monitor impacts to living resources from kelp harvest and desalination plants.

Using an existing inventory of monitoring programs in west coast sanctuaries (see Appendix I), we identified the programs that are collecting observing data applicable to each resource characterization or management action need. For resource characterization needs, we identified datasets that are: 1) being served by PaCOOS; 2) not being served by

PaCOOS (Table 1). For example, the annual surveys of kelp canopy in California and Washington are two observing datasets hosted by PaCOOS that help characterize the status and trend in abundance of this subtidal biogenic habitat in the sanctuaries. In contrast, PaCOOS is not currently serving observing datasets that would help characterize the status and trends of intertidal habitats and the associated living resources.

We also found that many management actions highlighted in management plans would benefit from better characterization of sanctuary resources. For example, assessing the effectiveness of areas within sanctuaries designed for additional levels of protection requires characterizing both habitat and living marine resources. Multiple monitoring programs are collecting these types of data in the intertidal and shallow subtidal habitats in Monterey Bay and Channel Islands NMSs. However, these data are not served by PaCOOS. Thus, for each management action, we identified which resources needed characterization and which monitoring programs were directly addressing the management issue (Table 2).

CCE-specific ecosystem assessments incorporating the IEA development framework in use by NOAA should also examine requirements in the context of ecological scales. Reviewing ecosystem assessments at different scales for the CCE allows us to evaluate how existing data and analysis capabilities inform their development and where gaps exist. This report also examines the link between available datasets and management priorities of the five national marine sanctuaries in the California Current Ecosystem. Our goal is to identify the IOOS datasets, as well as other datasets, that could be used in developing IEAs that are relevant in managing resources in the CCE.

## **Ecosystem Assessments in the California Current**

### *Survey of Ecosystem Assessments at Multiple Spatial Scales*

Organizations conduct assessments at scales representing different ecosystem components. These range from ecosystem (CCE scale) to ecosystem region (i.e., Northern CCE), management-unit specific (e.g., a Sanctuary), and sub-management unit (e.g., Monterey Bay). A sanctuary condition report is an example of a management unit-specific ecosystem assessment. Undertaking ecosystem-based management requires knowledge and understanding of the larger ecosystem components of a managed area. There are many ecosystem assessment efforts underway in the CCE, from the local scale to the scale of the entire CCE that make use of observing data (Figure 2). These efforts are interlinked in a hierarchy of scales (Table 3) that allow comparison of drivers, pressures, indicators, and management needs.

Examining ecosystem assessments at multiple scales enables us to frame the context for how observing data are being put to use across the CCE. It is necessary to look at specific examples to understand how existing data are being put to use in ecosystem assessments, where gaps exist, and why those gaps exist.

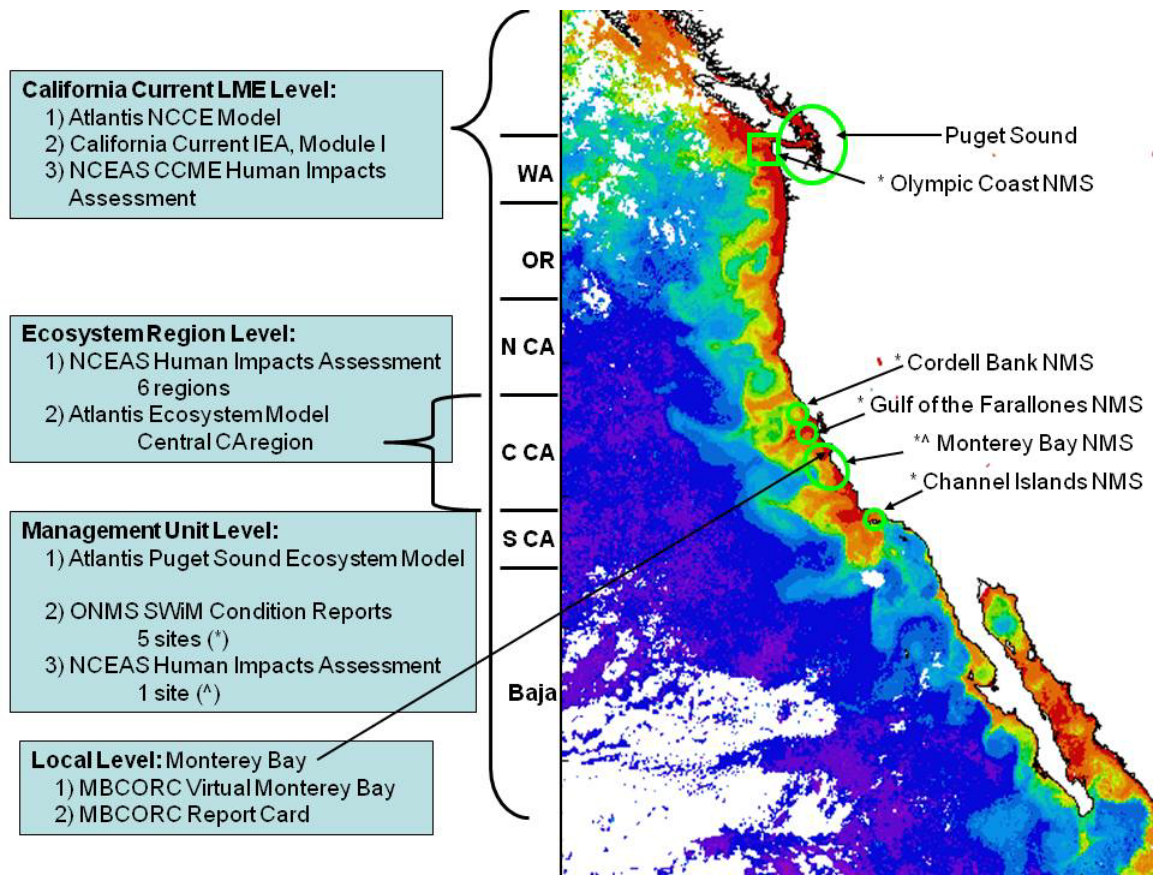


Figure 2 – Selected Ecosystem Assessments in the California Current Ecosystem. See Appendix 2 for background information on each of the ecosystem assessment efforts.

Three ecosystem assessments - the Atlantis model (Brand et al. 2007), Module I (Sydeman and Elliot 2008), and the NCEAS Human Impacts Assessment (Halpern et al 2009) examine the entire California Current Ecosystem. Two of these efforts – the Atlantis model and the NCEAS Human Impact Assessment – also create ecosystem assessments at the ecosystem region and management unit level. Each site in the National Marine Sanctuary system is completing a condition report on the status and trends of managed resources at the site level. Finally, the Monterey Bay Crescent Ocean Research Consortium (MBCORC) has begun efforts to assess the status of the ecosystem at the sub-management unit level through both a report card approach and an ecosystem modeling approach. See Appendix B for a more detailed background of these efforts.

Because these ecosystem assessment efforts differ in both their purpose and geographic scale, there are differences in which drivers are examined, and which indicators are being used to determine ecosystem state (Table 3). We found that each ecosystem assessment effort is using IOOS-related datasets to determine the state of some indicators. However, each of the ecosystem assessments also include datasets that are not integrated into IOOS, which indicates that currently, IOOS datasets are not sufficient to fully meet the data needs of ecosystem assessment efforts in the California Current.

### *Comparing Two Large-scale Ecosystem Assessment*

A more detailed comparison of two ecosystem scale assessments – California Current IEA, Module I (Sydeman and Elliott 2008) and the Northern California Current Ecosystem (NCCE), Atlantis Model (Brand et al. 2007) - illustrates how two ecosystem assessments with different approaches, result in substantial differences in their form and function. (Table 4). Although both the Atlantis model and Module I are focused on an assessment at the California Current Ecosystem scale, they have chosen to employ different approaches and, thus, indicators of ecosystem state.

The goal of California Current IEA Module I is to find a few good, robust indicator datasets that can be used to provide periodic reports on the status of the ecosystem. An additional goal is to identify important changes in ecosystem status and link those to changes in climate and human use drivers. This assessment includes oceanographic indexes and major components of the offshore, pelagic ecosystem such as forage species and top predators. They intend to use these datasets to understand the statistical relationships between the selected indicators and certain pressures to inform management. Based on the indicators that have been selected and the large geographic scale covered by those datasets, this assessment is best suited to drivers and pressures that operate at large spatial scales and those that impact foodweb dynamics, especially top-level vertebrate predators.

In contrast, the NCCE Atlantis is a simulation modeling approach that is spatially explicit and attempts to include as many ecosystem components as possible. Datasets include hydrographic processes, biogeochemical processes, foodweb relationships between multiple functional groups, and human-use patterns, such as harvest. Based on the structure of this model, the Atlantis NCCE can provide more spatial resolution than Module I, though the resolution is limited by how model compartments are established when the model is initialized. Depending on the model structure and datasets used, Atlantis works best for understanding the influence of pressures that impact high biomass, resident, and/or exploited species, such as those found in the middle of the foodweb.

Both Module I and Atlantis have the potential to inform resource management needs, such as those of the Office National Marine Sanctuaries or National Marine Fisheries service. Both assessment approaches can help address characterization and management action needs at large scales. However, the spatial scale of these two models will not be fine enough to address many management needs, such as those of a specific sanctuary site.

Some of the efforts in the CCE have both LME and ecosystem region components. For example, an Atlantis model for the central California ecosystem region is under development. The Atlantis model, which incorporates finer scale data when available, can be useful in addressing more management unit specific or broader regional management needs.

Comparison of the spatial scale of the ecosystem assessments underdevelopment in the CCE helps to illustrate the need to match assessment scale, type, and scope to management need. There needs to be a proper match between the spatial scale of the drivers and pressures that an assessment sets out to address, the data that are used, and the approach for reporting the assessment. Though data may be collected in the CCE on the status and trends of indicators of interest, it may not be collected at a spatial resolution that matches the scale at which the management decision must be made. Identifying the primary indicators for different drivers and pressures and the spatial scale of those management needs is a key step in identifying the observing datasets that are most valuable to the IEA process.

### **Identifying Applicable Observing Data for Drivers and Pressures in the CCE**

To identify the observing datasets that are most useful for IEAs in the CCE, it is important to understand the Drivers and Pressures operating in the ecosystem. A recent study lead by researchers at the National Center for Ecological Analysis and Synthesis (NCEAS) identified and mapped human threats to marine ecosystems in the California Current (Halpern et al. 2009). This study identified the human activities that are potential drivers and pressures on coastal and marine habitats in the CCE and determined the availability of data sets to model the impacts of those drivers. Of the 57 land-based or ocean-based human activities identified in Table 5, CCE-scale observing data were not available for 19 of them. For an additional eight pressures, the authors decided against using the available data because either a comprehensive dataset was not available and the impacts were likely small, or the direction of impacts was not clear (i.e., some positive impacts and some negative impacts) and would be difficult to model.

This study provides a good assessment of the human pressures in the CCE for which data is available for incorporation into an IEA. The available observing data are being combined with information on associated impacts to develop a spatially explicit model of the distribution and magnitude of human threats to marine resources in the CCE. The next step in the DPSIR approach would be to combine this information on the human pressures with observing data on the state of key indicators that will be influence by the pressures threatening the resource. This would allow managers to explore the impact of the pressures and the potential responses of those indicators to management actions that modify human activities. However, because this study is attempting to model pressures for the entire CCE some datasets that only cover a smaller spatial scale were not included. Current and future studies at the sub-regional level (Figure 2) should allow incorporation of those smaller scale datasets and allow further assessment of the variability in the intensity of human pressures at the sub-regional scale.

The drivers and pressures that are important at even smaller spatial scales, such as the ecoregion and local levels, can be examined by looking at ecosystem assessment efforts occurring at these smaller spatial scales (Figure 2). For example, each National Marine Sanctuary is developing, reviewing, and issuing their condition reports. The reports are



part of the ONMS System-Wide Monitoring framework (ONMS 2004). They were developed based on a Pressure-State-Response framework (PSR) that correlates to the (D)PSIR approach. Each report provides a summary of natural and anthropogenic pressures on resources in the focal sanctuary, the current conditions and trends in resources, and management responses to the anthropogenic pressures affecting resources. The PSR framework allows managers to both prioritize management actions and evaluate their effectiveness in meeting conservation or restoration goals.

To identify the current and emerging drivers and pressures at the sanctuary (management unit) scale, we reviewed the pressures section of condition reports from the five sanctuaries in the CCE – Olympic Coast (ONMS 2008), Cordell Bank (ONMS 2009b), Gulf of the Farallones (ONMS draft), Monterey Bay (ONMS 2009c), and Channel Islands (ONMS 2009a) (Table 6). Of the 26 current or emerging pressures identified by one or more sites, nine pressures were common to all sites. These pressures included such activities as harvesting, vessel traffic, oil spills, introduced species, and marine debris. Seven of the pressures were identified by only one or two sites. For example Monterey Bay and Gulf of the Farallones were the only sites to identify dredging/dredge disposal, road construction/landslide disposal, and coastal armoring as human activities that put pressure on sanctuary resources. One or more sites identified six human activities as an emerging pressure. These pressures included aquaculture (both coastal and open ocean based), global climate change, ocean-based energy generation, and bioprospecting.

Although three of the sanctuary sites – Cordell Bank, Gulf of the Farallones, and Monterey Bay – occur in the central California region, there is substantial variability in the pressures identified as important in the site’s condition reports (Table 6). There are a number of potential reasons for this variability. One of the sites, Cordell Bank, is an offshore site so land-based and nearshore human activities will not exert as strong of an influence on the resources in this sanctuary. Also, some inconsistencies may be due to each report being separately authored. For example, the sites differed in the extent to which emerging pressures were discussed in the reports.

Understanding the existing and emerging pressures allows us to frame the need for data to support the analysis of conditions and trends. Condition reports also identify the indicators and observing datasets used by each site to assess the current state of sanctuary resources (Table 7-11). Each site determined the status and trends of resources by responding to a standardized set of questions that covered the resource areas of water quality (4 questions), habitat (4 questions), and living resources (6 questions). Each site used readily available information, including observing datasets, to assess the state of multiple indicators and ultimately identify a status rating (e.g., Good, Fair, Poor) and trend (improving, declining, unchanging) for each question. The summaries provided in Tables 7-11 show a comparison of both the indicators identified by each site to address the fourteen standardized question as well as the information used to determine the state of those indicators.

Some of the datasets used in one or more condition reports are currently part of IOOS. Seafloor mapping data, collected by a variety of programs (e.g., CSUMB, OCNMS,

MBARI, USGS) and available on the PaCOOS West Coast Habitat Portal, were used by each site in the assessment of the abundance of benthic physical habitat. In addition, Monterey Bay and Olympic Coast used kelp canopy monitoring data available through the habitat portal to assess the status of this biogenic habitat. Datasets available on the PaCOOS Data Integration Demonstration website were used by one or more sites to assess the status of various living resource indicators. For example, Monterey Bay used data collected by CIMT on phytoplankton and harmful algal blooms. The Olympic Coast used data collected by COASST on beachcast seabirds. Multiple sites used data from NMFS monitoring programs, such as NWFSC groundfish surveys, NOAA Fisheries cold-water corals, and SWFSC marine mammal surveys. In some cases the PaCOOS Data Integration Demonstration website provides access to subsets of these data.

However, many of the datasets available through IOOS, such as those focused on physical oceanography, were not used in the condition reports. One reason that some IOOS datasets were not used is that most of the standardized questions in the condition reports are focused on subjects for which few data are available through IOOS. Of the four questions focused on water quality, at least two cannot be addressed by oceanographic data alone. For example, indicators of human health risks and indicators of human activity levels were needed to answer questions 3 and 4, respectively. The remaining 10 questions were focused on the conditions of habitats and living resources, subjects for which limited data is currently available through IOOS.

There are a variety of other potential reasons that some IOOS datasets, which were applicable to the standardized questions, were not used in the sanctuary condition reports. Sanctuary sites may not have been aware of the availability of some of the IOOS datasets. The PaCOOS data portals were being developed during the same time the condition reports were being drafted so the authors may not have been aware of the types of data available. Also, even if a site was familiar with the datasets available, that site may not have the time or expertise to access, analyze, or interpret the data. Alternatively, a site may have chosen to use other datasets. For example, a site may have used data collected at the site or local level instead of at the regional level.

Comparison of the indicators and datasets used in the five condition reports reveals that, although the questions were standardized, there was considerable variability in the indicators selected by each site to assess each question. Some of this variability was due to the lack of available observing data at larger spatial scales. For example, site-specific monitoring programs, such as the OCNMS intertidal monitoring program, Center for Integrated Marine Technology (CIMT), and Channel Islands National Park (CINP), collected much of the observing data used to assess the state of living resources.

Additional variability was due to the fact that on-going monitoring programs do not target some of the indicators of interest. For example, there are very few programs monitoring the abundance of contaminants in habitats and little monitoring data available to determine the health of the key species identified in the reports. Due to the lack of monitoring data, sites had to rely on one-time studies, which are often limited in spatial and/or temporal coverage, as a basis for their status assessment. For example, Olympic

Coast and Cordell Bank used one-time studies to assess the abundance of persistent organic contaminants in subtidal habitats. Lastly, when monitoring data and published studies were not available to the sites to evaluate the condition of indicators of interest, the sites had to rely on the professional opinion of local science experts.

### **Obstacles to Management Application of Observing Data**

Developing CCE IEA frameworks requires identifying gaps in existing observing capabilities so as to inform IOOS data and product development. While IOOS product development can initially focus on the five core variables, it will need to include other relevant data sets not yet incorporated into the IOOS system. Table 12 lists the datasets that were used by one or more of the CCE IEA frameworks and identifies the datasets that are currently available through PaCOOS data portals. Figure 3 illustrates which datasets were used by small-scale or large-scale ecosystem assessment efforts and highlights the datasets that were used at both scales. In addition, Figure 3 highlights the datasets available through IOOS, and identifies those that are not currently being used by any ecosystem assessment efforts in the CCE.

We identified six datasets available through PaCOOS that are being used by both large and small-scale ecosystem assessment efforts. The Essential Fish Habitat, NWFSC groundfish survey, SWFSC Upwelling Index, and the California Fish Landing database were used by IEAs at multiple spatial scales. Surprisingly, the CIMT and Monterey Bay Time Series datasets, though limited in spatial scale to the Monterey Bay, was used in ecosystem, management unit and, local ecosystem assessments. An additional eight datasets were used in assessments at both spatial scales, but were not available through IOOS. However, the overwhelming majority of the datasets identified in this analysis were used by either small or large-spatial scale ecosystem assessment efforts.

The limited overlap in the use of datasets at both the large and small-scale is likely due to multiple factors. Probably the most influential factor is the spatial scale over which the data are collected. Many of the datasets used in the LME and ecosystem region levels are collected over a fairly large geographic scale. These datasets provide the wide spatial coverage needed by large-scale IEAs, but may be very limited in the amount of data available for an IEA at the local or management unit level. Therefore, the small-scale IEAs must target datasets with higher density of data points at the small scale, but those studies may have limited utility for large-scale IEAs unless similar data are collected at other sites in the region.

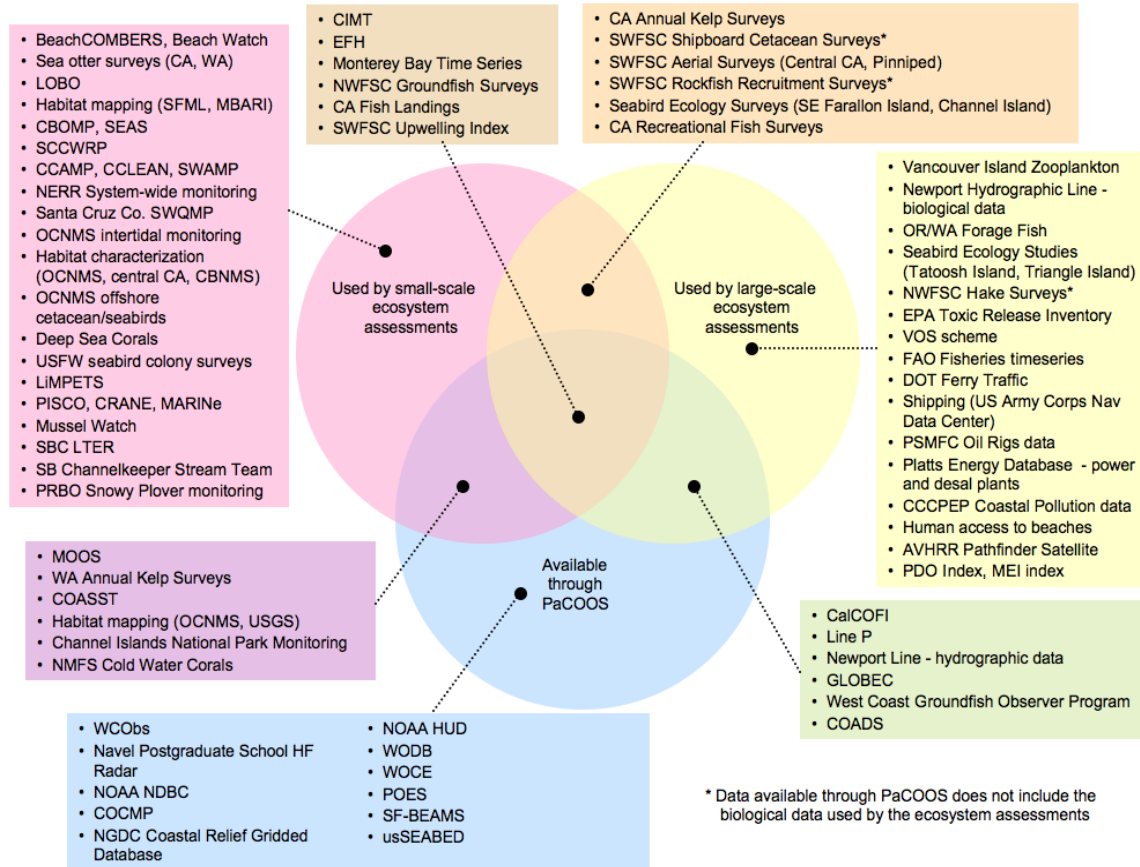


Figure 3. IOOS data as used by small-scale or large-scale ecosystem assessments considering availability through the PaCOOS data portal. At the time of the review, PaCOOS was only hosting oceanographic data and the ecosystem assessments were only using biological data so there was no overlap in the data hosted vs. data used.

There are some examples of datasets being used at both spatial scales (intersection of the pink and yellow circles in Figure 3). Most of these datasets can be used at both large and small scales because they are surveys with wide regional coverage, but fairly high data density at the local level. In addition, these surveys provide the basis for assessments of the status of either fished stocks (e.g., SWFSC rockfish recruitment surveys, CA Recreational Fish Surveys) or sensitive populations (e.g., SWFSC shipboard and aerial surveys) and thus can be a main source of data in any IEA incorporating those assessed species.

In some cases, similar data are collected by two or more studies at the ecosystem region, management unit or, local scale and have the potential to be combined to expand spatial coverage and utility for large-scale IEAs. The Module I large-scale IEA uses data from separate small scale studies occurring over the larger region of interest. For example, it uses hydrographic data collected by Line P in British Columbia, the Newport Hydrographic Line in Oregon, and the CalCOFI surveys in California. Seabird data collected by five different survey efforts are also incorporated into the Module I IEA. Many other datasets currently in use by small scale IEAs appear to have similar potential

for incorporation into larger-scale IEAs. These include annual kelp surveys, sea otter census data, beachcast seabird data (e.g., BeachCOMBERS, Beach Watch, COASST), and rocky intertidal surveys (OCNMS, PISCO, MARINe). Each monitoring effort is likely to have different data collection methods; therefore combining the datasets across larger areas will require a thorough understanding of how the data were collected and what types of intercomparisons are valid.

In some cases data are being collected on indicators of interest at multiple sites, but those datasets have not been integrated into a larger scale monitoring dataset because the monitoring programs at each site are using different methods. For example, beachcast seabirds are monitored in Olympic Coast, Gulf of the Farallones, and Monterey Bay sanctuaries by three separate monitoring efforts, COASST, Beach Watch, and BeachCOMBERS, respectively. Similarly the abundance of sea otters and of kelp canopy is being monitored in both the Monterey Bay and the Olympic Coast sanctuaries, but by separate programs with different methods.

Many of the datasets that are being used by ecosystem assessment efforts are not being hosted by IOOS. Data from many of the NMFS monitoring programs, such as the Newport Hydrographic Line time series, SWFSC Aerial and Shipboard Surveys, and Rockfish Recruitment Surveys, were used by multiple assessment efforts (see Figure 3). However, very few of the data collected by these efforts are currently available through PaCOOS data portals. In two cases (Newport Hydrographic Line and rockfish recruitment surveys) PaCOOS is hosting some oceanographic data, but the biological data, which are the primary data being used by the assessment efforts, are not hosted by PaCOOS data portals.

One very large gap in the data available from IOOS is the level of human activities that impact the marine environment. Although some data on fishing effort (e.g., California Fish Landing database) and impacts on sensitive species (e.g., West Coast Groundfish Observer Program) are available through PaCOOS, not enough data are available to create comprehensive catch reconstructions. This information is crucial for any type of model incorporating fishing activity (I. Kaplan, NMFS-NWFSC, pers. comm.). In addition, no data on the levels of other human activities are hosted. However, data on human activities that are pressures on marine resources in the CCE are available and could be targeted by IOOS. For example, the NCEAS regional ecosystem assessment identified 30 human activity datasets (Table 5). Additional data on the levels of human activities impacting water quality, habitat and living resources is a need identified in all the condition reports from the west coast region. Sydeman and Elliot (2008) also highlighted the need for socio-economic data and other long-term data on human activities in the CCE.

Conversely, many of the datasets available through IOOS were not used by any of the ecosystem assessments identified here (see blue shaded region of Figure 3). For example, much of the data hosted by IOOS could not help answer many of the standardized questions in the ONMS condition reports. Data on contaminants levels in habitats and organisms, such as the data collected by the mussel watch program and by harmful algal

bloom monitoring programs (e.g., ORHAB) are not currently hosted by PaCOOS. Very few data on the state of intertidal and nearshore living resources are available through PaCOOS, although this is a key data need for many management questions and there are a number of monitoring programs collecting the data at the local level and ecosystem region (e.g., PISCO, CRANE, MARINE, CINP, OCNMS intertidal monitoring). In general, biological data for a wide variety of indicator species were needed for the condition reports and very few biological data sets are available through IOOS.

Sydeman and Elliot (2008) discuss a number of gaps in the long-term datasets available for use in regional IEAs. For example the structure of the phytoplankton community (especially the ratio of diatoms to dinoflagellates) appears to be an important index for foodweb development. These data are available in the Monterey Bay region and data collection is commencing in Oregon, but having this type of information available for other locations in the CCE would be extremely valuable. In addition, the authors identify a need for more data collected at the sub-regional and local level. Currently, no single sub-region has the data available for all the physical, chemical, and especially biological indicators required for comprehensive analyses. For a full analysis the ecosystem data has to be combined between regions. However, because there are regional differences within the CCE in climate forcing and ecosystem response, it may prove most useful to evaluate each sub-region separately.

Data on the distribution and abundance of subtidal invertebrates and biogenic habitat was identified as a data gap by the Atlantis NCCE model team (I. Kaplan, NMFS-NWFSC, pers. comm.). Though some data are available through PaCOOS on biogenic habitat (e.g., corals, sponges), the existing data quality is poor relative to the high priority this indicator has for both ONMS and NMFS management needs. The existing Essential Fish Habitat (EFH) data primarily provide kelp and seagrass coverage and sediment type. The best sources of information on the distribution and abundance of structure-forming invertebrates (and the abundance of invertebrates in general) at depths deeper than about 25 meters, are a few scattered studies with limited sample sizes. The Atlantis ecosystem model is focused on groundfish, and one can expect these stocks to be influenced by abundance of invertebrate prey species. Data on the distribution and abundance of benthic invertebrates is a need highlighted in the ONMS condition reports (Table 7-11) and the resources characterization needs outlined in sanctuary management plans (Table 1).

Many other data gaps were identified based on west coast NMS management plans. Though some monitoring data are being collected related to most of the resource characterization (Table 1) and management action needs (Table 2) summarized in the management plans of the five west coast sanctuaries, a very limited amount of that data is currently available through IOOS. Notable gaps include water quality data (e.g., sediment, pathogens, chemical contaminants) and information on most living resources.

## Conclusions

Ecosystem-based management requires closely coupled Integrated Ecosystem Assessments to establish a feedback loop on the conditions in the systems under management. These IEAs require observing data that reflect the pressures and ecosystem indicators of concern to managers. The National Marine Protected Area Federal Advisory Committee (2008) identified this need to build strong links between IOOS capabilities and MPAs to provide the data necessary to support adaptive management. Marine protected areas such as national marine sanctuaries reinforce IOOS ocean observation efforts by serving as reference sites to monitor impacts from human activities. The information reported here provides comprehensive assessment of the relationship between IOOS and ocean management requirements. This report brings together information on multiple ecosystem assessment efforts allowing us to identify how existing IOOS capabilities inform IEAs in CCE, where key gaps exist in data necessary to support IEAs, and priorities for closing the gaps. This review recognized four key barriers to fully exploiting ocean-observing data for ecosystem-based management.

### Data Discovery

Data have been collected from decades of research and monitoring but managers or scientists cannot easily access them. The most common problems are inconsistency in nomenclature over the history of a data set, incomplete data documentation and quality control, and fragmented data access over the life of the data collection. It is also often difficult to identify data collections relevant to a specific management issue, such as ocean acidification or harmful algal blooms, across data holders. These issues are ones where the IOOS program and others such as NOAA's National Coastal Data Development Center (NCDDC) are making rapid progress by creating standards for data documentation, formatting, and exchange.

### Data Access

Bringing existing data into the IOOS system is the primary barrier to access. While in some cases the barrier is primarily one of available resources, there are other factors. There is often a significant lag between data collection and when a principle investigator is willing to make those data available either because of the potential for inappropriate data use or to allow time for their own analysis and publication. The cost and effort of data quality control and assurance is another common barrier. However, cost is not always the problem, access to expertise and computer tools often stymie potential data providers. The data gap is largest in the areas of biological data and data on human activities, the data often most critical to IEAs. There also needs to be a focus on including local data sets that can be highly relevant to specific management actions. For example, it would be useful for data on regional-scale pressures to be collected using the same methods at all locations. Because national programs often prioritize large data sets, multiple data sets at local scales are often overlooked. These are a few of the many cross-organizational issues that are hurdles to incorporating more datasets into IOOS. Solving

data access problems will take a large commitment of funds at the national, regional, and local levels.

### Integrating Disparate Data

Ecosystem analysis is fundamentally impeded by disparities among data sets. Those disparities range from incompatible methods, differences in spatial and temporal scale, and inconsistencies in documentation. Tools that help to match management needs with available data, for example bridging the spatial scale of data and the spatial scale of an ecosystem assessment, can help overcome these disparities. The Southwest Fisheries Science Center Environmental Research Division is developing tools that can have a large impact on how managers access and use data. Joint efforts between model developers and managers, such as the Northwest Fisheries Science Center working with Monterey Bay National Marine Sanctuary to implement the Atlantis model, are also key to useful application of observing data. The Atlantis model being implemented in Central California will allow managers to evaluate alternatives by using predictive scenarios to understand the consequences of actions on ecosystem components and humans. This fills a gap in the IEA process for Sanctuaries identified in Figure 1.

### Closing the Gap Between Data Needs and Data Collection

One of the key challenges to IEA application to ecosystem-based management is the increase in uncertainty the lack of available data creates for managers. Even if there were no barriers to discovering, accessing, and integrating existing data, effectively developing management alternatives and monitoring outcomes requires investments in data collection. In determining the types of data needed to meet the resource characterization and management actions, we found that while some data are hosted by PaCOOS or regional associations, in most cases, the necessary data are not available for all areas. This makes management unit and ecosystem scale analysis difficult.

Analysis of the indicators and datasets used by sanctuaries in the western region provides an opportunity to identify priority datasets for management at the management unit or larger spatial scale. A priority dataset should meet one or more of the following criteria:

- a. Provide the status and trend for one or more indicators related to the questions in the condition report
- b. Help accomplish one or more strategies in management plan action plans
- c. Observing data collected in more than one west coast sanctuary

While it is important to connect ecosystem assessment and observing data to management requirements, not all management challenges are known in advance. Management areas, like sanctuaries, can serve as sentinal sites for detecting, tracking and responding to human-caused and natural changes affecting ocean health. Sentinel sites are places that attract and support collaboration by researchers seeking to understand processes that control ecosystems. This understanding improves our ability to manage the human activities known to affect natural systems, respond to emerging threats, and adapt to changes that are beyond our control. For example, ocean acidification measurements



across all 5 west coast sanctuaries could provide a key indication of changes in ocean chemistry due to atmospheric CO<sub>2</sub> inputs.

IEAs and tools for evaluating management strategies depend upon useful, responsive indicators to address management issues and assess management effectiveness. Those indicators require data with temporal and spatial relevance that allows analyses rich enough to support adaptive management and monitoring of the impacts of management actions and progress towards ecosystem goals. While managers' ability to discover, access, and integrate California Current Ecosystem data is rapidly advancing, significant challenges remain in closing the gap between information needs and data availability and analysis capabilities. Resource managers must make the best decisions possible with available information. This requirement to move forward, even with insufficient data highlights the importance of maximizing the use of what we do have through data management, improved accessibility, improved integration and compatibility, and more comprehensive analysis.

Table 1

Table 1: Resource characterization needs of the five west coast national marine sanctuaries as described in each site's management plan or in the case of Olympic Coast, management plan review documents. (NOAA 2008a, 2008b, 2008c, 2009).

| ID # | Sanctuary          | Resource Characterization Need      | Specific Topics/Questions  | Data Needs  | Ocean Observing Data Available through PaCOOS (Appendix I ID #)   | Ocean Observing Data Not Available through PaCOOS (Appendix I ID #)  | Geographic Scale                                      |
|------|--------------------|-------------------------------------|--|---|---|--|---|
|      |                    | <b>Physical Habitat</b>             |  |   |   |  |   |
| 1    | OC, CB, GF, CI     | Oceanographic Habitat and Processes | Improved characterization of oceanographic and atmospheric conditions including spatial and temporal patterns          | wind speed and direction, current direction and speed, air and water temperature, density, salinity, upwelling, nutrients, dissolved oxygen, PAR              | WCObs (1); CIMT (3); MOOS (6); NPS HF Radar (8); SEAMAP (55); SWFSC Shipboard Cetacean Surveys (60); CoastWatch (64); CalCOFI (65); MBTS Program (66); NOAA NDBC (68); COCOMP (79); | R/V Fulmar and R/V Shearwater data logger (4); MBARI cruise data (11); CDIP/ Wave Rider buoys (14); NEOCO (16); CBOMP (19); TOPP (22); SCCWRP (26); SEAS (28); PnB Project (38); ASOS (52); BML-COS (58); Humboldt Line (69); PRBO At-Sea Surveys (81); Pt. Lobos time series (84) | Large Marine Ecosystem Region, Management Unit, Local |
| 2    | OC, GF, MB         | Coastal Habitat and Processes       | Improved understanding of nearshore circulation patterns. Monitor coastal and estuarine erosion and sediment transport | nearshore current meters, satellite images; current meters in coastal streams and estuaries; erosion rates; turbidity; currents; sediment transport; salinity | WCObs (1); CIMT (3); NPS HF Radar (8); COCOMP (79)  | USGS Stream Gauge Network (5); LOBO (12); CDIP/ Wave Rider buoys (14); NEOCO (16); CCLEAN (31); NERR system monitoring (32); SC Co SWQMP (33); CCoWS (34); PORTS (36); PnB Project (38); coastal LiDAR collection (45); MISO (57); PISCO (59); CI-CORE (75)                        | Management Unit, Local                                |
| 3    | MB                 | Wetlands                            | Wetlands: inventory and assessment   | map of existing coastal wetlands  |   | coastal LiDAR collection (45)  | Ecosystem Region, Management Unit, Local              |
| 4    | OC, CB, GF, MB, CI | Subtidal Benthic Habitat            | Improved characterization of benthic habitat. Improved understanding of spatial distribution of habitats.              | high resolution maps of benthos delineating depth, substrate type, relief, rugosity, etc.   | OCNMS Habitat Mapping (18); EFH (21); USGS Habitat Mapping (47)   | CSUMB-SFML (17); MBARI Monterey Bay Multibeam Survey (20); El Nino coastal erosion study (27); Central CA Habitat Characterization (37); Cordell Bank Habitat Characterization (77)  | Ecosystem Region, Management Unit, Local              |
|      |                    | <b>Water Quality</b>                |  |   |   |  |   |

Table 1

| ID #                           | Sanctuary      | Resource Characterization Need              | Specific Topics/Questions  | Data Needs   | Ocean Observing Data Available through PaCOOS (Appendix I ID #) | Ocean Observing Data Not Available through PaCOOS (Appendix I ID #)  | Geographic Scale                         |
|--------------------------------|----------------|---|--|--|---|--|--|
| 5                              | GF, MB, CI     | Sediment and Nutrients Loads                | Develop integrated water quality monitoring for estuarine and nearshore waters. Assess levels of land-based discharges and impacts on Sanctuary resources. | total suspended sediment/ turbidity, nutrients, chlorophyll/ phytoplankton; fresh water flow rates and inputs  |   | USGS Stream Gauge Network (5); LOBO (12); NEOCO (16); SCCWRP (26); CCAMP (30); CCLEAN (31); NERR system monitoring (32); SC Co SWQMP (33); CCoWS(34); PnB Project (38); SWAMP (41); USGS WQ monitoring (49); First Flush (56); USGS SFBay/Delta (63); SFEI RMP (86); Santa Barbara Channelkeeper Stream Team (93); Snapshot Day(100) | Ecosystem Region, Management Unit, Local |
| 6                              | OC, GF, MB, CI | Pathogens/ Biological Contaminants          | Monitoring of pathogens and biological contaminant loads.  | bacteria, viruses, HABS  |   | San Diego Ocean Monitoring (24); SCCWRP (26); CCAMP (30); CCLEAN (31); SC Co SWQMP (33); SWAMP (41); SFEI RMP (86); Mussel Watch (88); Santa Barbara Channelkeeper Stream Team (93); Snapshot Day (100)  | Ecosystem Region, Management Unit, Local |
| 7                              | OC, GF, MB, CI | Chemical Contaminants                       | Monitoring of chemical contaminant loads.  | heavy metals, organic pollutants   |   | SCCWRP (26); CCAMP (30); CCLEAN (31); EPA CA coastal Project (39); SWAMP (41); SFEI RMP (86); Mussel Watch (88)  | Ecosystem Region, Management Unit, Local |
| 8                              | OC, CB, GF     | Harmful Algal Blooms (HABs)                 | Track phytoplankton populations to detect HABs. Detect presence of biotoxins in Sanctuary waters or organisms.   | bioaccumulation monitoring (mussels, sand crabs, sardine/anchovy); phytoplankton abundance/species composition; bird and mammals stranding                     | CIMT (3); COASST (15)   | BeachCOMBERS (2); LOBO (12); NEOCO (16); CBOMP (19); SEAS (28); CCLEAN (31); PnB Project (38); BeachWatch (54); Mussel Watch (88); MBARI ESP (89); ORHAB (97)  | Ecosystem Region, Management Unit, Local |
| <b>Living Marine Resources</b> |                |   |  |  |   |  |  |
| 9                              | CB, GF, MB, CI | Biogenic Habitat                            | Improved characterization, distribution, and abundance of biogenic habitat including deep-sea corals, kelp beds, seagrass beds                             | Non-destructive sampling methods: video surveys of submerged habitats (reef and soft bottom); aerial surveys of kelp/seagrass to monitor bed location and size | WA Annual Kelp Surveys (9); NWFSC Groundfish Surveys (67)       | CA Annual Kelp Surveys (10); CenCA habitat characterization (37); deep-sea corals (43); SBC LTER (51); PISCO (59); CRANE (76); Habitat Characterization/ Biological Monitoring Cordell Bank (77); Love Lab Surveys (78); MARINe (91)   | Management Unit, Local                   |
| 10                             | OC, GF, MB, CI | Intertidal Habitat (hard bottom); Tidepools | Improved characterization of distribution and abundance of intertidal algae, fish, invertebrates; improved understanding of temporal and spatial patterns  | repeated surveys of intertidal sites; monitoring of recruitment  |   | OCNMS intertidal monitoring (35); LiMPETS (48); PISCO (59); MARINe (91); PRNS Intertidal Monitoring (95)   | Ecosystem Region, Management Unit, Local |

Table 1

| <b>ID #</b> | <b>Sanctuary</b>   | <b>Resource Characterization Need</b>                      | <b>Specific Topics/Questions</b>   | <b>Data Needs</b>  | <b>Ocean Observing Data Available through PaCOOS (Appendix I ID #)</b> | <b>Ocean Observing Data Not Available through PaCOOS (Appendix I ID #)</b>   | <b>Geographic Scale</b>                  |
|-------------|--------------------|--|--|--|--|--|--|
| 11          | MB, CI             | Intertidal Habitat (soft bottom); Beaches and estuaries    | Improved characterization of distribution and abundance of dune plants, invertebrates, shorebirds; improved understanding of temporal and spatial patterns                     | repeated surveys of dunes and surf zone; shorebird surveys; surveys of mudflats and marshes  |  | LiMPETS (48); BeachWatch (54); ESNERR bird monitoring (90); ESNERR elasmobranch monitoring (92); PRBO Snowy Plover monitoring (96); ESNERR invertebrate monitoring (99)  | Ecosystem Region, Management Unit, Local |
| 12          | OC, GF, CB, MB, CI | Subtidal Habitat (hard bottom); Kelp Forests and deep reef | Improved characterization of distribution and abundance of demersal, subtidal fish and invertebrates (hard substrate); improved understanding of temporal and spatial patterns | repeated surveys of subtidal reefs; monitoring of recruitment; movement patterns   | WA annual kelp surveys (9)   | sea otter surveys (7,25); CA annual kelp surveys (10); CDFG/CINP White abalone surveys (40); Deep Sea Corals (43); SBC LTER (51); PISCO (59); REEF Volunteer Surveys (72); CRANE (76); Habitat Characterization/ Biological Monitoring Cordell Bank (77); Love Lab subtidal surveys (78) | Ecosystem Region, Management Unit, Local |
| 13          | OC, GF, CB, MB, CI | Subtidal Habitat (soft bottom)                             | Improved characterization of distribution and abundance of demersal, subtidal fish and invertebrates (soft substrate); improved understanding of temporal and spatial patterns | repeated surveys of subtidal soft bottom habitats including epifauna and infauna; monitoring of recruitment  | NWFSC Groundfish Surveys (67)  | San Diego Ocean Monitoring (24); SCCWRP (26); CenCA habitat characterization (37); MB Cable Survey (62); CCSF Beach and Ocean Monitoring (74); MLML class trawls (98)  | Ecosystem Region, Management Unit, Local |
| 14          | OC, GF, CB, MB, CI | Pelagic Habitat (Invertebrates and Fish)                   | Improved characterization of distribution and abundance of pelagic fishes and invertebrates; improved understanding of temporal and spatial patterns                           | focus on fisheries independent data: net surveys of phytoplankton, larval fish and inverts, nekton (fish and invertebrates); acoustic backscatter surveys of zooplankton and nekton; satellite tagging | CIMT (3); CalCOFI (65); MBTS Program (66)                              | CBOMP (19); TOPP (22); SCCWRP (26); SEAS (28); PISCO (59); Humboldt Line (69); PWCC Surveys (80); PRBO At-Sea Surveys (81); MLML class trawls (98)   | Ecosystem Region, Management Unit, Local |

Table 1

| ID # | Sanctuary          | Resource Characterization Need               | Specific Topics/Questions  | Data Needs   | Ocean Observing Data Available through PaCOOS (Appendix I ID #) | Ocean Observing Data Not Available through PaCOOS (Appendix I ID #)  | Geographic Scale                         |
|------|--------------------|--|--|--|---|--|--|
| 15   | OC, GF, CB, MB, CI | Pelagic Habitat (Seabirds, Turtles, Mammals) | Improved characterization of distribution and abundance of seabirds, turtles, mammals; improved understanding of temporal and spatial patterns | seabird, mammal, marine turtle surveys (aerial, shipboard, land-based, acoustic); satellite tracking; rookery/haulout census | CIMT (3); COASST (15); SEAMAP (55)                              | BeachCOMBERS (2); sea otter surveys (7,25); SPLASH (13); CBOMP (19); TOPP (22); Tracking Black-footed Albatross (23); SEAS (28); OCNMS offshore surveys (42); SAMSAP (44); USFW seabird colony surveys (46); BeachWatch (54); SWFSC Shipboard Cetacean Surveys (60); SWFSC Central CA Aerial surveys (71); PRBO At-Sea Surveys (81); PRNS pinniped monitoring (94); SBC Aerial Surveys (101) | Ecosystem Region, Management Unit, Local |

Table 2

Table 2: Management drivers of the five west coast national marine sanctuaries as described in each site's management plan or in the case of Olympic Coast, a management plan under review. (NOAA 2008a, 2008b, 2008c, 2009).

| Sanctuary                      | Management Topic                | Specific Topics/Questions   | Data Needs   | General Resource Characterization Needs (Table 1 ID#)   | Monitoring Programs Directly Addressing Management Topic (Appendix I ID#)  | Geographic Scale  |
|--------------------------------|---------------------------------|---|--|---|--|---|
| <b>Marine Protected Areas</b>  |                                 |   |  |   |  |   |
| CB, MB, CI                     | Impacts to Physical Habitat     | Detecting impacts of spatial protection to health of the physical habitat inside and outside of MPAs  | habitat mapping, monitoring biogenic habitat (corals, kelp, etc.), structure of sediments; compare changes overtime inside and outside MPAs  | Subtidal benthic habitat mapping (4); Biogenic habitat surveys (9)  |  | Management Unit, Local                                    |
| OC, CB, GF, MB, CI             | Impacts to Biological Resources | Detecting impacts of spatial protection to health of the biological community inside and outside of MPAs. Evaluate spillover effect for harvested populations. Distinguish between natural and anthropogenic changes. | species composition, richness, diversity of intertidal and subtidal communities; size/age structure, abundance, distribution of populations (including harvested species)  | Intertidal habitats (10,11); subtidal benthic habitats (12,13); pelagic habitats (14,15)  | CRANE (76); CINMS marine reserve monitoring program [PISCO (59), REEF Volunteer Survey Project (72), Love Lab surveys (78), PIER Acoustic Telemetry Monitoring (82), CINP] | Management Unit, Local                                    |
| <b>Detecting Human Impacts</b> |                                 |   |  |   |  |   |
| OC, CB, GF, MB                 | Fishing                         | Identifying impacts of fishing on Sanctuary resources. Differentiate between fishing impacts and other human-induced or environmental changes.  | size/age structure, biodiversity, density of benthic and pelagic communities (including biogenic habitat); decreased reproductive output (larval abundance or juvenile recruitment); changes in physical structure of habitat; physical oceanography | Intertidal habitats (10,11); subtidal benthic habitats (12,13); pelagic habitats (14,15); biogenic habitat (9); seafloor mapping (4); oceanographic processes (1) | Olympic Coast cable recovery study   | Large Marine Ecosystem, Ecosystem Region, Management Unit |
| MB                             | Kelp Harvest                    | Monitor impacts to living resources from kelp harvest   | abundance of kelp canopy and associated fish, invertebrates, sea otters; compare areas with harvesting and without harvesting  | kelp canopy surveys (9); kelp forest habitat (12); sea otters (15)  |  | Management Unit, Local                                    |
| OC, GF, MB, CI                 | Tidepools                       | Detecting natural and human-induced changes to rocky intertidal habitat. Evaluating impacts of human activities (e.g., trampling, collecting) to tidepool communities   | Distribution and abundance of sessile and mobile species at accessible vs. non-accessible sites  | rocky intertidal habitat (10)   | Tenera Environmental study (Pt. Pinos)   | Management Unit, Local                                    |

Table 2

| Sanctuary      | Management Topic                      | Specific Topics/Questions  | Data Needs  | General Resource Characterization Needs (Table 1 ID#)   | Monitoring Programs Directly Addressing Management Topic (Appendix I ID#)  | Geographic Scale       |
|----------------|---------------------------------------|--|---|---|--|------------------------|
| OC, MB         | Submerged Cables; Benthic Disturbance | Identifying impacts of submerged cables and other seafloor disturbance to benthic habitats. Identify location of sensitive habitats and species. | Distribution of seafloor habitats, distribution and abundance of sensitive benthic fish and invertebrate species  | seafloor mapping (4); subtidal benthic habitat (12,13)  | Monterey Bay Cable Survey (62); Olympic Coast cable recovery study         | Management Unit, Local |
| MB             | Desalination                          | Monitor long-term impacts of discharge of desalination facilities.   | species composition around discharge; water circulation patterns; salinity  | subtidal soft-bottom community (13); coastal processes (2)  |  | Management Unit, Local |
| MB             | Coastal Armoring                      | Monitor long-term impacts of coastal armoring structures.  | monitor size and slope of beaches; develop sand budgets; nearshore currents, sediment transport, wave refraction patterns; map of existing coastal armoring sites; monitor biological community structure   | coastal habitat and processes (2); intertidal habitat - beaches (11)                                | El Nino coastal erosion study (27)   | Management Unit, Local |
| OC, GF, MB, CI | Introduced Species                    | Detection of new introductions, monitoring populations of existing introduced species.   | distribution and abundances of aquatic plants, algae, benthic fish and invertebrates; surveys to detect and monitor introduced species; maps of current distribution of introduced species; plankton surveys to detect larvae of introduced species | intertidal habitats, especially estuaries (10,11); subtidal habitats (12,13); pelagic habitats (14) | MBNMS <i>Undaria</i> monitoring, ESNERR "least wanted" monitoring program; | Management Unit, Local |

Table 2

| Sanctuary      | Management Topic            | Specific Topics/Questions  | Data Needs   | General Resource Characterization Needs (Table 1 ID#)                            | Monitoring Programs Directly Addressing Management Topic (Appendix I ID#)   | Geographic Scale   |
|----------------|-----------------------------|--|--|--|---|--|
| OC, GF, MB     | Special Status Species      | Improved understanding of population size and trends for special status species (species listed under the federal or state ESA or those designated as overharvested by NMFS) or other sensitive species identified by Sanctuary program. Identification of critical habitats for these species. Identification of causes of mortality. | distribution, abundance and population trends of special status and sensitive species; monitoring of sick, stranded, and dead organisms animals  | intertidal habitats (10,11); subtidal habitats (12,13); pelagic habitats (14,15) | Black Abalone monitoring; BeachCOMBERS (2), BeachWatch (54), COASST(15); most studies listed under "Pelagic habitat characterization - seabirds, turtles, mammals; PRNS pinniped monitoring (94); Xantus's Murrelet, Brown Pelican & Ashy Storm-Petrel nest monitoring (CINMS); Cascadia cetacean monitoring; USFWS Marbled Murrelet surveys; USFWS Common Murre restoration; PRBO Snowy Plover monitoring (96); sea otter necropsies | Large Marine Ecosystem, Ecosystem Region, Management Unit        |
| OC, GF, MB, CI | Wildlife Disturbance        | Disturbance to wildlife from human activities (e.g., marine vessels, low flying aircraft, acoustics): detecting disturbance and identifying sensitive areas, seasons, and migration routes   | bird, mammal, and turtle distributions, movement patterns over time, location and magnitude of disturbance; GIS database of mammal sightings   | pelagic habitats - seabirds, turtles, mammals (15)                               | SEALS program; CIMT passive acoustic monitoring (3); TeamOCEAN; BeachCOMBERS (2), BeachWatch (54), COASST (15)  | Ecosystem Region, Management Unit, Local                         |
| CB, GF, MB     | Entanglement/ Marine Debris | Identify impacts to wildlife from entanglement in active and abandoned fishing gear, aquaculture pens. Identify impacts of other marine debris (e.g., plastic debris). Monitor and inventory marine debris in the Sanctuary.   | location and abundance of beach cast birds, mammals; observer data of entanglement in active fishing gear; GIS database to track type, location, and amounts of debris; bird and mammals surveys | pelagic habitats - seabirds, turtles, mammals (15)                               | BeachCOMBERS (2), BeachWatch (54), COASST (15); Fishery bycatch and mortality (SWFSC); CBOMP (19)   | Large Marine Ecosystem, Ecosystem Region, Management Unit, Local |
| OC, GF, CI     | Oil or Chemical Spill       | Improve spill and drift models.  | surface currents, fine-scale bathymetry, biological productivity   | Oceanographic Habitat and Processes(1); Coastal habitat and Processes(2);        |   | Large Marine Ecosystem, Ecosystem Region, Management Unit        |



Table 2

| Sanctuary                                  | Management Topic  | Specific Topics/Questions  | Data Needs   | General Resource Characterization Needs (Table 1 ID#)  | Monitoring Programs Directly Addressing Management Topic (Appendix I ID#) | Geographic Scale   |
|--|---|--|--|--|---|--|
| OC, GF, MB                                 | Oil or Chemical Spill; Landslide  | Predicting impacts to and tracking recovery of Sanctuary resources.  | intertidal community structure; subtidal community structure; biogenic habitat (e.g., kelp, seagrass); seabird colony size; mammals rookery/haul-out size; seabird, turtle, mammal foraging hotspots | Biogenic habitat (9); intertidal habitat (10,11); subtidal habitat (12,13); pelagic habitats - seabirds, turtles, mammals (15) | BeachCOMBERS (2), BeachWatch (54), COASST(15)                             | Ecosystem Region, Management Unit, Local                         |
| <b>Ecosystem Monitoring and Assessment</b> |   |  |  |  |   |  |
| OC, CB, GF, MB                             | Integrated analysis and synthesis to determine the health of the ecosystem and track changes over time (e.g., SWiM condition reports) | How are the physical and biological resources changing in the ecosystem? How do changes in physical processes affect the distribution and abundance of organisms? How are changing oceanographic conditions affecting productivity and trophic dynamics? | extensive characterization of the physical process and biological resources  | All characterization data sources (1-15)   | CIMT (3); CBOMP (19)  | Large Marine Ecosystem, Ecosystem Region, Management Unit, Local |
| MB   | Integrated Monitoring of Big Sur Coast  | Integrated GIS database for Big Sur coastal and marine resource management   | maps of physical and biological resources along Big Sur coast (updated through "live" portals)   | All characterization data sources (but only data collected along Big Sur Coast)  | WCObs (1); PISCO (59); CRANE (76)   | Management Unit, Local   |

Table 3

Table 3: Description of Ecosystem Assessments in the California Current Ecosystem

| <b>Name</b>  | <b>Purpose</b>  | <b>Geographic Scale</b>  | <b>Output Type</b> | <b>Drivers/ Pressures</b>  | <b>Datasets used that are available through PaCOOS</b>   |
|--|---|--|--------------------|--|--|
| Atlantis Ecosystem Model   | Spatially explicit ecosystem modeling and management strategy evaluation  | California Current Ecosystem;<br>Central California ecosystem region | Dynamic            | Natural and anthropogenic, with emphasis on fisheries-related drivers.                 | GLOBEC, EFH, CalCOFI, NWFSC Groundfish Surveys, West coast groundfish observer program, California Fish Landings   |
| California Current IEA, Module I                                   | Identifying biological indicators of ecosystem state and ocean climate  | California Current Ecosystem; (3 ecosystem regions proposed)         | Static             | Natural and anthropogenic, with emphasis on drivers impacting top vertebrate predators | CIMT, CalCOFI, NWFSC Groundfish Surveys, MBTS?   |
| NCEAS California Current Marine Ecosystem Human Impacts Assessment | Mapping how human activities are affecting marine ecosystems  | California Current Ecosystem; and 6 ecosystem regions                | Static             | Anthropogenic  | Annual Kelp Surveys, EFH, AVHRR Pathfinder Satellite data, California Fish Landings  |
| ONMS SWiM Condition Reports  | Assessing the status and trends of water, habitat, and living resources and the human activities that affect them | 5 management units   | Static             | Natural and anthropogenic  | CIMT, NWFSC Groundfish Surveys, COASST, MBTS, Annual kelp surveys, CSUMB-SFML, USGS Pacific Coast Habitat Mapping Program, MBARI multibeam survey, OCNMS Habitat Mapping |
| MBCORC Report Card   | Assessing ecosystem health using a series of indicators   | 1 local site (Monterey Bay)  | Static             | Natural and anthropogenic, with emphasis on anthropogenic                              | CIMT, NWFSC Groundfish Surveys, MBTS, California Fish Landings   |
| MBCORC Virtual Monterey Bay  | Coastal oceanographic observing and modeling system   | 1 local site (Monterey Bay)  | Dynamic            | Primarily natural  | Not yet available  |

Table 4

Table 4: Comparing two Ecosystem Assessments for the California Current Ecosystem.

| <b>California Current IEA, Module I</b> (Sydeman and Elliott 2008)  | <b>Northern California Current Ecosystem, Atlantis model</b> (Brand et al. 2007)  |
|---|---|
| <p><b>Geographic Range:</b></p> <ul style="list-style-type: none"> <li>• Entire California Current Ecosystem (Vancouver Island, British Columbia, Canada to Punta Eugenia, Baja California Mexico)</li> <li>• Considering creating separate IEAs for the three sub-ecosystems               <ul style="list-style-type: none"> <li>○ Northern: southern B.C. to Cape Blanco, southern Oregon</li> <li>○ Central: Cape Blanco to Pt. Conception</li> <li>○ Southern: Pt. Conception to Punta Eugenia, Baja Mexico</li> </ul> </li> </ul>   | <p><b>Geographic Range:</b></p> <ul style="list-style-type: none"> <li>• Atlantis model has been created for the Northern California Current Ecosystem (Cape Flattery, Washington to Point Conception, California).</li> <li>• In the process of creating separate models for Puget Sound and central California</li> </ul>   |
| <p><b>Drivers/Pressures:</b> The Module I IEA will probably work better for drivers that operate at large spatial scales and/or impact foodweb dynamics, especially top vertebrate predators:</p> <ul style="list-style-type: none"> <li>• Environmental change               <ul style="list-style-type: none"> <li>○ Climate change / climate warming</li> <li>○ ENSO events</li> <li>○ PDO phases</li> <li>○ Ocean acidification (maybe)</li> </ul> </li> <li>• Wildlife disturbance               <ul style="list-style-type: none"> <li>○ Bycatch/ entanglement/ marine debris</li> <li>○ Oil spill</li> <li>○ Harmful Algal Blooms</li> </ul> </li> </ul>   | <p><b>Drivers/Pressures:</b> The Atlantis model will work for drivers that operate at the scale of the boxes in the model and impact large biomass population in the middle of the foodweb. May be able to detect changes in abundance of habitat type (at a large scale) and/or living resources with strong habitat associations:</p> <ul style="list-style-type: none"> <li>• Environmental change</li> <li>• Fishing-related removal of biomass               <ul style="list-style-type: none"> <li>○ Gear-types</li> <li>○ Spatial patterns</li> <li>○ Temporal patterns</li> </ul> </li> <li>• Gear-related impacts to benthic habitat</li> <li>• Bycatch/entanglement (of species with medium to high biomass)</li> <li>• Species introductions (e.g., jumbo squid)</li> </ul>          |
| <p><b>Indicators:</b> This model is currently based on the following indicators:</p> <ul style="list-style-type: none"> <li>• Environmental indices               <ul style="list-style-type: none"> <li>○ Basin-scale PDO index</li> <li>○ Basin-scale ENSO index</li> <li>○ Sub-ecoregion Wind, Upwelling, SST</li> </ul> </li> <li>• Zooplankton               <ul style="list-style-type: none"> <li>○ Copepod species richness and biomass indices (Newport Hydrographic Line)</li> <li>○ Small plankton volume index (CaICOFI data)</li> <li>○ Krill abundance (<i>Thysanoessa spinifera</i>) in diet of fish (Vancouver Island Zooplankton study)</li> <li>○ Krill abundance in diet of Cassin's Auklet (Southeast Farallon Island Seabird Ecology Surveys)</li> </ul> </li> </ul> | <p><b>Indicators:</b> this model is based on the following indicators:</p> <ul style="list-style-type: none"> <li>• Benthic Habitat (from EFH data set)               <ul style="list-style-type: none"> <li>○ Sediment type (hard or soft)</li> <li>○ Kelp and seagrass</li> </ul> </li> <li>• Hydrographic submodel               <ul style="list-style-type: none"> <li>○ Nutrients</li> <li>○ Salinity</li> <li>○ Dissolved oxygen</li> </ul> </li> <li>• Ecology submodel contains 54 biomass pools (species or functional groups)               <ul style="list-style-type: none"> <li>○ Abundance and distribution information</li> <li>○ Growth and consumption rates</li> <li>○ Reproduction rates</li> <li>○ Migration rates</li> <li>○ Predator-prey dynamics</li> </ul> </li> </ul> |

Table 4

| <b>California Current IEA, Module I</b> (Sydeman and Elliott 2008)  | <b>Northern California Current Ecosystem, Atlantis model</b> (Brand et al. 2007)  |
|---|---|
| <ul style="list-style-type: none"> <li>• Squid abundance from fishery landings and diet of CA sea lions</li> <li>• Forage fish               <ul style="list-style-type: none"> <li>○ Anchovy egg abundance (CalCOFI data)</li> <li>○ Sardine egg abundance (CalCOFI data)</li> <li>○ Juvenile rockfish abundance in surveys (Rockfish Recruitment Surveys) and diet of Common Murre (Southeast Farallon Island Seabird Ecology Surveys)</li> </ul> </li> <li>• Vertebrate predators               <ul style="list-style-type: none"> <li>○ Coho salmon survival and juvenile coho growth</li> <li>○ Pacific hake biomass (NWFSC Groundfish Surveys)</li> <li>○ Seabird breeding success (Southeast Farallon Island Seabird Ecology Surveys)</li> <li>○ CA sealion pup abundance (Pinniped Aerial Surveys Project)</li> </ul> </li> </ul> | <p>This model works best for indicators that have:</p> <ul style="list-style-type: none"> <li>• Medium to high biomass               <ul style="list-style-type: none"> <li>○ especially good for species with good information / high volume in fisheries (as bycatch or target species)</li> <li>○ not good for species with small biomass levels</li> </ul> </li> <li>• Good information on feeding habits               <ul style="list-style-type: none"> <li>○ model works well for main predators in the study system</li> </ul> </li> <li>• Good information on spatial distribution;               <ul style="list-style-type: none"> <li>○ model works well for species with widespread distribution in the study area</li> <li>○ model works well for species that spend most of their time in the study area</li> <li>○ Not good for highly migratory species and/or seasonal visitors</li> </ul> </li> </ul> |
| <p><b>ONMS or NMFS management needs</b></p> <ul style="list-style-type: none"> <li>• Characterization of primarily pelagic habitat, species, and foodweb</li> <li>• Special status species management</li> <li>• Wildlife disturbance issues</li> <li>• Offshore Spatial Management (identification of hotspots / pelagic MPAs / areas to avoid for offshore energy production or aquaculture)</li> </ul>   | <p><b>ONMS or NMFS management needs</b></p> <ul style="list-style-type: none"> <li>• Characterization               <ul style="list-style-type: none"> <li>○ pelagic habitat and foodweb especially middle levels of foodweb</li> <li>○ benthic habitat and demersal fishes</li> </ul> </li> <li>• Fisheries management               <ul style="list-style-type: none"> <li>○ Gear changes</li> <li>○ Size limits</li> <li>○ Take restrictions</li> </ul> </li> <li>• Spatial management               <ul style="list-style-type: none"> <li>○ Time-area closures</li> <li>○ Marine protected areas (fewer larger MPAs will be easier to model than many smaller MPAs)</li> </ul> </li> <li>• Special Status Species (those with medium biomass and/or fairly resident in area)</li> </ul>  |

Table 5

Table 5. Human activities that are potential drivers and pressures in the California Current Ecosystem as identified by the National Center for Ecological Analysis and Synthesis (NCEAS) working group (Carrie Kappel, NCEAS, pers. comm.). The availability of ecosystem-wide observing data used to assess the impact of the pressures on ecosystem resources are identified. Authors decided against inclusion of data for some human activities for various reasons, such as too difficult to model with available data and comprehensive dataset not available.

| Human Activities                      | Data Source  | Data Not Available | Decided Against |
|---------------------------------------|--|--------------------|-----------------|
| <b>Land-based</b>                     |  |                    |                 |
| Agriculture                           | National Atlas of Canada   |                    |                 |
| Industrial farms                      | EPA Toxics Release Inventory   |                    |                 |
| Small farms                           |  | X                  |                 |
| Urbanization                          | National Atmospheric Deposition Program  |                    |                 |
| Land infill                           |  | X                  |                 |
| Forestry                              |  | X                  |                 |
| Road building                         |  | X                  |                 |
| Shoreline hardening                   | NOAA's Environmental Sensitivity Index (ESI)   |                    |                 |
| Estuarine mouth alterations           |  | X                  |                 |
| Salt ponds/mines                      |  | X                  |                 |
| Human access to beaches, intertidal   | California Coastal Access Guide; Oregon Geospatial Enterprise Office; Washington State Department of Ecology BEACH Program |                    |                 |
| Atmospheric deposition                | National Atmospheric Deposition Program  |                    |                 |
| Dams                                  | National Inventory of Dams (Army Corps of Engineers)   |                    |                 |
| Sewage outfall/ Septic                | EPA Toxics Release Inventory   |                    |                 |
| Factories                             | EPA Toxics Release Inventory   |                    |                 |
| Paper/ Pulp mills                     | EPA Toxics Release Inventory   |                    |                 |
| Mines                                 | EPA Toxics Release Inventory   |                    |                 |
|                                       |  |                    |                 |
| <b>Ocean-based</b>                    |  |                    |                 |
| Aquaculture                           |  |                    |                 |
| Marine plant                          |  | X                  |                 |
| Shellfish                             |  | X                  |                 |
| Finfish (herbivores)                  |  | X                  |                 |
| Finfish (predators)                   | visually located using Google Earth  |                    |                 |
| Fishing                               |  |                    |                 |
| Demersal destructive                  | California Fish Landings; FAO & Sea Around Us Project  |                    |                 |
| Demersal non-destructive low bycatch  | California Fish Landings; FAO & Sea Around Us Project  |                    |                 |
| Demersal non-destructive high bycatch | California Fish Landings; FAO & Sea Around Us Project  |                    |                 |
| Pelagic low bycatch                   | California Fish Landings; FAO & Sea Around Us Project  |                    |                 |
| Pelagic high bycatch                  | California Fish Landings; FAO & Sea Around Us Project  |                    |                 |
| Aquarium fishing                      |  | X                  |                 |
| Recreational fishing                  | California Recreational Fisheries Survey   |                    |                 |
| Artisanal fishing                     | FAO & Sea Around Us Project  |                    |                 |
| Forestry operations                   |  |                    |                 |
| Log booms, dumps, sorts               |  | X                  |                 |
| Scientific research                   |  |                    |                 |
| Collecting                            |  |                    | X               |
| Experiments                           |  |                    | X               |
| Surveys                               |  |                    | X               |
| Ocean mining                          |  | X                  |                 |

Table 5

| Human Activities                 | Data Source  | Data Not Available | Decided Against |
|----------------------------------|--|--------------------|-----------------|
| Dredging                         |  | X                  |                 |
| Shipping                         |  |                    |                 |
| Commercial shipping traffic      | World Meteorological Organization Voluntary Observing Ships Scheme |                    |                 |
| Cruise ship traffic              |  | X                  |                 |
| Ferry traffic                    | Department of Transportation (California and Washington)           |                    |                 |
| Invasive species (Ports)         | US Army Corps of Engineers Navigation Data Center                  |                    |                 |
| Oil rigs                         | Pacific States Marine Fisheries Commission                         |                    |                 |
| Ocean dumping                    |  |                    |                 |
| Marine debris on beaches         | California Coastal Commission Public Education Program             |                    |                 |
| Toxic materials                  |  | X                  |                 |
| Lost fishing gear                |  | X                  |                 |
| Ship wrecks                      |  |                    | X               |
| Tourism                          |  |                    |                 |
| SCUBA diving                     |  |                    | X               |
| Recreational boating             |  |                    | X               |
| Kayaking                         |  |                    | X               |
| Power or Desalination plants     | Platts database (part of McGraw-Hill Companies)                    |                    |                 |
| Military Activity                |  |                    | X               |
| Harmful Algal Blooms             |  | X                  |                 |
| Hypoxic zones                    |  | X                  |                 |
| Ocean pollution (oil, chemicals) | California Coastal Commission Public Education Program             |                    |                 |
| Climate change                   |  |                    |                 |
| Sea surface temperature          | AVHRR Pathfinder Version 5.0 SST data                              |                    |                 |
| UV radiance                      | GSFC TOMS EP/TOMS satellite program at NASA                        |                    |                 |
| Ocean acidification              | aragonite saturation state (Guinotte et al. 2003)                  |                    |                 |
| Sea level rise                   |  | X                  |                 |

Table 6

Table 6. Drivers and pressures identified in the condition reports for Olympic Coast (OC; ONMS 2008), Cordell Bank (CB; ONMS 2009b), Gulf of the Farallones (GF; ONMS DRAFT), Monterey Bay (MB; ONMS 2009c), and Channel Islands (CI; ONMS 2009a) National Marine Sanctuaries. Grey shading is used to identify the three sanctuaries that occur in the central California sub-region. X = current pressure; E = emerging pressure

| Drivers   | Pressures   | OC | CB | GF | MB | CI | Potential impacts  |
|---|---|----|----|----|----|----|--|
| Seafood consumption; Commerce; Recreational activities  | Harvesting - targeted species   | X  | X  | X  | X  | X  | Population, community, and ecosystem-level impacts from biomass reduction and removal of forage species or predators   |
| Seafood consumption; Commerce; Recreational activities  | Harvesting - bycatch  |    | X  |    | X  | X  | Entanglement in active fishing gear by mammals, birds, turtles; Harvest of non-target fishes and invertebrates   |
| Seafood consumption; Commerce; Recreational activities  | Harvesting - habitat impacts  | X  | X  | X  | X  | X  | Disturbance to seafloor habitat and biogenic habitat from bottom-contact gear; Disturbance of seabirds and mammals from lights   |
| Seafood consumption   | Land-based/Nearshore Aquaculture  | E  |    | X  | X  | E  | introduction of pathogens, chemicals, non-native species; eutrophication and/or harmful algae blooms near enclosures or discharges; disturbance of kelp-associated species from kelp harvest to feed cultured abalone; disturbance to seabed |
| Seafood consumption; Recreational activities; Land-based commerce and development; Maritime trade                       | Marine debris (lost fishing gear, plastics, etc.)                       | X  | X  | X  | X  | X  | Entanglement of habitat, organisms, humans, and vessels; Diminished aesthetic qualities of sanctuary; Ingestion; Transfer of disease, harmful chemicals, non-indigenous species  |
| Maritime trade (vessel traffic, cruise ships, marinas, sunken vessels); Petroleum exploration, production, and refining | Oil and hazardous material spill  | X  | X  | X  | X  | X  | wildlife injury and mortality (seabirds, marine mammals, intertidal communities); habitat degradation (physical and biogenic); fishing closures; water quality; reductions in tourism and local economy                                      |
| Maritime trade; National security (military operations)   | Vessel traffic  | X  | X  | X  | X  | X  | noise pollution (see below); oil or hazardous material spill; lost containers and other large debris; Disturbance to wildlife (e.g., mammals, sharks); Collisions with mammals, turtles  |
| Commerce and development  | Global climate change   | E  | X  | E  | E  | X  | sea level rise, temperature increase, acidification, etc.; changes in species distribution, primary productivity, community composition, etc.  |
| Oceanographic conditions  | Natural shifts in climate: seasonal, annual, and longer-term (ENSO/PDO) | X  | X  | X  |    | X  | shifts in prey availability and distribution; altered body condition, survivorship and reproductive success; shifts in migratory patterns and timing   |
| Maritime trade; Seafood consumption (aquaculture, harvesting); Aquarium trade; Research; Restoration                    | Non-indigenous species  | X  | X  | X  | X  | E  | competing with or preying on native and harvested species; altering species composition; altering ecosystem function; habitat degradation; disrupting commercial and recreational activities; introduction and spread of infectious disease  |

Table 6

| Drivers  | Pressures  | OC | CB | GF | MB | CI | Potential impacts  |
|--|--|----|----|----|----|----|--|
| Maritime trade (marinas); Seafood consumption, Recreational activities                                 | Dredging and dredge material disposal  |    |    | X  | X  |    | physical disturbance to seafloor and benthic organisms; burial of benthic organisms; chemical contamination; turbidity; alteration of water flow and sedimentation and erosion rates |
| Commerce and development   | Coastal armoring   |    |    | X  | X  |    | habitat conversion or loss; alteration of erosion and sediment transport and deposition patterns;  |
| Commerce and development   | Road construction and landslide disposal   |    |    | X  | X  |    | burial of intertidal and subtidal habitat and organisms; increased sand scour  |
| Livestock and agriculture; Forestry; Maritime commerce (marinas and cruise ships); Coastal development | Sediment and nutrient pollution  | X  |    | X  | X  | X  | elevated nutrient levels, sedimentation, turbidity; harmful algal blooms;  |
| Livestock and agriculture; Maritime commerce (marinas and cruise ships); Coastal development           | Chemical pollution (pesticides, oil and grease, heavy metals, detergents, industrial chemicals, radioactive waste) |    | X  | X  | X  | X  | contamination of water, habitat and food chain; health impacts to animals and humans   |
| Livestock and agriculture; Maritime commerce (marinas and cruise ships); Coastal development           | Biological contamination (biotoxins/harmful algal blooms, bacteria, protozoa, viruses)                             | X  | X  | X  | X  | X  | contamination of water, habitat and food chain; health impacts to animals and humans; beach closures   |
| Ecotourism; Research; Seafood consumption; Recreational Activities                                     | Wildlife disturbance - shore-based (tidepoolers, hikers)   | X  |    | X  | X  | X  | trampling; collecting; flushing breeding, foraging, and resting seabirds and mammals;  |
| Ecotourism; Research; Seafood consumption; Recreational Activities                                     | Wildlife disturbance - water-based (whale, bird and shark watching, kayaking, surfing, SCUBA)                      | X  |    | X  | X  | X  | flushing breeding, foraging, and resting seabirds and mammals;   |
| Ecotourism; Research; Coastal commerce; National security (military operations)                        | Wildlife disturbance - aircraft  | X  |    | X  | X  |    | flushing breeding, foraging, and resting seabirds and mammals; collisions with whales, sea otters  |
| National security (military operations); Petroleum exploration; Maritime trade; Research               | Wildlife disturbance: noise pollution/sonar  | X  | X  | X  | X  | X  | altered behavior, injury, or death in marine mammals and fish;   |
| Commerce and development; National security (military operations); Research                            | Submerged cables   | X  |    |    | X  |    | seafloor habitat disturbance; entanglement of anchors, fishing gear and organisms  |
| Commerce and development   | Ocean-based energy generation  | E  |    |    | E  |    | damage to seafloor habitat, disturbance of marine mammals and seabirds   |
| Commerce and development   | Open-Ocean Aquaculture   | E  |    |    | E  | E  | pathogen and nutrient loading, seafloor disturbance, entanglement or other disturbance to wildlife   |
| Commerce and development   | Desalination   |    |    |    | X  |    | brine waste effluent, disturbance to the seafloor; entrainment and impingement of fish and invertebrates   |
| Maritime trade; National Security (military operations); Fishing; Recreational Activities              | Sunken vessels   | X  |    | X  | X  |    | release of hazardous materials (e.g., fuel), entanglement of fishing gear, anchors, etc.   |



Table 6

| Drivers            | Pressures      | OC | CB | GF | MB | CI | Potential impacts  |
|--------------------|----------------|----|----|----|----|----|--|
| Commerce; Research | Bioprospecting |    |    |    |    | E  | excessive removal of marine life or plants; habitat disturbance; alteration to structure or function of the community or local ecosystem |

Table 7

Table 7. Datasets used to assess the current condition of water, habitat, and living resources as identified in the condition report for the Olympic Coast National Marine Sanctuary (ONMS 2008). References listed in this table can be found in the "Cited Resources" section of the OCNMS condition report. Blue Text = lack of information noted in report. Green Text = Project ID # from Appendix 1.

| Questions  | Indicators  | Source  |
|--|---|---|
| <b>Water</b>   |   |   |
| 1) Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality? |   |   |
|  | dissolved oxygen  | oceanography monitoring stations (OCNMS monitoring data); <a href="#">long-term dataset in sanctuary waters lacking</a>   |
|  | dead crabs, fish kills  | reported observations (Quinault Natural Resources Department)   |
|  | seawater acidity (pH), water temperature, current direction and velocity, fluorometry, conductivity | Wootton unpublished data, Grantham et al. 2004, Barth et al. 2007, Chan et al. 2008; oceanography monitoring stations (OCNMS monitoring data)                                   |
|  | HABs/domoic acid levels in razor clams  | monitoring since early 1990s (Washington Department of Fish and Wildlife); <a href="#">long-term dataset not available</a>  |
|  | chemicals in water, sediment and biota at 30 stations in OCNMS                                      | 30 stations sampled as part of EMAP in 2003 (Partridge 2007); long-term monitoring of some chemicals (NOAA's Status and Trends, Mussel Watch Program ( <a href="#">ID 88</a> )) |
| 2) What is the eutrophic condition of sanctuary waters and how is it changing?   |   |   |
|  | nutrient concentrations in coastal waters   | EMAP 2003/Partridge 2007; <a href="#">long-term datasets and sufficient instrumentation are lacking - trend unknown</a>   |
|  | water circulation/nutrients/primary production/HABs   | satellite imagery (temperature, color), buoy data in and near OCNMS; Foreman et al. 2007, MacFadyen et al. 2008   |
| 3) Do sanctuary waters pose risks to human health?   |   |   |
|  | biotoxins (PSP and ASP) in shellfish  | routine monitoring since 1991 (coastal tribes and Washington Department of Health)  |
|  | Harmful Algal Blooms  | monitoring began in the 1990s (Juan de Fuca Eddy Steering Committee 2004; Trainer 2005; Trainer & Suddeson 2005)  |
|  | bacteria (e.g, fecal coliform, <i>E. coli</i> , <i>Enterococcus</i> ) in marine waters              | Washington Department of Health 2008; Surfrider's Blue water task force 2003-05; <a href="#">limited monitoring</a>   |
| 4) What are the levels of human activities that may influence water quality and how are they changing?                       |   |   |
|  | frequency and tracks of vessel traffic  | Canadian vessel traffic system at mouth of Strait of Juan de Fuca; Marine Exchange of Seattle vessel tracking throughout sanctuary  |
|  | timber harvest levels   | general public information; data not researched   |
|  | annual number of cruise ship passengers through the Port of Seattle (2000-2007)                     | WDOE 2008   |
|  | coastal population size and rate of coastal development   | Chamber of Commerce and US Census   |
| <b>Habitats</b>  |   |   |
| 5) What is the abundance and distribution of major habitat types and how is it changing?                                     |   |   |
|  | relative abundance of species and number of trampled organisms in rocky intertidal                  | infrequent monitoring of high and low traffic sites (Erickson and Wullschleger 1998; Erickson 2005)   |
|  | high resolution imaging of seafloor   | Intelmann 2006; Bowlby et al. 2008, unpublished OCNMS data ( <a href="#">ID 18</a> )  |
|  | low resolution mapping surveys  | Intelmann 2006; Bowlby et al. 2008, unpublished OCNMS data ( <a href="#">ID 18</a> )  |

Table 7

| Questions  | Indicators   | Source  |
|--|--|---|
|  | seafloor habitat (impacts of submarine cable installation and bottom contact fishing gear); ROV and video used | periodic monitoring on submarine cable route and benthic surveys (OCNMS data)   |
|  | location and intensity of bottom trawling effort   | Shoji 1999, National Marine Fisheries Service and Washington Department of Fish and Wildlife data   |
|  | groundfish landings  | Shoji 1999; National Marine Fisheries Service data  |
|  | number of vessels in the trawl fishery   | Shoji 1999  |
| 6) What is the condition of biologically-structured habitats and how is it changing?                     |  |   |
|  | abundance and distribution of rocky intertidal macroalgae and invertebrates                                    | monitored since 1989 (Olympic National Park and OCNMS data (ID 35))   |
|  | spatial extent of kelp canopy  | monitored since 1989 (Washington Department of Natural Resources, in collaboration with OCNMS since 1995) (ID 9)  |
|  | distribution and abundance of subtidal structure-forming invertebrates   | NWFSC Groundfish Surveys (ID 67) data since 1980 (Whitmore and Clarke 2007); occasional observations (Etnoyer and Morgan 2003); OCNMS video surveys in limited areas (Brancato et al. 2007 (ID 43)); aerial extent of monitoring data is <a href="#">very limited</a> |
|  | Location of hard substrate with potential to host biologically-structured habitat                              | Essential Fish Habitat (ID 21)  |
| 7) What are the contaminant concentrations in sanctuary habitats and how are they changing?              |  |   |
|  |  | <a href="#">limited data available to determine trends</a>  |
|  | PCBs, DDT, and other chlorinated pesticides  | 30 stations sampled as part of EMAP in 2003 (Partridge 2007)  |
|  | PAHs and metals in the sediment  | Washington State Department of Ecology 1995   |
|  | Silver and chromium in sediments   | Long et al. 1995, O'Connor 2004   |
|  | Chemical concentrations of contaminants in tissues in a variety of invertebrates and sea otters                | NOAA's Status and Trends, Mussel Watch Program (ID 88); EMAP 2003 study; Brancato et al. 2006   |
|  | tar balls on beaches and oil sheens  | noted during monthly beach surveys for dead seabirds (COASST monitoring data (ID 15))   |
|  | deposition of atmospheric contaminants   | some air contaminant monitoring conducted in adjacent freshwater systems  |
| 8) What are the levels of human activities that may influence habitat quality and how are they changing? |  |   |
|  | bottom trawl effort  | WDFW and NMFS data  |
|  | area subject to commercial trawling  | Shoji 1999; National Marine Fisheries Service data  |
|  | visitation rates and locations in Olympic National Park  | on-going monitoring (Olympic National Park data)  |
|  | other intertidal recreational harvesting activities  | haphazard and infrequently monitored  |
|  | trampling and intertidal exploration   | Erickson 2005; not currently monitored  |
|  | razor clam digs (harvesting activity)  | on-going monitoring (Erickson and Wullschleger 1998)  |
|  | amount and location of marine debris on beaches  | annual beach cleanup event since 2000 (OCNMS data)  |
|  | location and type of subtidal derelict fishing gear  | one-time subtidal survey around Cape Flattery (OCNMS data); <a href="#">limited area of survey</a>  |
|  | rates of coastal development, road building, timber harvest  | anecdotal information   |
|  | location and frequency of military operations  | broad area information only; no details on types of operations  |
|  | location and frequency of underwater noise generation  | <a href="#">monitoring data not available</a>   |

Table 7

| Questions   | Indicators  | Source  |
|---|---|---|
|   | location and intensity of vessel traffic  | vessel traffic monitoring (Canadian vessel traffic system; Marine Exchange of Seattle)  |
| <b>Living Resources</b>   |   |   |
| 9) What is the status of biodiversity and how is it changing?                         |   |   |
|   |   | No monitoring of biodiversity except in the intertidal portion of the OCNMS   |
|   | biodiversity in the rocky intertidal  | monitored at sites in ONP since 1989 (Olympic National Park data and OCNMS data (ID 35)); Dethier 1995  |
|   | abundance of harbor seals   | On-going monitoring by WDFW (Jeffries et al. 2003)  |
|   | abundance of sea otters   | on-going collaborative monitoring program (WDFW, USFWS, and OCNMS data (ID 25)); Lance et al. 2004  |
|   | seabird abundance (especially Common Murre, Tufted Puffin, Marbled Murrelet, Cassin's Auklet, Brandt's Cormorant) | monitored during periodic flights and cruises (US Fish and Wildlife Service (ID 46) and OCNMS data (ID 42))   |
|   | abundance of assessed fished stocks   | NMFS /PFMC stock assessments  |
|   | fish species of concern   | no monitoring studies focused on population changes in sanctuary waters   |
|   | abundance and distribution of listed marine bird and mammal species   | some species monitored during periodic flights and cruises (US Fish and Wildlife Service (ID 46) and OCNMS data (ID 42))  |
|   | biodiversity of deep water fish assemblages   | Rogers and Pikitch 1992, Jagielo et al. 2003; very limited monitoring   |
|   | biodiversity in deep water invertebrate communities   | Etnoyer and Morgan 2003, Morgan et al. 2006, Lumsden et al. 2007, Brancato et al. 2007 (ID 43); very limited monitoring   |
| 10) What is the status of environmentally sustainable fishing and how is it changing? |   |   |
|   | abundance of 22 groundfish species managed at the species level   | NMFS/PFMC stock assessments (PFMC 2008a)  |
|   | other groundfish grouping or stock complexes  | assessed and managed in groupings or stock assessments not available or insufficient data available   |
|   | abundance of groundfish species in OCNMS and/or off Washington state  | data collected and available (NWFSC Groundfish Surveys (ID 67)), but not analyzed at this spatial scale   |
|   | Dungeness crab landings and number of license holders   | Washington Department of Fish and Wildlife data   |
|   | pink shrimp landings and number of vessels in fishery   | Washington Department of Fish and Wildlife data   |
|   | Pacific halibut spawning biomass off WA, OR, CA combined  | NMFS 2004   |
|   | landings from ocean troll fishery for salmon off WA   | PFMC 2008b  |
| 11) What is the status of non-indigenous species and how is it changing?              |   |   |
|   | abundance of <i>Sargassum muticum</i>   | ONP and OCNMS observations  |
|   | range expansion of green crab   | collaborative monitoring program (OCNMS and other partners including Canada)  |
|   | intertidal surveys  | OCNMS Rapid Assessment 2001-2002  |
|   | monitoring for invasives  | one-time snapshot in 2005 using settlement plates (deRivera et al. 2005); OCNMS monitoring  |
| 12) What is the status of key species and how is it changing?                         |   |   |
|   | abundance of 5 seabird species of concern   | monitoring along Washington coast (WDFW data; Wahl and Tweit 2000, Manuwal et al. 2001, Warheit and Thompson 2003, Wahl et al. 2005, Raphael 2006; Lance et al. 2008) |

Table 7

| Questions   | Indicators  | Source   |
|---|---|--|
|   | abundance of sea otters                                   | annual census since 1989 (ID 25) (Jameson and Jeffries 2008)   |
|   | abundance of deep sea coral and sponge communities        | OCNMS data primary source (ID 43); aerial extent of monitoring is limited  |
|   | regional abundance of groundfish stocks                   | few stock assessments are completed at the regional level  |
| 13) What is the condition or health of key species and how is it changing?  |   |  |
|   | pathogens and chemical contaminants in sea otters         | Brancato et al. 2006   |
|   | contaminant loads in killer whales                        | Ross et al. 2000, Ross 2006  |
|   | genetic variability in sea otters                         | Larson et al. 2002   |
|   | age structure in rockfish                                 | PFMC 2008a; data not available for all species   |
|   | mortality and reproductive rates of Common Murres         | Parrish et al. 2001, Warheit and Thompson 2003   |
|   | beach-cast seabirds                                       | COASST monitoring data since 1999 (ID 15), Hass and Parrish 2000   |
|   | nesting success in Marbled Murrelets                      | Raphael and Bloxton 2008   |
| 14) What are the levels of human activities that may influence living resource quality and how are they changing? |   |  |
|   | shipping traffic frequency and location/risk of oil spill | vessel traffic monitoring (Canadian vessel traffic system; Marine Exchange of Seattle); Washington Dept. of Ecology data |
|   | location and intensity of fishing activity                | National Marine Fisheries Service and Washington Department of Fish and Wildlife data                                    |

Table 8

Table 8. Datasets used to assess the current condition of water, habitat, and living resources as identified in the condition report for the Cordell Bank National Marine Sanctuary (ONMS 2009b). References listed in this table can be found in the “Cited Resources” section of the CBNMS condition report. Blue Text = lack of information noted in report. Green Text = Project ID # from Appendix 1

| Questions  | Indicators   | Source  |
|--|--|---|
| <b>Water</b>   |  |   |
| 1) Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality? |  |   |
|  | salinity, water temperature, fluorescence chlorophyll-a levels, stratification                             | Cordell Bank Ocean Monitoring Program (CBOMP) monthly cruises (ID 19) unpubl. data  |
|  | satellite-based-SST (AVHRR), chlorophyll-a levels (SeaWiFS) and turbidity (SeaWiFS) assessed for 1997-2004 | Stumpf et al. 2005  |
|  | upwelling index, regional buoy data (not specific to CBNMS)  | Peterson et al. 2006  |
|  | terrestrial-based floating debris and trash  | CBOMP monthly cruises (ID 19) unpubl. data  |
|  | compounds in treated wastewater (e.g., pharmaceuticals, personal care products, household chemicals)       | concern, but no data available  |
| 2) What is the eutrophic condition of sanctuary waters and how is it changing?   |  |   |
|  | monthly chlorophyll-a levels 1997-2008   | 1997-2004 in Stumpf et al. 2005; 2004-present CBOMP monthly cruises (ID 19) unpubl. data  |
|  | chlorophyll-a and presence of HABs   | CBOMP monthly cruises (ID 19) collects samples; samples analyzed by and data available from California Department of Health Services  |
| 3) Do sanctuary waters pose risks to human health?   |  |   |
|  | HABs [dinoflagellate <i>Alexandrium catenella</i> , diatom <i>Pseudonitzschia</i> spp]                     | CBOMP monthly cruises (ID 19) collects samples; samples analyzed by and data available from California Department of Health Services  |
|  | discharges from cruise ships   | concern, but no data available  |
| 4) What are the levels of human activities that may influence water quality and how are they changing?                       |  |   |
|  | Large vessel traffic (1999-2005)   | USCG Automatic Identification System unpubl. data   |
|  | discharges from large vessels and cruise ships   | no data available   |
| <b>Habitats</b>  |  |   |
| 5) What is the abundance and distribution of major habitat types and how is it changing?                                     |  |   |
|  | High resolution backscatter and bathymetry data  | California State University Monterey Bay - Seafloor Mapping Lab (CSUMB-SFML) (ID 17); not enough data to determine trend  |
|  | benthic communities, habitats, derelict fishing gear   | Habitat Characterization and Biological Monitoring of Cordell Bank submersible surveys 2001-2005 (ID 77); CBNMS continental shelf soft bottom community characterization camera sled surveys 2004, 2007 (ID 37)                                       |
| 6) What is the condition of biologically-structured habitats and how is it changing?   |  |   |
|  | benthic communities, habitats; derelict fishing gear   | Habitat Characterization and Biological Monitoring of Cordell Bank submersible surveys 2001-2005 (ID 77); CBNMS continental shelf soft bottom community characterization camera sled surveys 2004, 2007 (ID 37); not enough data to determine a trend |
| 7) What are the contaminant concentrations in sanctuary habitats and how are they changing?                                  |  |   |
|  | contaminants (e.g., DDT, PCB, PAH) in sediments (limited samples from shelf and                            | I. Hartwell, unpublished data   |

Table 8

| Questions  | Indicators   | Source   |
|--|--|--|
|  | slope in CBNMS and Bodega Canyon)  |  |
|  | contaminants in benthic habitats   | Very limited data; further work is needed to understand contaminant levels, transport pathways, and changes in contaminant concentrations over time  |
| 8) What are the levels of human activities that may influence habitat quality and how are they changing? |  |  |
|  | Fishing with bottom-tending fishing gear   | no monitoring data available   |
| <b>Living Resources</b>  |  |  |
| 9) What is the status of biodiversity and how is it changing?  |  |  |
|  | seabird population size, migratory species population size, local breeding colony size, mortality rates and reproductive success rates | shipboard monitoring of seabirds during NMFS rockfish recruitment cruises (data published in Ainley and Hyrenbach 2007), Sydeman et al. 2006   |
|  | marine mammals stock assessments   | Carretta et al. 2007   |
|  | distribution of marine mammal in CBNMS   | CBOMP monthly cruises (ID 19) unpubl. data, PRBO Conservation Science at-sea monitoring unpubl. data (ID 81); Peterson et al. 2006   |
|  | krill abundance  | Peterson et al. 2006; PRBO Conservation Science at-sea monitoring (ID 81), Sydeman et al. 2006, Jahncke et al. 2008  |
|  | Abundance of groundfish stocks   | NMFS/PFMC stock assessments (PFMC 2006)  |
|  | Abundance of pelagic juvenile rockfish   | Peterson et al. 2006; S. Ralston, unpubl. data, SWFSC Rockfish Recruitment Surveys   |
|  | Rockfish fish assemblage   | Baskett et al. 2006; Habitat Characterization and Biological Monitoring of Cordell Bank submersible surveys 2001 - 2005 (ID 77); Anderson et al. 2009  |
|  | reef-top invertebrates shallower than 60 m   | photos from 1970s (Schmieder 1991) and 2005 (ID 77; CBNMS unpubl. data)  |
|  | soft bottom invertebrates  | limited data on continental shelf (CBNMS camera sled surveys 2004, 2007 (ID 37)), no data for continental slope invertebrates  |
|  | pelagic invertebrates (including Humboldt squid)   | Zeidberg and Robison 2007  |
| 10) What is the status of environmentally sustainable fishing and how is it changing?                    |  |  |
|  | impacts of long lines, gillnets and bottom trawls on seafloor habitats and benthic organisms   | based on 20 submersible dives in 2002, CBNMS unpub data (ID 77)  |
| 11) What is the status of non-indigenous species and how is it changing?                                 |  |  |
|  | Abundance of non-indigenous species  | Currently no monitoring data   |
|  | Comprehensive inventory of species within the sanctuary  | Data needed  |
| 12) What is the status of key species and how is it changing?  |  |  |
|  | Cassin's Auklet  | Sydeman et al. 2006, Peterson et al. 2006, Goericke et al. 2007, Ainley and Hyrenbach 2007   |
|  | Black-footed Albatross, Sooty Shearwater   | world-wide trend (Naughton et al. 2007, U.S. Fish and Wildlife Service 2006); local distribution and abundance (Ainley and Hyrenbach 2007, PRBO Conservation Science unpubl. data (ID 81), CBOMP monthly cruises (ID 19) unpubl. data) |
|  | humpback whales, blue whale  | stock-wide trends (Carretta et al. 2007); region-wide distribution changes (Peterson et al. 2006, PRBO Conservation Science unpubl. data (ID 81), CBOMP monthly cruises (ID 19) unpubl. data)  |

Table 8

| Questions   | Indicators  | Source  |
|---|---|---|
|   | Abundance and distribution of California sea lion   | stock-wide trends (Carretta et al. 2007); local patterns (SWFSC Central California Aerial Surveys (ID 71), Lowry and Forney 2005, CBOMP monthly cruises (ID 19) unpubl. data) |
|   | rockfish - abundance trends   | NMFS/PFMC stock assessments   |
|   | species composition patterns  | Anderson et al. 2007  |
|   | krill abundance   | PRBO Conservation Science at-sea monitoring (ID 81), Sydeman et al. 2006, Jahncke et al. 2008   |
|   | reef-top invertebrates shallower than 60 m  | photos from 1970s (Schmieder 1991) and 2005 (ID 77; CBNMS unpubl. data)   |
|   | leatherback turtle stock population trend and local distribution and abundance  | worldwide trends (Spotila et al. 2000); local distribution and abundance (SWFSC Aerial Surveys along the Central California coast (ID 71), Benson et al. 2007)                |
|   | Monthly monitoring of marine mammals and seabirds   | CBOMP monthly cruises (ID 19) unpubl. data  |
| 13) What is the condition or health of key species and how is it changing?  |   |   |
|   | lesions on rockfish   | Okihiro et al. 1992   |
|   | beach cast marine mammals and seabirds linked to HABs   | Scholin et al. 2000, Work et al. 1993   |
|   | poor condition of seabirds, marine mammals and fishes (related to reduced ocean productivity resulting from anomalous conditions) | Sydeman et al. 2006   |
| 14) What are the levels of human activities that may influence living resource quality and how are they changing? |   |   |
|   | landings as indicator of fishing activity   | Scholtz et al. 2005   |
|   | commercial vessels/month  | USCG AIS data   |
|   | marine debris (such as plastics)  | CBOMP monthly cruises (ID 19) unpubl. data; <b>not enough data to determine a trend</b>   |



Table 9

Table 9. Datasets used to assess the current condition of water, habitat, and living resources as identified in the draft condition report for the Gulf of the Farallones National Marine Sanctuary (ONMS draft). References listed in this table can be found in the “Cited Resources” section of the GFNMS condition report. Blue Text = lack of information noted in report. Green Text = Project ID # from Appendix 1

| Questions  | Indicators   | Source   |
|--|--|--|
| <b>Water</b>   |  |  |
| 1) Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality? |  |  |
|  | sedimentation rates, period estero mouths are open vs. closed, salinity (Esteros Americano and de San Antonio) | Gold Ridge Resource Conservation District 2007   |
|  | salinity, sedimentation rates, tidal prism (Bollinas Lagoon)   | State Water Resources Control Board 2006   |
|  | impaired water bodies  | State water board 303(d) listing   |
|  | coliform and bacterial counts at beaches and estuaries   | California Dept. Public Health, State Water Resources Control Board 2006                           |
|  | sedimentation rates and mercury concentration  |  |
|  | area of eelgrass beds  |  |
|  | chronic oil pollution - oily tarballs and oiled birds on shoreline   | BeachWatch monitoring data (ID 54)   |
|  | discharges of dredge spoil from transport barges   | GFNMS enforcement records  |
|  | chemicals (DDT, PAHs, PCBs) in sediments   | Hartwell 2004, 2007, 2008; <b>limited data - not enough data to determine a trend in estuaries</b> |
| 2) What is the eutrophic condition of sanctuary waters and how is it changing?   |  |  |
|  | nutrient concentration, dissolved oxygen, eutrophication, shellfish contamination in Tomales and Bodega bays   | Airamé 2003  |
|  |  | <b>not enough data to determine a trend in eutrophic condition for bays and estuaries</b>          |
|  | precursors of biotoxin-producing phytoplankton in water samples and domoic acid toxicity in shellfish          | 15 years of monitoring data, G. Langlois unpub. data. California Department of Public Health       |
| 3) Do sanctuary waters pose risks to human health?   |  |  |
|  | presence of pathogens in commercial shellfish growing areas  | monitoring since the mid-1980s (California Dept Public Health)                                     |
|  | presence of pathogens in swimming areas  | monitoring for the last 7 years (CA Dept Public Health?)   |
|  | number of shellfish harvesting closures  | California Department of Public Health data  |
|  |  | <b>not enough data to determine a trend in estuaries</b>   |
|  | bacteria counts at beaches, impaired water bodies  | 303(d) list, State Water Resources Control Board 2006  |
|  | DDT, PAHs and PCBs in sediments  | Hartwell 2007, 2008  |
|  | pollutant accumulation in upper trophic level organisms  | <b>a concern, but no data available</b>  |
| 4) What are the levels of human activities that may influence water quality and how are they changing?                       |  |  |
|  | nutrient and sediment loads in runoff from agriculture   |  |

Table 9

| Questions   | Indicators   | Source  |
|---|--|---|
|   | amount of mudflat and diked marshes in Bolinas Lagoon and Tomales Bay  |   |
|   | amount of freshwater diversion   |   |
|   | urbanization/development in watershed  |   |
|   | number of vessel transiting sanctuary  | Harbor Safety Committee of the SF Bay Region 2007   |
|   | discharges of oil - based on number of oiled wildlife and tarballs on outer coast beaches  | Beach Watch monitoring since 1993 (ID 54)   |
| <b>Habitats</b>   |  |   |
| 5) What is the abundance and distribution of major habitat types and how is it changing?    |  |   |
|   | sedimentation rates in estuaries   |   |
|   | change in area of estuarine habitat types, including wetlands, eelgrass beds, marsh  |   |
|   | volume of tidal prism in Bolinas Lagoon  |   |
|   | volume of freshwater input into estuaries  |   |
|   | number of harbor seals at haul-outs  | SEALS monitoring program, Tezak et al. 2004   |
|   | abundance of habitat-forming algae and surfgrass in rocky intertidal   | Tenera 2003, 2004; S. Kimura, pers. comm.   |
|   | shoreline erosion rates (both short-term and long-term)  | Hapke et al. 2006   |
|   | beach width  | Marin County Open Space District 2006   |
|   | beach profile  | BeachWatch photo-documentation monitoring (ID 54)   |
|   | number trawl tracks, sediment topography and structure, infaunal and epifaunal community composition in areas previously trawled | Engel and Kvitek 1998; Lindholm, pers. comm.; deMarignac et al. 2009  |
|   | spills of dredge spoil from barges into GFNMS  | GFNMS data  |
|   | location of radioactive waste  | sidescan and submersible surveys  |
|   | radioactivity levels in sediments and fish   | Suchanek 1988, Lindsay 1992, Jones et al. 2001, Karl 2001; <a href="#">more monitoring is needed</a>                          |
| 6) What is the condition of biologically-structured habitats and how is it changing?        |  |   |
|   | area of eelgrass beds  | California Department of Fish and Game 2001; Gold Ridge Resource Conservation District 2007                                   |
|   | abundance native oyster  | Kimbro and Grosholz 2006  |
|   | distribution and abundance of beach wrack  | Beach Watch (ID 54); <a href="#">trend information not available</a>  |
|   | distribution and abundance drift algae   | Sanctuary Ecosystem Assessment Surveys - Pelagic Habitat (SEAS) (ID 28); <a href="#">not enough data to determine a trend</a> |
|   | impact of trawling on biogenic habitat   | <a href="#">limited data, not enough data to determine a trend for coastal/offshore areas</a>                                 |
| 7) What are the contaminant concentrations in sanctuary habitats and how are they changing? |  |   |
|   |  | <a href="#">limited data available to determine status and trend in estuaries</a>   |
|   | levels of mercury in clams   | Gassell et al. 2004   |
|   | contaminants in marinas and boat-works in Tomales Bay and Bolinas Lagoon   | <a href="#">data needed</a>   |
|   | non-point source discharges of chemicals, metals, and sediments from SF Bay and Russian River                                    | SFPUC 2006  |

Table 9

| Questions  | Indicators  | Source  |
|--|---|---|
|  | concentration of DDT, PAHs, PCBs in sediments   | Hartwell 2007, Hartwell pers. comm.   |
|  | organic pollutants (butyltin, chlordane, DDT, dieldrin, PAHs, and PCB) and metals (As, Cd, Cu, Hg, Ni, Pb, Sn, Zn) in mussels | Mussel Watch Program (ID 88) stations in Tomales and Bodega Bays, Kimbrough et al. 2008 |
|  |   | limited data makes it difficult to determine a status for coastal and offshore habitats |
| 8) What are the levels of human activities that may influence habitat quality and how are they changing? |   |   |
|  | road construction and maintenance activity levels   |   |
|  | boating activity and number of moorings in Tomales Bay  |   |
|  | location and intensity of fishing and mariculture activity  |   |
|  | visitation rates at beaches   |   |
|  | number of vessel transiting sanctuary   | Harbor Safety Committee of the SF Bay Region 2007                                       |
|  | management and enforcement activities to reduce chronic oil pollution from sunken vessels and discharges of oily bilge water  |   |
|  | amount of trawling/area open to trawling  |   |
|  | intensity and frequency of road maintenance and coastal armoring  |   |
| <b>Living Resources</b>  |   |   |
| 9) What is the status of biodiversity and how is it changing?  |   |   |
|  | eelgrass abundance/area   | T. Moore, CDFG, pers. comm.   |
|  | abundance of forage species such as pacific sardine, northern anchovy, pelagic juvenile rockfish                              | SWFSC Rockfish Recruitment surveys (S. Ralston, NMFS-SWFSC, unpubl. data)               |
|  | breeding success of Cassin's Auklets  | Abraham 2007  |
|  | seabird diet composition (krill abundance)  | Edgar 1997  |
|  | abundance of sea otters, sea urchin, kelp; sea urchin fishery   | Paul Peilly, CDFG, pers. comm.  |
|  | abundance of Steller sea lions, northern fur seals  |   |
| 10) What is the status of environmentally sustainable fishing and how is it changing?                    |   |   |
|  | aquaculture of oysters; harvest of clams, herring, rock crab, perch, halibut  | little information available on status of these populations in estuaries                |
|  | local abundance of Common Murre   | Manuwal et al. 2001   |
|  | bycatch of Common Murre, harbor porpoise, sea otters in gillnets  | Manuwal et al. 2001, Forney 1999, Carretta et al. 2005                                  |
|  | recreational fish landings and effort   | California Recreational Fisheries Survey  |
|  | recreational landings of Humboldt squid   | no data available   |
|  | abundance of pelagic juvenile rockfish  | SWFSC Rockfish Recruitment Surveys (S. Ralston, NMFS-SWFSC, unpubl. data, )             |
|  | abundance of overfished rockfish species  | NMFS/PFMC stock assessments   |
|  | number of vessel in the trawl fishery/trawling effort   | California Fisheries Information Systems 2007   |
|  | abundance of 5 abalone species  | Abalone Recovery and Management Plan  |
| 11) What is the status of non-indigenous species and how is it changing?                                 |   |   |
|  | number of non-indigenous species in the estuaries   | Byrnes 2007   |
|  | extent and geographic coverage of non-indigenous species  | very little is known, no data to determine a trend in estuaries                         |
|  | abundance of native gobies  | USFWS 2005  |
|  | abundance and distribution of <i>Spartina alterniflora</i>  |   |

Table 9

| Questions   | Indicators  | Source   |
|---|---|--|
|   | Abundance of green crab and mud snails  |  |
|   | non-indigenous planktonic species   | <a href="#">little data available</a>                                  |
|   | abundance of striped bass   | Bennett, pers. comm.   |
|   | monitoring in rocky intertidal  | <a href="#">limited data</a>   |
| 12) What is the status of key species and how is it changing?   |   |  |
|   | abundance of eelgrass   | <a href="#">limited data</a>   |
|   | abundance of tidewater goby   | USFWS 2005   |
|   | abundance of Brandt   |  |
|   | abundance of other key estuarine species including herring, leopard shark, bat ray, harbor seal, Brandt's Cormorant, Snowy Plover                                     |  |
|   | 10 species of mammal, 9 species of birds, 1 species of reptile, 13 species of fish, 11 species of invertebrates, 5 species of plant                                   |  |
| 13) What is the condition or health of key species and how is it changing?  |   |  |
|   | Mercury levels in fish  |  |
|   | disturbance of harbor seals in Tomales Bay  | Tezak et al. 2005, SEALS monitoring                                    |
|   |   | <a href="#">very little data on condition of key estuarine species</a> |
|   | frequency of domoic acid events   |  |
|   | toxin accumulation in pinniped and seabirds (organochlorines and domoic acid) as an indicator   |  |
|   | gray whale weight   | S. Swartz, pers. comm.   |
|   | seabird condition   |  |
|   | pinniped population size  |  |
| 14) What are the levels of human activities that may influence living resource quality and how are they changing? |   |  |
|   | disturbance of harbor seals (clam digging, kayaking, boating)   | Tezak 2005   |
|   | levels of poaching, boating, anchoring, visitation, trampling, oil spills, illegal discharges, runoff from agricultural and developed lands, upland hydromodification |  |
|   | disturbance at seabird colonies (low flying aircraft, boats, human on foot)   |  |
|   | flushing of waste and ballast water from vessels  |  |
|   | vessel traffic levels   |  |
|   | vessel noise  | <a href="#">no recent data</a>   |
|   | vessel strikes of whales  |  |
|   | impact of lights on crab fishing vessels  | <a href="#">no data</a>  |
|   | frequency of illegal discharges (dredge material, oily bilge water)   |  |
|   | trawling effort   |  |
|   | incidence of oiled of birds and mammals   |  |

Table 10

Table 10. Datasets used to assess the current condition of water, habitat, and living resources as identified in the condition report for the Monterey Bay National Marine Sanctuary (ONMS 2009c). References listed in this table can be found in the “Cited Resources” section of the MBNMS condition report. Blue Text = lack of information noted in report. Green Text = Project ID # from Appendix 1.

| Questions  | Indicators   | Source  |
|--|--|---|
| <b>Water</b>   |  |   |
| 1) Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality? |  |   |
|  | rates of sediment erosion and deposition   | Phillip Williams & Associates 1992; Monismith et al. 2005   |
|  | dissolved oxygen levels  | Beck and Bruland 2000; LOBO (ID 12), Chapin et al. 2004   |
|  | levels of organic matter accumulation  | ESTWPT 2007   |
|  | species distribution related to water quality  | Ritter et al. 2008  |
|  | waterbodies impaired by levels of pathogens, pesticides, sediments, dissolved oxygen, nutrients, heavy metals  | list of impaired waterbodies (SWRCB 2006)   |
|  | levels of nutrients and legacy agricultural pesticides (e.g., DDT)   | ESNERR et al. 2009; Phillips et al. 2002  |
|  | levels of organophosphate pesticides and pyrethroid pesticides in coastal watersheds   | Hunt et al. 2003, Anderson et al. 2006; Phillips et al. 2006  |
|  | EPA Water Quality Index based on levels of dissolved oxygen, dissolved inorganic nitrogen, ortho-phosphate, chlorophyll, and water clarity in water, sediment and tissue samples | CCAMP monitoring program (ID 30); Sigala et al. 2007  |
|  | pollutant concentrations at coastal confluences of watersheds  | Conley et al. 2008  |
|  | concentration of POPs (e.g., PCBs, PAHs, dieldrin, DDT) in rivers that drain to the sanctuary  | CCLEAN monitoring program (ID 31); CCLEAN 2006, 2007  |
|  | concentration of emerging pollutants (e.g., pyrethroid pesticides, fire retardants (PBDEs), pharmaceuticals, and personal hygiene products)                                      | a concern, but little information regarding presence or effects in the environment and no water quality standards have been developed |
|  | concentration of nutrients (e.g., nitrate, orthophosphate, urea) and POPs (e.g., PAHs, PCBs, dieldrin) in water samples  | CCLEAN monitoring program (ID 31); CCLEAN 2007  |
|  | concentration of POPs (e.g., DDT, PCBs, PAHs) in sediments   | Hartwell 2008; CCLEAN monitoring program (ID 31); CCLEAN 2007, 2009   |
|  | cumulative concentration of POPs and abundance of benthic fauna  | CCLEAN monitoring program (ID 31); CCLEAN 2007  |
|  | concentration of POPs in sea otters  | Miller et al. 2007  |
|  | temperature at surface and 60 m, nitrate concentration at 60 m, and chlorophyll concentration at surface, water column stratification 0-20 m                                     | MOOS (ID 6), MBTS Program (ID 66); MBARI 2006, Tanner 2006  |
|  | biomass and taxonomic structure of phytoplankton   | Jester 2008; MBTS Program (ID 66); CIMT HAB monitoring data (ID 3)  |
| 2) What is the eutrophic condition of sanctuary waters and how is it changing?   |  |   |
|  | levels of dissolved oxygen, nutrients  | list of impaired waterbodies (SWRCB 2006)   |
|  | dissolved oxygen, chlorophyll-a, and nitrate concentrations  | Bricker et al. 1999, 2007   |
|  | nitrate levels and turbidity (from phytoplankton biomass, suspended sediments)   | CCAMP (ID 30), Conley et al. 2008; Elkhorn Slough NERR (ID 32), M. Los Huertos, pers. comm.   |
|  | nitrate concentration  | Elkhorn Slough NERR (ID 32); Caffrey 2002; LOBO (ID 12), K. Johnson in prep   |

Table 10

| Questions  | Indicators   | Source   |
|--|--|--|
|  | ecological impacts of eutrophication at Elkhorn Slough   | limited data   |
|  | waterbodies impaired by elevated nutrient levels   | list of impaired waterbodies (SWRCB 2006)  |
|  | nutrient (nitrate, urea, orthophosphate, ammonia) concentration in river discharges and wastewater                   | CCLEAN monitoring program (ID 31); CCLEAN 2006, 2007   |
|  | HABs and freshwater runoff events and nutrient loading   | Kudela and Chavez 2004, Kudela et al. 2008a, 2008b   |
|  | toxins in higher trophic level species   | Fritz et al. 1992, Scholin et al. 2000, Kreuder et al. 2005, Jester 2008   |
|  | concentration of urea  | Cochlan et al. 2008, Anderson et al. 2008  |
|  | HABs caused by nutrient runoffs  | Scholin et al. 2000, Ryan et al. 2008  |
|  | Fluorescence Line Height (FLH) = abundance and health of phytoplankton/red tide indicator                            | Moderate Resolution Imaging Spectrometer (MODIS) aboard the Aqua satellite; J. Ryan, unpublished monitoring data; Ryan et al. 2008 |
|  | frequency, spatial extent, and duration of algal blooms in Monterey Bay  | CIMT monitoring 2002-2006 (ID 3), CIMT 2006, Howarth 2008  |
|  | number of stranded seabirds due to algal bloom   | Beach COMBERS (ID 2); Jessup et al. 2009   |
| 3) Do sanctuary waters pose risks to human health?   |  |  |
|  | levels of pesticides, pathogens  | list of impaired waterbodies (SWRCB 2006)  |
|  | DDT and other pesticides in bivalve tissue   | Phillips et al. 2002   |
|  | levels of heavy metals and POPs in mussels   | NOAA's National Status and Trends' Mussel Watch program (ID 88) (Kimbrough 2008)   |
|  | levels of organophosphate in water and toxicity to small crustaceans   | ESNERR et al. 2009, Hunt et al. 2003, Anderson et al. 2004   |
|  | number of beach warnings and closures  | Rickers and Peters 2006; NOAA 2008a  |
|  | Levels of bacterial contamination at local beaches and in coastal lagoons  | Santa Cruz County Surface Water Quality Monitoring Program (ID 33); Rickers and Peters 2006  |
|  | incidence of illness likely caused by water contact (e.g., earaches, gastrointestinal distress) in beachgoers        | Santa Cruz County Department of Health (Rickers and Peters 2006)   |
|  | estimated loading of <i>E. coli</i> and <i>Enterococcus</i> bacteria to nearshore waters                             | CCLEAN monitoring program (ID 31); CCLEAN 2007   |
|  | concentration of chemical contaminants (e.g., dieldrin, DDT, PAHs, PCBs) in mussel tissue                            | CCLEAN monitoring program (ID 31); CCLEAN 2007   |
|  | Mercury concentration in tissue of fish and shellfish collected from coastal areas                                   | SWAMP (ID 41); SWAMP 2005  |
|  | concentrations of particulate domoic acid and <i>Pseudonitzschia</i> at the Monterey Wharf                           | J. Smith, MLML, unpubl. monitoring data  |
|  | number of shellfish samples with PSP toxin levels above regulatory limits; PSP toxins detected in planktivorous fish | Jester 2008  |
|  | contaminants (DDT, PCBs) in killer whales  | monitoring in Monterey Bay (Black et al. 2003)   |
|  | contaminants (DDT, PCBs) in Black-Footed Albatross   | Finkelstein et al. 2006  |
|  | contaminants (DDT, PCBs) in California sea lion  | Kannan et al. 2004   |
|  | mercury concentration in water and large pelagic fishes  | little monitoring data available   |
|  | biotoxins in planktivorous fishes  | Fritz et al. 1992, Scholin et al. 2000, Jester 2008  |
|  | domoic acid in beached birds and mammals   | Fritz et al. 1992, Scholin et al. 2000; Beach COMBERS data (ID 2)  |
| 4) What are the levels of human activities that may influence water quality and how are they changing? |  |  |

Table 10

| Questions  | Indicators  | Source  |
|--|---|---|
|  | levels of non-point source pollution from agriculture, urbanization and other human activities      | limited data  |
|  | levels of nutrients and legacy organochlorines pesticides in watershed wetlands                     | ESNERR et al. 2009; Phillips et al. 2002  |
|  | levels of organophosphate pesticides in watershed   | Hunt et al. 2003  |
|  | levels of pyrethroid pesticides in watershed sediments  | Anderson et al. 2006; Phillips et al. 2006  |
|  | alteration of sediment and freshwater flows (e.g., construction of levees, diversion of freshwater) | Van Dyke and Wasson 2005  |
|  | changes in water quality in response to management practices to reduce pollution sources            | limited data  |
|  | nutrient loads from heavily cultivated watersheds   | CCLEAN monitoring program (ID 31); CCLEAN 2007; Los Huertos et al. 2003   |
|  | levels of regulation of non-point source contaminants   |   |
|  | level of implementation of better management practices  |   |
|  | sources of bacterial pollution (e.g., condition of sewer systems, stormwater drainage)              | County of Santa Cruz 2006   |
|  | application of nutrient management practices  | Monterey County 2002  |
|  | application of nutrient, pesticide, erosion, and irrigation management practices                    | RWQCB 2007  |
|  | frequency and persistence of algal blooms in Monterey Bay   | CIMT (ID 3)   |
|  | nutrient loading from human activities  | Glibert et al. 1995, CIMT 2006  |
|  | number of deep draft vessels entering San Francisco Bay   | Harbor Safety Committee of the San Francisco Bay Region 2007  |
|  | deposition of oiled seabirds on beaches in MBNMS  | monitored by BeachCOMBERS program (ID 2) since 1997 (Nevins et al. in prep), PRBO monitoring program 1971-1985 (Nevins et al. 2003) |
|  | oil slicks on water surface in MBNMS  | recorded since 2001 during SWFSC Central California aerial surveys (ID 71) (K. Forney, NMFS-SWFSC, unpubl. data)                    |
| <b>Habitats</b>  |   |   |
| 5) What is the abundance and distribution of major habitat types and how is it changing? |   |   |
|  | relative abundance of estuarine habitat types   | Van Dyke and Wasson 2005, ESNERR unpubl. data   |
|  | volume of exported sediment   | Sampey 2006   |
|  | tidal prism volume  | Broenkow and Breaker 2005, Sampey 2006  |
|  | bank erosion rates  | ESNERR Tidal Erosion Monitoring Program, Van Dyke and Wasosn 2005   |
|  | mean cross sectional area of main channel   | Dean 2003, Malzone 1999   |
|  | sediment composition of main channel  | Kvitek et al. 1996  |
|  | abundance and distribution of fishes and invertebrates  | Yoklavich et al. 2002, Lindquist 2008   |
|  | shoreline habitat type  | NOAA-Office of Response and Restoration-Environmental Sensitivity Index (Research Planning Inc. 2006)                               |
|  | rate of change of sandy shoreline habitat   | Hapke et al. 2006   |
|  | percentage of shoreline that is armored   | California Coastal Commission 2005  |
|  | location and impacts of burial of rocky intertidal and subtidal habitats                            | MBNMS Rocky Shores Monitoring Project   |

Table 10

| Questions   | Indicators   | Source  |
|---|--|---|
|   | Erosion at the head of the Monterey Submarine Canyon   | Wong 2006   |
|   | benthic habitat type - low resolution multibeam  | NOS   |
|   | benthic habitat type - med and high resolution multibeam data  | MBARI Monterey Bay Multibeam Survey (ID 20), CSUMB Seafloor Mapping Lab (ID 17), Fugro Pelagos International  |
|   | benthic habitat type - sidescan sonar  | USGS U.S. Pacific Coast habitat mapping program (ID 47)   |
|   | impacts to benthic habitat and associated species by submerged cable   | Kogan et al. 2006   |
|   | abundance of microtopographic structures   | Central California Habitat Characterization (ID 37); deMarignac et al. 2009; Engel and Kvitek 1998  |
|   | trawling gear footprint  | PacFIN trawl logbook data 1997-2007 (from California Department of Fish and Game)   |
| 6) What is the condition of biologically-structured habitats and how is it changing?        |  |   |
|   | abundance and distribution of eelgrass   | MacGinitie 1935; Zimmerman and Caffrey 2002; ESNERR unpubl. data  |
|   | abundance and distribution of native oysters   | MacGinitie 1935; Heiman 2006; Heiman et al. 2008  |
|   | recruitment rates of juvenile oysters  | K. Heiman, unpubl. data   |
|   | abundance and distribution of non-native tubeworm  | Heiman 2006, Heiman et al. 2008   |
|   | abundance and distribution of subtidal structure-forming species   | PISCO (ID 59), CRANE (ID 76), MBNMS rocky shores monitoring programs  |
|   | aerial extent of kelp canopy   | CA Annual Kelp Surveys (ID 10)  |
|   | abundance and distribution of rocky intertidal structure-forming species   | PISCO (ID 59) and MARINe (ID 91) monitoring programs, Pete Raimondi, pers. comm.  |
|   | levels of human visitation and abundance and diversity of intertidal structure-forming species   | Tenera Environmental 2003   |
|   | abundance and distribution of biologically-structured habitats   | limited data available  |
|   | distribution of structure-forming species on the continental shelf, slope and submarine canyons  | MBARI ROV survey data (Jim Barry, unpublished data); NWFSC Groundfish Surveys (ID 67); NMFS 2004; Central California Habitat Characterization (ID 37) |
|   | occurrence of deep-sea corals  | Etnoyer and Morgan 2003, Morgan et al. 2005   |
|   | distribution of cold seep communities  | MBARI ROV surveys of cold seeps (Barry 1996, Paull 2005)  |
|   | species composition on whale falls   | Monitoring of whale falls in Monterey Bay (Goffredi et al. 2004)  |
|   | extent of trawling footprint   | PacFIN trawl logbook data (from California Department of Fish and Game)   |
|   | impacts of trawling and other human activities   | little data available   |
| 7) What are the contaminant concentrations in sanctuary habitats and how are they changing? |  |   |
|   | distribution and concentration of contaminants in Elkhorn Slough and Monterey Bay area   | literature review (Hardin et al. 2007)  |
|   | concentrations of dieldrin, DDT and PCB in mussels from Elkhorn Slough and Moss Landing  | Hardin et al. 2007  |
|   | concentration of DDT and contaminants in Caspian Tern eggs and embryos   | Parkin 1998   |
|   | toxicity of sediments in Moss Landing Harbor to crustaceans  | Anderson et al. 2004  |
|   | concentration of POPS (e.g., PCB, DDT, chlordanes) and metals (e.g., arsenic, mercury, lead) in sediment and tissue samples from harbors | CCAMP monitoring program (ID 30); Sigala et al. 2007  |



Table 10

| Questions   | Indicators  | Source  |
|---|---|---|
|   | concentration of contaminants (e.g., oxychlorane, DDT, PCBs) in sand crabs                                      | Dugan et al. 2005   |
|   | concentration of DDT in mussels   | CCLEAN monitoring program (ID 31); CCLEAN 2006  |
|   | concentration of POPs in stranded sea otters  | California Department of Fish and Game study from 2000-2005 (Miller et al. 2007)              |
|   | concentration of POPs (e.g., DDT, dieldrin, PAH, PCB) in sediment samples from shelf, slope and canyon habitats | CCLEAN monitoring program (ID 31); CCLEAN 2009, Hartwell 2008, Paull et al. 2002              |
|   | impacts of contaminants in sediments on living resources  | limited data available  |
|   | abundance of infaunal species and cumulative concentration of POPs  | CCLEAN monitoring program (ID 31); CCLEAN 2006  |
|   | POPs in demersal fish and invertebrate samples  | Froescheis et al. 2000, Looser et al. 2000  |
| <b>8) What are the levels of human activities that may influence habitat quality and how are they changing?</b> |   |   |
|   | changes in land use practices to decrease inputs from agricultural fields                                       | ESNERR et al. 2009  |
|   | land acquisition for conservation or restoration  | ESNERR et al. 2009  |
|   | acres under cultivation   | ESNERR et al. 2009  |
|   | levels of human visitation at rocky intertidal sites  | Tenera Environmental 2003   |
|   | levels of human harvesting of mussels   | PISCO (ID 59) and MARINE (ID 91) monitoring program, Pete Raimondi, pers. comm.               |
|   | intensity and frequency of coastal armoring activity  |   |
|   | location and volume of sand mining  | PWA 2008  |
|   | volume of kelp harvested from beds in MBNMS   | CDFG Kelp Harvesters Monthly Reports  |
|   | location and intensity of fishing with trawl gear   | PacFIN trawl logbook data 1997-2007 (from California Fish Landings)                           |
|   | installation of submerged cables  | MBNMS submerged cable permitting information  |
|   | impacts of ATOC/Pioneer Seamount cable  | Kogan et al. 2006   |
|   | distribution, abundance and composition of benthic marine debris in Monterey Bay                                | surveyed in 1993-1994 (Watters et al. 2008)   |
|   | distribution and abundance of pelagic marine debris   | no data available   |
| <b>Living Resources</b>   |   |   |
| <b>9) What is the status of biodiversity and how is it changing?</b>  |   |   |
|   | overall native species richness (including plants, algae, fish, birds, invertebrates) and biodiversity          | Caffrey et al. 2002   |
|   | loss of once common invertebrate species  | comparison of historical accounts to recent surveys (summarized in Wasson et al. 2002)        |
|   | biodiversity in benthic invertebrate fauna (including sediment cores)   | Wasson et al. 2002  |
|   | relative abundance of prey organisms in the stomachs of benthic foraging fish                                   | Lindquist 1998  |
|   | relative abundance of clam species  | Oliver et al. unpublished data  |
|   | relative abundance of large fish and mammalian predators  | Yoklavich et al. 2002, Harvey 2002  |
|   | relative abundance and biodiversity of fish   | Yoklavich et al. 1991, Oxman 1995   |
|   | fish assemblages in different habitat types   | Yoklavich et al. 2002   |
|   | biodiversity in the rocky intertidal  | Wasson et al. 2005; PISCO (ID 59) and MARINE (ID 91) monitoring data, P. Raimondi pers. comm. |
|   | composition of intertidal community in relation to black abalone abundance                                      | PISCO (ID 59) and MARINE (ID 91) monitoring data (Miner et al. 2006)                          |

Table 10

| Questions   | Indicators   | Source  |
|---|--|---|
|   | relative abundance of fish species   | Starr et al. 2004, PISCO (ID 59) subtidal monitoring data, M. Carr pers. comm.  |
|   | biodiversity in the rocky subtidal and kelp forest   | PISCO (ID 59) monitoring data   |
|   | relative abundance of shallow subtidal fishes inside and outside marine reserves             | PISCO (ID 59) monitoring data   |
|   | rockfish recruitment levels  | SWFSC rockfish recruitment surveys; PISCO (ID 59) monitoring data   |
|   | species distribution along the coast   | Lonhart and Tupen 2001  |
|   | biodiversity in subtidal soft bottom   | MLML 2006; <a href="#">very limited data</a>  |
|   | abundance of sand crabs  | LiMPETS program data (ID 48), George 2008   |
|   | abundance of marine mammal stocks  | NMFS stock monitoring and assessments (Angliss and Allen 2009, Carretta et al. 2008)                                      |
|   | abundance of locally breeding seabirds   | Goericke et al. 2007; PRBO Conservation Science breeding colony monitoring (including surveys on SE Farallon)             |
|   | abundance of Sooty Shearwater  | Ainley and Hyrenbach, unpubl. seabird data from SWFSC rockfish recruitment surveys  |
|   | abundance of Marbled Murrelets in central California   | Peery et al. 2008   |
|   | relative abundance of groundfishes (e.g., flatfishes, cartilaginous fishes, rockfishes)      | Levin et al. 2006 based on NWFS Groundfish Surveys (ID 67)  |
|   | abundance of jumbo squid   | Field et al. 2007 based on SWFSC rockfish recruitment survey  |
|   | relative abundance of jumbo squid and Pacific hake   | Zeidberg and Robison 2007 based on MBARI ROV mid-water monitoring data  |
|   | composition and distribution of midwater assemblage  | MBARI Midwater Ecology ROV surveys  |
|   | composition and distribution of deep benthic assemblage                                      | MBARI Benthic Ecology ROV surveys   |
| 10) What is the status of environmentally sustainable fishing and how is it changing? |  |   |
|   | levels of take of shellfish and mudflat invertebrates  | Wasson et al. 2002; regulated by CDFG   |
|   | abundance and distribution of elasmobranchs based on catch records from elasmobranch derbies | Carlisle et al. 2007  |
|   | level of recreational hook -and-line fishing   | Yoklavich et al. 2002; <a href="#">limited data available</a>   |
|   | impacts of extraction  | <a href="#">no data available</a>   |
|   | local abundance of large, mobile species in areas open or closed to public access            | PISCO (ID 59) and MARINe (ID 91) monitoring data  |
|   | size frequency of large, mobile species in areas open or closed to public access             | PISCO (ID 59) and MARINe (ID 91) monitoring data, Sagarin et al. 2007   |
|   | levels of poaching of black abalone  | PISCO (ID 59) intertidal monitoring data, Pete Raimondi, pers. comm.  |
|   | abundance of targeted nearshore fish stocks  | stock assessments when available; <a href="#">stock assessments not available for many targeted nearshore fish stocks</a> |
|   | local abundance of targeted species in open and closed areas                                 | PISCO (ID 59) monitoring data; Mason 1998, Paddock and Estes 2000, Dorn 2002, Starr et al. 2004                           |
|   | size frequency of targeted species in open and closed areas                                  | Mason 1998, Paddock and Estes 2000, Dorn 2002, Starr et al. 2004  |
|   | impacts of reduced abundance on community and ecosystem function                             | Berkeley et al. 2004, Palumbi 2004, PISCO 2007; <a href="#">very little information available</a>                         |
|   | market squid landings  | Porzio and Brady 2008   |
|   | direct and indirect impacts of squid harvesting on the ecosystem                             | <a href="#">very little information available</a>   |

Table 10

| Questions  | Indicators   | Source  |
|--|--|---|
|  | population size of assessed groundfish stocks  | groundfish stock assessments (various authors) based in part on NWFSC Groundfish Surveys (ID 67) and SWFSC rockfish recruitment surveys |
|  | average body size of targeted rockfish species   | Steve Ralston, SWFSC, unpublished data based on data available in the California Fish Landings  |
|  | abundance of Pacific hake  | stock assessment (Helser and Martell 2007)  |
|  | population size of sardine and mackerel stocks   | NMFS stock assessments  |
|  | population size of market squid and anchovy stocks   | CDFG/PFMC stock assessments   |
|  | sustainability of Dungeness crab fishery   | Hankin et al. 2004 (no formal population assessment)  |
|  | sustainability of spot prawn fishery   | Larson and Reilly 2008 (no formal population assessment)  |
|  | abundance of benthic invertebrate fauna  | MBARI ROV survey data (Jim Barry, unpublished data)   |
|  | Composition of the fish assemblage on the continental shelf and slope  | Levin et al. 2006 based on NWFSC Groundfish Surveys (ID 67)   |
|  | Fish assemblage composition and relative density of large and small bodied rockfish  | Yoklavich et al. 2000   |
|  | Mean body size of harvested rockfish   | Mason 1998  |
| 11) What is the status of non-indigenous species and how is it changing? |  |   |
|  | number of non-indigenous, cryptogenic, and native invertebrate species in Elkhorn Slough   | Wasson et al. 2005  |
|  | number of non-native fish species in Elkhorn Slough  | Yoklavich et al. 2002   |
|  | relative abundance of native horn snail and Japanese mud snail   | Byers 1999, 2000  |
|  | distribution and abundance of non-native tube worm and associated invertebrate assemblage  | Heiman et al. 2008  |
|  | abundance and distribution of the European green crab  | ESNERR monitoring data  |
|  | presence of non-indigenous species in the rocky intertidal   | one-time surveys (Wasson et al. 2005)   |
|  | presence of non-indigenous species in the sandy and rocky intertidal, and sandy and rocky subtidal   | one-time surveys (Maloney et al. 2006)  |
|  | amount of <i>Undaria pinnatifida</i> removed from Monterey Harbor  | S. Lonhart, MBNMS monitoring data   |
|  | abundance and distribution of Japanese bryozoan <i>Watersipora subtorquata</i> , Asian kelp <i>Sargassum muticum</i> , and red algae <i>Caulacanthus ustulatus</i> | S. Lonhart, MBNMS monitoring program  |
|  | presence of non-indigenous species in infaunal samples   | one-time surveys (Maloney et al. 2006)  |
| 12) What is the status of key species and how is it changing?            |  |   |
|  | status of native oysters   | MacGinitie 1935; Heiman et al. 2008, Heiman 2006; K. Wasson and K. Heiman, pers. comm.  |
|  | status of eelgrass   | MacGinitie 1935; Zimmerman and Caffrey 2002; analysis of aerial photographs (ESNERR unpublished data)                                   |
|  | status of pickleweed salt marsh  | analysis of aerial photographs (ESNERR unpublished data), Zimmerman and Caffrey 2002  |
|  | abundance of non-native species on native biodiversity   | Wasson et al. 2002  |
|  | abundance of black abalone, mussels and structure-forming algae  | PISCO (ID 59) and MARINe (ID 91) monitoring data  |

Table 10

| Questions   | Indicators  | Source   |
|---|---|--|
|   | trampling of algae and invertebrates  | Tenera 2003  |
|   | status of subtidal kelp and sea urchins   | PISCO (ID 59) and CRANE (ID 76), and MBNMS monitoring data   |
|   | abundance of rockfishes, cabezon, lingcod   | stock assessments when available   |
|   | abundance of California sea otter   | California Sea Otter Surveys (ID 7)  |
|   | abundance of Pismo clams  | Kim et al. 2006  |
|   | status of sand dollars  | no available data  |
|   | status of ornate tubeworm <i>Diopatra ornate</i>  | no available data  |
|   | abundance of Sooty Shearwaters  | in Monterey Bay (Adams and Harvey 2006); in central California (Ainley and Hyrenbach, unpubl. seabird data from SWFSC rockfish recruitment surveys)                          |
|   | abundance of marine mammal stocks   | Carretta et al. 2008, Angliss and Allen 2009; based on SWFSC Shipboard Cetacean Surveys (ID 60)  |
|   | Steller sea lion population size  | NMFS stock assessments (Angliss and Allen 2009)  |
|   | Steller sea lion pup counts at Año Nuevo  | SWFSC Pinniped Aerial Surveys, M. Lowry, per. comm.  |
|   | Chinook salmon abundance  |  |
|   | abundance of market squid   | Porzio and Brady 2008  |
|   | relative abundance of phytoplankton groups  | MOOS (ID 6), MBTS Program (ID 66); Pennington et al. 2007  |
| 13) What is the condition or health of key species and how is it changing?  |   |  |
|   | turbidity   | Elkhorn Slough NERR water quality monitoring program (ID 32); M. Los Huertos, pers. comm.  |
|   | levels of contaminants  | Hardin et al. 2007   |
|   | health of key estuarine species   | not being monitored, very little data available  |
|   | trend in abundance of black abalone and incidence of withering syndrome at monitoring sites in central California | PISCO (ID 59) and MARINe (ID 91) intertidal monitoring data; Raimondi et al. 2002  |
|   | trend in abundance of sea otters  | California Sea Otter Surveys (ID 7)  |
|   | cause of death in beach cast southern sea otters  | Kreuder et al. 2003, Tinker et al. 2006  |
|   | POPs in tissues of beach cast sea otters  | Miller et al. 2007   |
|   | incidence of food limitation in southern sea otter population   | Tinker et al. 2006   |
|   | domoic acid poisoning in sea lions  | Scholin et al. 2000  |
|   | deposition of seabirds and mammals on area beaches  | BeachCOMBERS (ID 2) data   |
|   | monitoring of pinnipeds entangled in synthetic materials  | PRBO Conservation Science Monitoring data (Hanni and Pyle 2000)  |
|   | number of stranded pinnipeds injured by entanglement in synthetic materials                                       | Marine Mammal Center data (Goldstein et al. 1999)  |
|   | proportion of seabird carcasses with plastic in stomach   | Beach COMBERS (ID 2) data, Nevins et al. 2005, Zabka et al. 2006, Phillips et al. 2007   |
|   | contaminants in marine mammals, seabirds, and seabird eggs  | Jarman et al. 1996, Calambokidis and Barlow 1991, Black et al. 2003, Krahn et al. 2007, Finkelstein et al. 2006, Pyle 1999; lack of consistent monitoring and long-term data |
| 14) What are the levels of human activities that may influence living resource quality and how are they changing? |   |  |
|   | land use, agriculture and development, in surrounding watershed   |  |

Table 10

| Questions | Indicators   | Source   |
|-----------|--|--|
|           | run-off of nutrients and contaminants from agricultural activities   | Caffrey et al. 2002  |
|           | levels of aquaculture in Elkhorn Slough area   |  |
|           | boating activity in Moss Landing Harbor  |  |
|           | harvest of living resources  | <a href="#">little data available</a>  |
|           | entrainment of fish and invertebrates larvae in power plant intake pipes   | Wasson, pers. comm.  |
|           | human visitation to rocky intertidal   | Tenera 2003, PISCO ( <a href="#">ID 59</a> ) and MARINe ( <a href="#">ID 91</a> ) monitoring data, P. Raimondi pers. comm. |
|           | extraction of rocky intertidal organisms   | PISCO ( <a href="#">ID 59</a> ) and MARINe ( <a href="#">ID 91</a> ) monitoring data, P. Raimondi pers. comm.              |
|           | distribution and intensity of fishing effort   |  |
|           | impacts of landslide-caused burial of intertidal and subtidal organisms  | CRANE ( <a href="#">ID 76</a> ) monitoring data (Carr et al. 2006)   |
|           | activities that impact sandy beach and subtidal: coastal armoring, sand mining, beach grooming, dredge disposal, discharge from outfalls, recreational use |  |
|           | location and intensity of fishing with trawl gear  | PacFIN trawl logbook data 1997-2007 (from California Fish Landings)  |
|           | level of fishing with bottom contact fishing gear  |  |
|           | level of bycatch of sensitive or protected species   | Forney et al. 2001   |
|           | Number of commercial fishermen and fishing vessels   | MLPA 2005, CDFG 2007   |
|           | Total Landings and total value   | MLPA 2005, CDFG 2007   |
|           | volume and composition of trash in storm drains  | California Department of Transportation pilot study (CIWMB 2004)   |
|           | volume and composition of trash on beaches   | U.S. Coastal Cleanup Day   |
|           | length of submerged cables in MBNMS  | MBNMS submerged cable permitting information   |
|           | impacts of ATOC/Pioneer Seamount cable   | Kogan et al. 2006  |
|           | impacts of increasing pH on living resources   | <a href="#">limited data</a>   |
|           | impacts of acoustic pollution on living resources  | NRC 2005; <a href="#">limited data</a>   |

Table 11

Table 11. Datasets used to assess the current condition of water, habitat, and living resources as identified in the condition report for the Channel Islands National Marine Sanctuary (ONMS 2009a). References listed in this table can be found in the "Cited Resources" section of the CINMS condition report. Blue Text = lack of information noted in report. Green Text = Project ID # from Appendix

| Questions  | Indicators  | Source   |
|--|---|--|
| <b>Water</b>   |   |  |
| 1) Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality? |   |  |
|  | satellite images of sediment plumes from mainland rivers  | Otero and Siegel 2004  |
|  | sediment toxicity   | on-going monitoring by SCCWRP Southern California Bight Regional Surveys (ID 26), Bay et al. 2005                |
|  | DDT in sediment   | on-going monitoring by SCCWRP Southern California Bight Regional Surveys (ID 26), Schiff et al. 2006             |
|  | DDT in birds  | Sydeman et al. 2001, on-going monitoring by Channel Islands National Park  |
|  | DDT in fish and other organisms   | Jarvis et al. 2007   |
|  | intensity and length of <i>Pseudo-nitzschia</i> blooms  | Anderson et al. in press, Busse et al. 2006, Schnetzer et al. 2007   |
|  | domoic acid mortality events  | Gulland 2000, Scholin et al. 2000  |
|  | effects of global warming (e.g., sea level rise, changes in ocean chemistry, sea water temperature increases) | Not well understood  |
|  | withering syndrome pathogen in red abalone  | CDFG 2007  |
| 2) What is the eutrophic condition of sanctuary waters and how is it changing?   |   |  |
|  | nutrient input (from mainland streams/rivers)   | On-going monitoring Santa Barbara Coastal Long Term Ecological Research Program (ID 51), McPhee-Shaw et al. 2007 |
|  | amount of nutrient enrichment (from island streams)   |  |
|  | frequency and intensity of harmful diatom blooms  | Anderson et al. in press   |
|  | nutrient inputs and HABs  | Schnetzer et al. 2007  |
| 3) Do sanctuary waters pose risks to human health?   |   |  |
|  | number of human illnesses reported due to shellfish consumption   |  |
|  | concentration of biotoxins in harvested shellfish   | Novelli et al. 1991  |
|  | human fecal pollution in sanctuary waters   |  |
|  | concentration of harmful bacteria (from vessel discharges)  | Santa Barbara ChannelKeeper (ID 93), Altstatt 2007   |
| 4) What are the levels of human activities that may influence water quality and how are they changing?                       |   |  |
|  | number of cargo ship transits   |  |
|  | effects of vessel discharges  | little information available   |
|  | concentration of airborne contaminants from shipping traffic  | little information available   |
|  | contaminants (e.g., DDT) in sediment  | on-going monitoring by SCCWRP Southern California Bight Regional Surveys (ID 26), Schiff et al. 2006             |

Table 11

| Questions  | Indicators   | Source   |
|--|--|--|
|  | abundance of brown pelicans and bald eagles  | Sydeman et al. 2001, Engle 2006, H. Carter personal communication 2007, on-going monitoring by Channel Islands National Park |
|  | satellite images of mainland runoff from agriculture and development                 | Otero and Siegel 2004  |
| <b>Habitats</b>  |  |  |
| 5) What is the abundance and distribution of major habitat types and how is it changing?                 |  |  |
|  | health of deep water habitats  | J. Engle (UCSB) personal communication 2007; <a href="#">not well studied</a>  |
|  | area closed to fishing with bottom-tending gear                                      |  |
|  | impacts of fish traps  |  |
|  | impacts of marine debris   |  |
| 6) What is the condition of biologically-structured habitats and how is it changing?                     |  |  |
|  | abundance of giant kelp and understory habitat-forming algae                         | Channel Islands National Park Kelp Forest Monitoring Program, Behrens and Lafferty 2004, Lafferty 2004                       |
|  | abundance/health of deeper hard-bottom coral communities                             | J. Engle (UCSB) personal communication 2007; <a href="#">not well studied</a>  |
|  | area closed to trawling and trapping   |  |
|  | eelgrass abundance   | on-going monitoring, Engle and Miller 2005   |
|  | frequency of recreational anchoring  |  |
|  | mussel bed thickness, biomass, and community diversity                               | Smith et al. 2006a, Smith et al. 2006b   |
| 7) What are the contaminant concentrations in sanctuary habitats and how are they changing?              |  |  |
|  | DDT concentrations in sediments  | on-going monitoring by SCCWRP Southern California Bight Regional Surveys ( <a href="#">ID 26</a> ), Schiff et al. 2006       |
|  | DDT influence on nesting birds   | Channel Islands National Park on-going monitoring, Sydeman et al. 2001, Engle 2006, H. Carter personal communication 2007    |
|  | area/geographic extent of plumes of suspended sediments                              | Otero and Siegel 2004  |
|  | illegal discharge from vessels   | <a href="#">no data available</a>  |
|  | frequency of vessel groundings   |  |
| 8) What are the levels of human activities that may influence habitat quality and how are they changing? |  |  |
|  | area closed to trawling and trapping activity in the CINMS                           |  |
|  | commercial and sport harvesting of community dominant species (historic and current) |  |
|  | marine debris  | Richards 1993, National Park Service marine debris surveys   |
|  | illegal vessel discharges  |  |
|  | anchoring  |  |
|  | commercial and recreational fishing activities                                       | on-going monitoring, Senyk et al. 2008   |
|  | visitation by non-consumptive users  | on-going monitoring, Senyk et al. 2008   |
|  | enforcement of marine reserves   |  |
|  | public awareness of marine reserve regulations                                       |  |

Table 11

| Questions   | Indicators   | Source  |
|---|--|---|
|   | number of boats/boating disturbance of wildlife  |   |
|   | oil production and transport   |   |
| <b>Living Resources</b>   |  |   |
| 9) What is the status of biodiversity and how is it changing?                         |  |   |
|   | abundance and size structure of key species (e.g., sheephead, kelp bass, rockfishes, shark, swordfish, lobster, abalone)                                     | Channel Islands National Park Kelp Forest Monitoring Program, D. Richards personal communication 2007   |
|   | biodiversity in kelp forest  | Channel Islands National Park Kelp Forest Monitoring Program, D. Kushner personal communication 2007  |
|   | fishing pressure   | Channel Islands National Park monitoring, D. Kushner personal communication 2007  |
|   | abundance of kelp and eelgrass   | Channel Islands National Park Kelp Forest Monitoring Program, J. Altstatt personal communication 2007, Engle personal communication 2007                      |
|   | abundance of urchins and brittle stars   | Channel Islands National Park Kelp Forest Monitoring Program, J. Altstatt 2005, J. Altstatt personal communication 2007, J. Engle personal communication 2007 |
|   | biodiversity (in areas dominated by brittle stars)   | J. Altstatt personal communication 2007   |
|   | abundance and diversity of mussel bed communities  | Smith et al. 2006a, Smith et al. 2006b  |
| 10) What is the status of environmentally sustainable fishing and how is it changing? |  |   |
|   | location and intensity of gill netting   |   |
|   | ghost fishing by lobster and fish traps  |   |
|   | abundance of sea otter, sharks, giant sea bass, swordfish, rockfishes, abalone   | on-going monitoring by CDFG, Leet et al. 2001, Rogers-Bennet et al. 2004  |
|   | size structure of red sea urchin, sheephead  | Channel Islands National Park Kelp Forest Monitoring Program, D. Richards personal communication 2007   |
|   | relative abundance of lobster, urchin, kelp  | Channel Islands National Park Kelp Forest Monitoring Program, Behrens and Lafferty 2004   |
|   | abundance and distribution of anchovy and sardine (as prey for Brown Pelican)  |   |
|   | bycatch rates of cormorants and alcids in gill nets  |   |
|   | bycatch rates of pelicans in recreations fishing gear  |   |
|   | rates of avian predation, nest abandonments, and collisions with lighted structures and vessels due to light pollution                                       |   |
|   |  | significant gaps in our knowledge of fishery effects and basic life history that impede management  |
| 11) What is the status of non-indigenous species and how is it changing?              |  |   |
|   | abundance and distribution of several algal species (including <i>Undaria pinnatifida</i> , <i>Sargassum filicinum</i> , and <i>Caulacanthus ustulatus</i> ) | on-going monitoring, Miller et al. 2006   |
| 12) What is the status of key species and how is it changing?                         |  |   |
|   | relative abundance of echinoderms, kelp, lobster, and fishes (e.g., sheephead and rockfishes)  | Channel Islands National Park Kelp Forest Monitoring Program, Lafferty and Kushner 2000, Lafferty 2004, D. Kushner personal communication 2007                |



Table 11

| Questions   | Indicators   | Source  |
|---|--|---|
|   | giant seabass abundance  | Leet et al. 2001  |
|   | distribution and abundance of giant kelp                       | Channel Islands National Park Kelp Forest Monitoring Program, Lafferty and Behrens 2004               |
|   | abundance of red abalone                                       |   |
|   | abundance of sea otters  |   |
|   | abundance of Brown Pelicans                                    |   |
|   | abundance of Peregrine Falcons                                 |   |
|   | abundance of Bald Eagles                                       |   |
|   | abundance of Brandt's Cormorant                                | on-going monitoring, Capitolo et al. 2004 unpublished data, as reported in CINMS Biogeographic Report |
|   | abundance of cormorant   |   |
|   | abundance of Cassin's Auklet                                   | on-going monitoring, Carter et al. 2007   |
|   | abundance of Xantus's Murrelets                                | on-going monitoring, Whitworth et al. 2006  |
|   | abundance of Ashy Storm-Petrels                                | on-going monitoring, Wolf 2007  |
|   | abundance of Tufted Puffins                                    |   |
|   | abundance of fin whale, humpback whale, gray whale             | on-going monitoring, J. Calambokidis personal communication 2007                                      |
|   | abundance of blue whales                                       | on-going monitoring including Shipboard Cetacean Survey (ID 60), Barlow and Forney 2007               |
| 13) What is the condition or health of key species and how is it changing?  |  |   |
|   | withering syndrome disease in red abalone                      | CDFG 2007   |
|   | abundance of black abalone and incidence of disease            |   |
|   | diseases in echinoderms  |   |
|   | size structure of spiny lobster                                | on-going monitoring, CINP unpublished data, D. Kushner personal communication 2007                    |
|   | abundance and size structure of sheephead and kelp bass        | on-going monitoring, D. Kushner personal communication 2007   |
|   | nest failure rates of Cassin's Auklet                          | on-going monitoring, Carter et al 2007  |
|   | timing of nesting of Xantus's Murrelets                        | on-going monitoring, Whitworth et al 2006   |
|   | nesting rates of Ashy Storm-Petrels                            | on-going monitoring, Carter et al 2007  |
| 14) What are the levels of human activities that may influence living resource quality and how are they changing? |  |   |
|   | extraction rates for exploited species                         |   |
|   | number of recreational kayaker                                 |   |
|   | trampling rates of nests and intertidal animals                |   |
|   | amount of recreational boating/anchoring                       |   |
|   | amount of shipping traffic                                     |   |
|   | runoff/storm events on mainland - pollutants and marine debris |   |

Table 12

Table 12. Observing datasets that are being used by one or more of the on-going ecosystem assessment efforts in the California Current Ecosystem. Datasets that are currently hosted by PaCOOS (<http://www.pacoos.org/DataMgt.htm>) are indicated. A project identification number is provided for observing datasets identified by the West Coast Sanctuary Data Inventory project (see Appendix I).

| Project Name   | Project Description  | Available though PaCOOS | ONMS SWiM Condition Reports | Module I, CCE IEA | Atlantis NCCE model | NCEAS CCME Human Impact Assessment | MBCO RC Report Card | ID # |
|--|--|-------------------------|-----------------------------|-------------------|---------------------|------------------------------------|---------------------|------|
| West Coast Observatories (WCObs)                               | WCObs deals with oceanographic data collected at the five west coast sanctuaries. The project began in 2004 and focuses on various data streams collected at instrument moorings.  | X                       |                             |                   |                     |                                    |                     | 1    |
| Beach COMBERS  | Beach COMBERS (Coastal Ocean Marine Mammal & Bird Education and Research Surveys) uses volunteers to survey beached marine birds and mammals monthly at selected beach segments in central and southern portions of Monterey Bay sanctuary.  |                         | MB                          |                   |                     |                                    | X                   | 2    |
| Center for Integrated Marine Technologies (CIMT)               | CIMT simultaneously collected data on physical, chemical, and biological (from phytoplankton to marine mammals) via moorings, shipboard surveys, apex predator tagging and tracking, and satellite, aircraft, and land-based remote sensing in Monterey Bay from 2002-2007 and was built on a foundation of data collection initiated in 1997. | CTD & Chloro only       | MB                          | X                 |                     |                                    | X                   | 3    |
| MBARI Ocean Observing System (MOOS)                            | Since 1989 Monterey Bay Aquarium Research Institute (MBARI) has operated a mooring observing system in Monterey Bay.   | X                       | MB                          |                   |                     |                                    | X                   | 6    |
| California Sea Otter Survey                                    | Bi-annual aerial and land-based standardized surveys of Southern sea otters have been conducted in California (from Santa Barbara to Half Moon Bay) during late spring and early fall since 1983.  |                         | MB                          |                   |                     |                                    | X                   | 7    |
| Naval Postgraduate School HF Radar                             | HF radar hardware and software have allowed examination of circulation in Monterey Bay since 1994.   | X                       |                             |                   |                     |                                    |                     | 8    |
| WA Annual Kelp Surveys   | Aerial photographs taken in the late summer are used to monitor maximum bed extent of floating kelp along the Strait of Juan de Fuca and outer coast in the Olympic Coast sanctuary. Data collected by Washington State Department of Natural Resources in 1989-1992 and 1994-present.   | X                       | OC                          |                   |                     |                                    |                     | 9    |
| CA Annual Kelp Surveys   | Aerial photographs taken in the late summer have been used to monitor maximum bed extent of floating kelp along the California mainland coast. Data collected by California Department of Fish and Game in 1989 and 1999-present.  |                         | MB                          |                   |                     | X                                  |                     | 10   |
| Land/Ocean Biogeochemical Observatory in Elkhorn Slough (LOBO) | The LOBO project uses in situ chemical sensors to determine chemical fluxes into, within, and out of Elkhorn Slough in the Monterey Bay sanctuary. The primary focus is to measure nutrients, such as nitrate, ammonium, and phosphate. Data collected since 2003.   |                         | MB                          |                   |                     |                                    |                     | 12   |
| Coastal Observation and Seabird Survey Team (COASST)           | COASST, which began in 1999, uses volunteers to survey beached marine birds at selected beach segments in Washington and northern Oregon. Beach segments are surveyed either monthly or  | 2006 data only          | OC                          |                   |                     |                                    |                     | 15   |

Table 12

| Project Name                                      | Project Description  | Available though PaCOOS | ONMS SWiM Condition Reports | Module I, CCE IEA | Atlantis NCCE model | NCEAS CCME Human Impact Assessment | MBCO RC Report Card | ID # |
|---|--|-------------------------|-----------------------------|-------------------|---------------------|------------------------------------|---------------------|------|
|   | every two weeks.   |                         |                             |                   |                     |                                    |                     |      |
| CSUMB Seafloor Mapping Lab (SFML)                 | The CSUMB SFML specializes in high-resolution acoustic remote sensing for coastal habitats. Data collection in coastal California began in 1993.   |                         | CB, MB                      |                   |                     |                                    |                     | 17   |
| OCNMS Habitat Mapping                             | In August 2004 and May and July 2005, OCNMS imaged several regions of the sea floor in the northern OCNMS. Video from a towed camera sled, bathymetry data, sedimentary samples and side scan sonar mapping were integrated to describe geological and biological aspects of habitat.  | X                       | OC                          |                   |                     |                                    |                     | 18   |
| Cordell Bank Ocean Monitoring Program (CBOMP)     | A monthly census of birds, marine mammals, krill and physical oceanographic conditions in the CBNMS began in 2004. Data collection methods were designed so that data could be integrated with CIMT.   |                         | CB                          |                   |                     |                                    |                     | 19   |
| MBARI Monterey Bay Multibeam Survey               | In June 1998 MBARI completed surveys of selected areas of the Monterey Bay sanctuary and surrounding features using a multibeam echo sounder.  |                         | MB                          |                   |                     |                                    |                     | 20   |
| Essential Fish Habitat (EFH)                      | The EFH data set contains physical seafloor characteristics considered important for identifying essential habitat for groundfish. Seafloor feature data sets include side-scan sonar, bottom samples, seismic data, and multibeam bathymetry. The Active Tectonics and Seafloor Mapping Lab, College of Oceanic and Atmospheric Sciences, Oregon State University developed the data for Oregon and Washington. The Center for Habitat Studies, Moss Landing Marine Laboratories developed the data for California. | X                       | OC                          |                   | X                   | X                                  |                     | 21   |
| OCNMS multi-agency census of sea otters           | Monitoring the sea otter population in Washington state since 1995. Annual surveys in July.  |                         | OC                          |                   |                     |                                    |                     | 25   |
| SCCWRP Southern California Bight Regional Surveys | Beginning in 1994 and repeating every 5 years, Southern California Coastal Water Research Project (SCCWRP) has led a consortium of 13 organizations in conducting a integrated, coordinated regional monitoring survey for the Southern California Bight. The surveys include measurement of chemistry, toxicity, benthic infauna, and fish assemblages at 261 sites between Point Conception and the Mexican border.  |                         | CI                          |                   |                     |                                    |                     | 26   |
| Sanctuary Ecosystem Assessment Surveys (SEAS)     | SEAS collect data on the abundance and distribution of bird, mammals, turtles, jellyfish, krill, vessel activities, harmful algal blooms, and location of surface fronts and convergent zones. 2005-2008 annual 10 day cruise  |                         | GF                          |                   |                     |                                    |                     | 28   |
| Central Coast Ambient Monitoring Program (CCAMP)  | A water quality monitoring and assessment program for the central California region that began in 1998.  |                         | MB                          |                   |                     |                                    |                     | 30   |

Table 12

| Project Name  | Project Description  | Available though PaCOOS | ONMS SWiM Condition Reports | Module I, CCE IEA | Atlantis NCCE model | NCEAS CCME Human Impact Assessment | MBCO RC Report Card | ID # |
|---|--|-------------------------|-----------------------------|-------------------|---------------------|------------------------------------|---------------------|------|
| Central Coast Long Term Environmental Network (CCLEAN)                      | A long-term regional monitoring program for central California that began in 2000. Water quality is monitored in watersheds that flow into coastal regions, in estuarine coastal confluences, and at coastal sites. Monitoring persistent organic pollutants in water and sediment, nutrients, pathogens, and suspended sediments in rivers. |                         | MB                          |                   |                     |                                    | X                   | 31   |
| National Estuarine Research Reserve (NERR) System-Wide Monitoring Program   | Part of a system-wide long-term monitoring program that focuses on short-term variability and long-term changes in key properties of water quality. Monthly sampling in Elkhorn Slough since 1988 and in San Francisco NERR since 2005.  |                         | MB                          |                   |                     |                                    |                     | 32   |
| Santa Cruz County Surface Water Quality Monitoring Program                  | The Santa Cruz County Surface Water Quality Monitoring Program began in 1975, and is conducted by the Santa Cruz County Environmental Health Services Agency. Measures baseline water quality and identifies sources of water quality degradation in the marine and fresh waters of Santa Cruz County.                                       |                         | MB                          |                   |                     |                                    |                     | 33   |
| OCNMS intertidal monitoring   | Bi-annual monitoring of baseline information and trends over time for intertidal living resources along the Olympic Coast began in 1996. Conducted by OCNMS and Olympic National Park.   |                         | OC                          |                   |                     |                                    |                     | 35   |
| Central California Habitat Characterization                                 | Starting in 2004, this project has been mapping the seafloor and characterizing habitats and associated benthic macroinvertebrates and fish assemblages in the three West Coast national marine sanctuaries.   |                         | MB, CB                      |                   |                     |                                    |                     | 37   |
| Statewide Water Ambient Monitoring Program (SWAMP)                          | SWAMP data currently consists of field observations, discrete field measures and laboratory, bacteria indicators, and toxicity results for sediment and water samples throughout the state of California. Tissue, bioassessment (organisms and physical habitat) and time series data are being added to the database.                       |                         | MB                          |                   |                     |                                    |                     | 41   |
| OCNMS offshore cetacean and seabird surveys                                 | Binocular and naked-eye surveys using ship-based line transects following permanent east-west tracklines; photo ID catalogue collected. Annual surveys in late May to July since 1995.   |                         | OC                          |                   |                     |                                    |                     | 42   |
| Deep Sea Corals   | Expeditions to inventory deep sea corals from Olympic Coast NMS (in 2006) and the Davidson Seamount (in 2002 and 2006).  |                         | OC                          |                   |                     |                                    |                     | 43   |
| USFW seabird colony surveys   | Annual surveys of seabird colonies in the Olympic Coast sanctuary conducted by USFW.   |                         | OC                          |                   |                     |                                    |                     | 46   |
| USGS Pacific Coast habitat mapping program                                  | Various remotely-sensed data available for download. Primarily sidescan.   | X                       | MB                          |                   |                     |                                    |                     | 47   |
| Long-term Monitoring Program & Experiential Training for Students (LiMPETS) | The LiMPETS program began in 2002. Middle school, high school, and other volunteer groups monitor rocky intertidal and sandy shore areas in four of the west coast National Marine Sanctuaries.  |                         | MB                          |                   |                     |                                    |                     | 48   |
| Santa Barbara Coastal Long Term Ecological                                  | The primary research objective of the SBC LTER is to investigate the relative importance of land and ocean processes in structuring  |                         | CI                          |                   |                     |                                    |                     | 51   |

Table 12

| Project Name  | Project Description   | Available though PaCOOS                                   | ONMS SWIM Condition Reports | Module I, CCE IEA | Atlantis NCCE model | NCEAS CCME Human Impact Assessment | MBCO RC Report Card | ID # |
|---|---|---|-----------------------------|-------------------|---------------------|------------------------------------|---------------------|------|
| Research Program (SBC LTER)   | giant kelp forest ecosystems. This monitoring program began in 2000.  |   |                             |                   |                     |                                    |                     |      |
| Beach Watch   | Beach Watch is a long-term shoreline monitoring project that was founded in 1993. Volunteers conduct monthly surveys of assigned beaches within the Gulf of the Farallones and Monterey Bay National Marine Sanctuaries. Data is collected on live and dead species of birds and marine mammals as well as oil pollution.   |   | GF                          |                   |                     |                                    |                     | 54   |
| Partnership for the Interdisciplinary Study of Coastal Oceans (PISCO) | PISCO conducts experiments & long-term monitoring of west coast nearshore ecosystems (e.g., rocky intertidal, kelp forest and rocky reef). Components include nearshore oceanography, larval dispersal, recruitment, physiology, ecological interactions, community structure. Began in 1999.   |   | MB                          |                   |                     |                                    |                     | 59   |
| SWFSC Shipboard Cetacean Survey                                       | Survey to assess the abundance and distribution of marine mammals and to characterize the pelagic ecosystem off the U.S. West Coast out to a distance of approximately 300 nautical miles. Surveys occurred in 1991, 1993, 1996, 2001, 2005, and 2008. The 2005 cruise, called the Collaborative Survey of Cetacean Abundance and the Pelagic Ecosystem (CSCAPE), was a collaboration with ONMS and included additional fine-scale surveys within the NMS boundaries. | CTD data only   | MB, CI                      |                   | X                   |                                    |                     | 60   |
| California Cooperative Oceanic Fisheries Investigations (CalCOFI)     | CalCOFI are a series of shipboard surveys along fixed transect lines off central and southern California to collect physical and chemical oceanographic data and to census populations from phytoplankton to avifauna. Began in 1949. Some transects are still sampled annually through a partnership including SIO, SWFSC and CDFG   | Biological data: Phytoplankton, fish eggs and larvae only |                             | X                 | X                   |                                    |                     | 65   |
| Monterey Bay Time Series (MBTS) Program                               | Shipboard measurements of physical, chemical and biological parameters are made during quarterly MBARI cruises. Data collection in Monterey Bay began in 1989. Data collection was expanded offshore into the California Current (along CalCOFI transect line 67) in 1997 under the name SECRET (Studies of Ecological and Chemical Responses to Environmental Trends).   | X   | MB                          | X                 |                     |                                    | X                   | 66   |
| NWFSC Groundfish Surveys  | Annual trawl groundfish surveys are conducted by NMFS NWFSC from the Canadian border to the Mexican border along the West Coast of the U.S. These surveys provide information about distribution, relative abundance, and age structure of important groundfish populations. Occurrence of structure-forming invertebrates in trawls is recorded when possible.   | X   | OC, MB                      | X                 | X                   |                                    | X                   | 67   |
| NOAA National Data Buoy Center (NDBC)                                 | The NOAA NDBC collects recent and historical buoy data and observations from various types of buoys around the world, including the entire U.S. West Coast  | X   |                             |                   |                     |                                    |                     | 68   |
| Humboldt Line Survey  | Monitoring of ocean structure and the spatial distribution of plankton species including egg and larval stages of fish and select invertebrate species along a 60 nautical mile cross-shelf transect off Trinidad Head. Quarterly sampling by NOAA and Humboldt State   |   |                             |                   |                     |                                    |                     | 69   |

Table 12

| Project Name  | Project Description   | Available though PaCOOS                    | ONMS SWiM Condition Reports | Module I, CCE IEA | Atlantis NCCE model | NCEAS CCME Human Impact Assessment | MBCO RC Report Card | ID # |
|---|---|--|-----------------------------|-------------------|---------------------|------------------------------------|---------------------|------|
|   | University starting April 2006.   |  |                             |                   |                     |                                    |                     |      |
| SWFSC Central California Aerial Surveys                             | Aerial surveys to quantify the spatial and temporal distribution of marine mammals, seabirds and leatherback turtles in coastal waters of central California. Began in 1997.  |  | CB                          |                   | X                   |                                    |                     | 71   |
| Cooperative Research and Assessment of Nearshore Ecosystems (CRANE) | CRANE, which began in 2002, is a collaborative effort to gather data for fishery management and performance of marine protected areas in central and southern California. Data collection includes wide-scale survey of fish and invertebrate populations in shallow, rocky habitats accessible to divers (Monterey to San Diego, including the Channel Islands).   |  | MB                          |                   |                     |                                    |                     | 76   |
| Habitat Characterization and Biological Monitoring of Cordell Bank  | In 2001, Cordell Bank sanctuary, in partnership with the SWFSC, USGS, and CDFG, initiated a long-term study to classify habitats and monitor fishes and macro-invertebrates on and around Cordell Bank. Underwater surveys of fishes, invertebrates, and their habitats are conducted on and around Cordell Bank using direct observation and video-transect methods from an occupied research submersible (Delta). |  | CB                          |                   |                     |                                    |                     | 77   |
| Coastal Ocean Currents Monitoring Program (COCMP)                   | COCMP uses an integrated set of high frequency radar systems to measure and map surface currents over large areas of the coastal ocean in central and southern California.  | Monterey Bay, San Francisco Bay and outlet |                             |                   |                     |                                    |                     | 79   |
| PRBO At-Sea Marine Mammal and Seabird Surveys                       | Surveys in the Gulf of the Farallones to determine the distribution and abundance of marine birds and mammals, to quantify the distribution and abundance of euphausiids and other bird/mammals prey, to characterize the zooplankton community in the upper water column, and to characterize the physical oceanographic conditions.   |  | CB                          |                   |                     |                                    |                     | 81   |
| Mussel Watch Program  | The NOAA National Status and Trends Mussel Watch Program monitors chemical contamination in the coastal United States. Since 1986 mussels and oysters have been annually collected at more than 200 sites around the nation and analyzed for a suite of chemical contaminants.  |  | OC, GF, MB                  |                   |                     |                                    | X                   | 88   |
| Multi-Agency Rocky Intertidal Network (MARiNe)                      | MARiNe monitors sites along the Pacific Coast using two different approaches—target assemblage monitoring (biannually at 80 locations in California and Oregon), and biodiversity community monitoring (less frequent at 91 locations from Alaska to Mexico). Sites are selected to provide data about different rocky habitats, different exposure variables, different public uses.                               |  | MB                          |                   |                     |                                    |                     | 91   |

Table 12

| Project Name   | Project Description  | Available though PaCOOS     | ONMS SWiM Condition Reports | Module I, CCE IEA | Atlantis NCCE model | NCEAS CCME Human Impact Assessment | MBCO RC Report Card | ID # |
|--|--|-----------------------------|-----------------------------|-------------------|---------------------|------------------------------------|---------------------|------|
| Santa Barbara Channelkeeper Stream Team monitoring program | Channelkeeper has run a volunteer-based water quality monitoring program - Stream Team - since 2001 in the Ventura River watershed (in partnership with the Ventura County chapter of the Surfrider Foundation), and since 2002 in the Goleta Slough watershed. Water quality is tested monthly at every major reach and junction to locate the 'trouble' spots.   |                             | CI                          |                   |                     |                                    |                     | 93   |
| PRBO Snowy Plover monitoring                               | PRBO Conservation Science has two monitoring projects for Snowy Plover, one in Monterey Bay and one at Point Reyes. Since 1976, the Monterey project has monitored Snowy Plovers nesting in coastal habitats of Santa Cruz and Monterey counties. Since 1996, the Point Reyes project has been protecting and monitoring nesting Snowy Plovers within the Point Reyes National Seashore.                         |                             |                             |                   |                     |                                    | X                   | 96   |
| Line P   | Department of Fisheries and Oceans Canada (DFO) & others. Oceanographic sampling off British Columbia, Canada. Hydrography, nutrients and lower trophic level productivity is measured. Seabirds and marine mammals are also surveyed. On-going monitoring began in 1949.  | X                           |                             | X                 |                     |                                    |                     |      |
| SWFSC Rockfish Recruitment Survey                          | NMFS-SWFSC and other collaborators have conducted annual mid-water trawl surveys in the greater Gulf of the Farallones (Monterey Bay to Bodega Bay) region off central California. Hydrography and estimates of recruitment for young-of-the-year (age-0) <i>Sebastes</i> are priorities for this survey. On-going monitoring began in 1983. Data on abundance of seabirds and marine mammals is also collected. | CTD and Thermosal data only | CB, GF, MB                  | X                 |                     |                                    | X                   |      |
| Southeast Farallon Island Seabird Ecology Surveys          | Under contract with USFWS, PRBO Conservation Science monitors and studies the ecology of 12 seabird species and 5 pinniped species at this site. Daily measurements of SST, salinity, and weather are also made. On-going monitoring began in 1971.  |                             | CB, MB                      | X                 | cenCA model only    |                                    | X                   |      |
| Channel Islands Seabird Ecology Surveys                    | The California Center for Environmental Studies initiated research on Brown Pelicans in the Channel Islands in the late 1960s. In 1985, the Channel Islands National Park initiated long-term studies of a variety of seabirds at Santa Barbara, Anacapa, and San Miguel islands. On-going monitoring began in 1968.   |                             | CI                          | X                 |                     |                                    |                     |      |
| Vancouver Island Zooplankton                               | Since 1979, DFO Canada has measured zooplankton and hydrographic conditions on the Vancouver Island continental margin.  |                             |                             | X                 |                     |                                    |                     |      |
| Newport Hydrographic Line                                  | Biweekly surveys of this line have been conducted by NMFS-NWFSC off Newport, Oregon since 1996. Priorities for this survey include hydrography and zooplankton (copepods and euphausiids) and more recently seabirds.  | hydrography data            |                             | X                 | X                   |                                    |                     |      |
| Oregon and Washington Forage Fish                          | Hydrography, nutrients, chlorophyll-a, zooplankton and pelagic forage fish are sampled by NMFS-NWFSC at six stations along each of eight transects ranging from Newport, Oregon to the Washington-Canadian border. 1998 - present  |                             |                             | X                 | TBD                 |                                    |                     |      |

Table 12

| Project Name  | Project Description  | Available though PaCOOS           | ONMS SWiM Condition Reports | Module I, CCE IEA | Atlantis NCCE model | NCEAS CCME Human Impact Assessment | MBCO RC Report Card | ID # |
|---|--|-----------------------------------|-----------------------------|-------------------|---------------------|------------------------------------|---------------------|------|
| Tatoosh Island Seabird Ecology Study                  | Studies of the breeding success and diet of seabirds that inhabit Tatoosh Island, WA, focused on Common Murres began in 1990 by University of Washington.  |                                   |                             | X                 |                     |                                    |                     |      |
| Triangle Island Seabird Ecology                       | Canadian Wildlife Service and Simon Fraser University are studying the breeding success and diet of the seabirds that inhabit Triangle Island. Focus on Rhinoceros Auklet and Cassin's Auklet. On-going monitoring began in 1994.  |                                   |                             | X                 |                     |                                    |                     |      |
| SWFSC Pinniped Aerial Surveys Project                 | SWFSC conducts censuses of five species of pinnipeds.. Pups and other age/sex classes are counted from color photographs taken at rookeries and haulouts during aerial surveys of islands and the mainland coast of California.  |                                   | MB                          | X                 | X                   |                                    |                     |      |
| CINP Monitoring                                       | Subsurface temperature and biological monitoring data at numerous subtidal sites in the Channel Islands National Park (CINP).  | Temp, kelp, inverts and fish data | CI                          |                   |                     |                                    |                     |      |
| GLOBEC  | GLOBEC (Global Ocean Ecosystem Dynamics) was initiated in 1991. Oceanographic data including temperature, salinity, oxygen, nutrients, phytoplankton, birds, cetaceans.  | X                                 |                             |                   | X                   |                                    |                     |      |
| World Ocean Database (WODB)                           | The World Ocean Database is a collection of scientifically quality-controlled ocean profiles from the National Oceanographic Data Center (NODC). This dataset contains measurements of temperature, salinity, oxygen, chlorophyll.   | X                                 |                             |                   |                     |                                    |                     |      |
| NOAA Habitat Use Database (HUD)                       | This NWFSC database Includes Fish Occurrence Details, Fish Species Details, Predators and Prey, References.  | X                                 |                             |                   |                     |                                    |                     |      |
| West Coast Groundfish Observer Program                | This NWFSC Observer Program conducts sampling of groundfish discarded by commercial fisheries along the entire continental U.S. West Coast. The seventeen species included in this data product are those of most interest to fisheries management and commercial fishing communities. Data available for both trawl and fixed gear. | X                                 |                             |                   | X                   |                                    |                     |      |
| Integrated Acoustic and Trawl Surveys of Pacific Hake | Shipboard acoustic Doppler current profiler data collected by NWFSC during the Integrated Acoustic and Trawl Surveys of Pacific Hake, years: 1995, 1998, 2001, 2003, and 2005.   | ADCP data only                    |                             |                   | X                   |                                    |                     |      |
| NGDC Coastal Relief Gridded database                  | The National Geophysical Data Center (NGDC) Coastal Relief model provides bathymetry from the coastal state boundaries to as far offshore as the NOS hydrographic data will support a continuous view of the seafloor.   | X                                 | ?                           |                   |                     |                                    |                     |      |
| WOCE  | World Ocean Circulation Experiment (WOCE) in-situ tide gauge data (data on sea level) as part of the Global Sea Level Observing System (GLOSS) network   | X                                 |                             |                   |                     |                                    |                     |      |
| POES  | Polar Operational Environmental Satellites (POES) provide ocean surface temperature data.  | X                                 |                             |                   |                     |                                    |                     |      |



Table 12

| Project Name                                    | Project Description  | Available though PaCOOS | ONMS SWiM Condition Reports | Module I, CCE IEA | Atlantis NCCE model | NCEAS CCME Human Impact Assessment | MBCO RC Report Card | ID # |
|---|--|-------------------------|-----------------------------|-------------------|---------------------|------------------------------------|---------------------|------|
| California Fish Landings                        | Database includes commercial landings of fish and invertebrates caught off California and landed in California. Landing receipt data began in 1928. Includes PacFIN database which began in 1981. Also includes length and age compositions.   | X                       | MB                          |                   | X                   | X                                  | X                   |      |
| SF-BEAMS  | The San Francisco Bay Environmental Assessment and Monitoring Station (SF-BEAMS) continuously monitors San Francisco Bay water quality and weather conditions at a location approximately 200 ft offshore on the Romberg Tiberon Center pier. SF-BEAMS is part of CICORE.  | X                       |                             |                   |                     |                                    |                     |      |
| COADS   | Comprehensive Ocean-Atmosphere Data Set (COADS) Project provides monthly time series (1854-1993) of atmospheric variables including SST, Sea Level Pressure, Wind.   | X                       |                             |                   | X                   |                                    |                     |      |
| usSEABED  | usSEABED provides data from seafloor samples on sediment and rock distributions in the waters off the United States. Part of the USGS Coastal & Marine Geology Program   | X                       |                             |                   |                     |                                    |                     |      |
| NMFS Cold Water Corals                          | The location of some observations of cold-water/deep-sea corals off the west coast of the United States. Records of coral catch originate from bottom trawl surveys conducted from 1980 to 2001 by the Alaska Fisheries Science Center (AFSC) and 2001 to 2005 by the Northwest Fisheries Science Center (NWFS). | X                       | OC, MB                      |                   |                     |                                    |                     |      |
| EPA Toxic Release Inventory                     | The EPA Toxics Release Inventory contains information on toxic chemical releases and waste management activities reported annually by certain industries as well as federal facilities.  |                         |                             |                   |                     | X                                  |                     |      |
| California Recreational Fisheries Survey (CRFS) | CRFS is a coordinated sampling survey designed to gather catch and effort data from anglers in all modes of marine recreational finfish fishing. It can be used to estimate total marine recreational finfish catch and effort in California   |                         | GF                          |                   |                     | X                                  |                     |      |
| VOS Scheme                                      | World Meteorological Organization Voluntary Observing Ship (VOS) Scheme provides information on commercial shipping traffic patterns.  |                         |                             |                   |                     | X                                  |                     |      |
| FAO Fisheries time-series                       | The Food and Agriculture Organization (FAO) of the United Nations Fisheries and Aquaculture department collects data on demersal and pelagic fisheries   |                         |                             |                   |                     | X                                  |                     |      |
| DOT Ferry Traffic                               | Data on ferry traffic available from the state Department of Transportation (California and Washington)  |                         |                             |                   |                     | X                                  |                     |      |
| Shipping  | Tonnage data available from the US Army Corps of Engineers Navigation Data Center  |                         |                             |                   |                     | X                                  |                     |      |
| Oil Rigs  | Data available from Pacific States Marine Fisheries Commission   |                         |                             |                   |                     | X                                  |                     |      |
| Platts energy database                          | Location of power plants and desalination plants. Provided by Platts (part of McGraw-Hill Companies)   |                         |                             |                   |                     | X                                  |                     |      |

Table 12

| Project Name   | Project Description  | Available though PaCOOS | ONMS SWiM Condition Reports | Module I, CCE IEA | Atlantis NCCE model | NCEAS CCME Human Impact Assessment | MBCO RC Report Card | ID # |
|--|--|-------------------------|-----------------------------|-------------------|---------------------|------------------------------------|---------------------|------|
| California Coastal Commission Public Education Program | Data on coastal pollution including marine debris (other than fishing gear) and oil, chemicals, etc.   |                         |                             |                   |                     | X                                  |                     |      |
| AVHRR Pathfinder Satellite data                        | Sea surface temperature data produced by NOAA's National Oceanographic Data Center and the University of Miami's Rosenstiel School of Marine and Atmospheric Science.  |                         |                             |                   | ?                   | X                                  |                     |      |
| Human access to beaches, intertidal                    | California: California Coastal Access Guide (MLPA); Oregon: Oregon Geospatial Enterprise Office; Washington: Washington State Department of Ecology BEACH (Beach Environmental Assessment, Communication and Health) Program   |                         |                             |                   |                     | X                                  |                     |      |
| PDO index  | The Pacific Decadal Oscillation (PDO) index (1900-2006). Data courtesy Nate Mantua (Joint Institute for the Study of the Atmosphere and Ocean, UW). <a href="http://jisao.washington.edu/pdo/PDO.latest">http://jisao.washington.edu/pdo/PDO.latest</a>  |                         |                             | X                 |                     |                                    |                     |      |
| MEI  | The Multivariate El Niño Index (MEI), 1950-2006. Data courtesy Klaus Wolter (NOAA-Earth System Research Laboratory). The MEI is a composite index constructed using 7 environmental variables. <a href="http://www.cdc.noaa.gov/people/klaus.wolter/MEI/table.html">http://www.cdc.noaa.gov/people/klaus.wolter/MEI/table.html</a> . |                         |                             | X                 |                     |                                    |                     |      |
| SWFSC Upwelling Index                                  | The SWFSC Pacific Fisheries Environmental Laboratory generates indices of the intensity of large-scale, wind-induced coastal upwelling and along-shore transport at 15 standard locations along the west coast of North America.   | X                       |                             | X                 | x                   |                                    | x                   |      |

## References

- Brand, E.J., I.C. Kaplan, C.J. Harvey, E.A. Fulton, A.J. Hermann, J.C. Field, P.S. Levin. 2007. A spatially explicit ecosystem model of the California current's foodweb and oceanography. NOAA Tech. Memo. NMFS-NWFSC-84.
- deReynier, Y.L., Levin, P.S., Shoji, N.L.. In press. Bringing stakeholders, scientists, and managers together through an integrated ecosystem assessment process. *Marine Policy*.
- Ekstrom, J.A. 2009. California current large marine ecosystem: publicly available dataset of state and federal laws and regulations. *Marine Policy* 33(3):528-531.
- Environmental Protection Agency (EPA). 2000. Evaluation Guidelines For Ecological Indicators. U.S. Environmental Protection Agency Office of Research and Development Research Triangle Park, NC. EP A/620/R-99/005.
- Fulton, E.A. 2004. Biogeochemical marine ecosystem models II: the effect of physiological detail on model performance. *Ecological Modeling* 173:371-406.
- Fulton, E.A., Smith, A.D.M., Punt, A.E. 2005. Which ecological indicators can robustly detect effects of fishing? *ICES Journal of Marine Science* 62:540-551.
- Fulton, E.A., A.D.M. Smith, D.C. Smith. 2007. Alternative management strategies for SE Australian commonwealth fisheries: stage 2: quantitative management strategy evaluation. Australian Fisheries Management Authority, Fisheries Research and Development Corporation.
- Halpern, B.S., C.V. Kappel, K.A. Selkoe, F. Micheli, C.M. Ebert, C. Kontgis, C.M. Crain, R.G. Martone, C. Shearer, S.J. Teck. 2009. Mapping cumulative human impacts to California Current marine ecosystems. *Conservation Letters* 2:138-148.
- Hickey, B.M. and N.S. Banas. 2008. Why is the northern end of the California current system so productive? *Oceanography* 21(4):90-107.
- Koshel, P. and K. Mcallister. 2008. Transitioning to Sustainability Through Research and Development on Ecosystem Services and Biofuels: Workshop Summary. National Academies Press, Washington, D.C. 130pp.
- Levin, P.S., M.J. Fogarty, G.C. Matlock, M. Ernst. 2008. Integrated ecosystem assessments. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-92, 20pp.
- Levin, P.S., M.J. Fogarty, S.A. Murawski, D. Fluharty. 2009. Integrated ecosystem assessments: developing the scientific basis for ecosystem-based management of the ocean. *PLoS Biol* 7(1).

Murawski, S.A., G.C. Matlock (eds.). Ecosystem Science Capabilities Required to Support NOAA's Mission in the year 2020. National Oceanic and Atmospheric Administration (NOAA) Technical Memorandum NMFS-F/SPO-74, 2006.

National Marine Protected Area Federal Advisory Committee. 2008. Linking ocean observing systems with the national system of marine protected areas. Washington, D.C., National Marine Protected Areas Center, 10pp.

National Oceanic and Atmospheric Administration (NOAA). 2008a. Cordell Bank National Marine Sanctuary final management plan. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. Silver Spring, MD. 161pp + appendices.

National Oceanic and Atmospheric Administration (NOAA). 2008b. Gulf of the Farallones National Marine Sanctuary final management plan. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. Silver Spring, MD. 311pp + appendices.

National Oceanic and Atmospheric Administration (NOAA). 2008c. Monterey Bay National Marine Sanctuary final management plan. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. Silver Spring, MD. 426pp + appendices.

National Oceanic and Atmospheric Administration (NOAA). 2009. Channel Islands National Marine Sanctuary Management Plan / Final Impact Statement. U.S. Dept. of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service. Silver Spring, MD. 217pp + appendices.

National Oceanic and Atmospheric Administration (NOAA). 2009. National Oceanic and Atmospheric Administration Strategic Plan FY2009-2014. National Oceanic and Atmospheric Administration Silver Spring, MD. 32pp.

Office of National Marine Sanctuaries (ONMS). 2006. A Monitoring Framework for the National Marine Sanctuary System. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 22pp.

Office of National Marine Sanctuaries (ONMS). 2008. Olympic Coast National Marine Sanctuary Condition Report 2008. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 72pp.

Office of National Marine Sanctuaries (ONMS). 2009a. Channel Islands National Marine Sanctuary Condition Report. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 60pp.

Office of National Marine Sanctuaries (ONMS). 2009b. Cordell Bank National Marine Sanctuary Condition Report 2009. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 58pp.

Office of National Marine Sanctuaries (ONMS). 2009c. Monterey Bay National Marine Sanctuary Condition Report. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 128pp.

Office of National Marine Sanctuaries (ONMS). Draft. Gulf of the Farallones National Marine Sanctuary Condition Report. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD..

Pacific Fisheries Management Council (2008). Pacific coast groundfish fishery stock assessment and fishery evaluation, Pacific Fisheries Management Council. 2:75-98.

Sydeman, W.J. and M.L. Elliot. 2008. Developing the California Current Integrated Ecosystem Assessment, Module I: Select Time-Series of Ecosystem State. Final Report. Marine Ecology Division, PRBO Conservation Science, Petaluma, CA. 37pp.

Tallis, H. P.S. Levin, M. Ruckelshaus, S.E. Lester, K.L. McLeod, D.L. Fluharty, B.S. Halpern. 2009. The many faces of ecosystem-based management: Making the process work today in real places. *Marine Policy* 34(2010):340-348.

van Woerden, J., C. Wieler, E. Gutierrez-Espeleta, R. Grosshans, A. Abdelrehim, P. Chandra, L. Rajbhandari. 2007. IEA Training Manual. A training manual on integrated environmental assessment and reporting. Training Module 4. United Nations Environment Program. Web published at: <http://hqweb.unep.org/ieacp/iea/training/manual/introduction.aspx>

### Appendix 1 - West Coast Sanctuary Data Inventory

A west coast sanctuary data inventory was built by identifying monitoring programs in the five west coast sanctuaries: Olympic Coast, Cordell Bank, Gulf of the Farallones, Monterey Bay, and Channel Islands National Marine Sanctuaries. Initial requirements for inventory inclusion were subjectively based on (in no particular order) geographic range, monitoring frequency, duration, future longevity, variables measured, and ONMS participation. Since PaCOOS primarily seeks to integrate data from the relatively large area of the U.S. Pacific west coast Exclusive Economic Zone (EEZ; from shore out to 200 nautical miles), monitoring efforts with a small footprint were considered lower priority. Emphasis was placed on monitoring efforts that were multi-year with frequent data collection. Future longevity of a project was also a key consideration.

| ID | Project Name                     | Project Description  | Character ID # | ONMS Site |    |    |    |    |             | Biological data |               |             |                  |               |                 |               |            |                |          |             |           | Physical data |          |            |          |             |                     |          |               |                 |          |       |                | Project URL |   |     |   |
|----|----------------------------------|--|----------------|-----------|----|----|----|----|-------------|-----------------|---------------|-------------|------------------|---------------|-----------------|---------------|------------|----------------|----------|-------------|-----------|---------------|----------|------------|----------|-------------|---------------------|----------|---------------|-----------------|----------|-------|----------------|-------------|---|-----|---|
|    |                                  |  |                | OC        | CB | GF | MB | CI | Chlorophyll | Fluorescence    | Phytoplankton | Zooplankton | Juvenile Inverts | Adult Inverts | Ichthyoplankton | Juvenile fish | Adult fish | Marine mammals | Seabirds | Other - bio | Neustonic | Plankton Q2   | Salinity | Water temp | Rainfall | Wave height | Barometric pressure | Moisture | Transmittance | Currents (ADCP) | Air temp | Depth | Wave direction |             | Wind  | PAR | Aerial/est. volume  |
| 1  | West Coast Observatories (WCObs) | WCObs deals with oceanographic data collected at all five sanctuary sites located on the west coast. The project began in 2004 and focuses on various data streams collected at instrument moorings.   | 1, 2           | x         | x  | x  | x  | x  |             | x               |               |             |                  |               |                 |               |            |                |          |             |           |               |          |            |          |             |                     |          |               |                 |          |       |                |             |   |     | <a href="http://www.sanctuariesimon.org/regional_sections/obs/">http://www.sanctuariesimon.org/regional_sections/obs/</a> |
| 2  | Beach COMBERS                    | Beach COMBERS (Coastal Ocean Marine Mammal & Bird Education and Research Surveys) uses volunteers to survey beached marine birds and mammals monthly at selected sections of beaches in the central and southern portions of the Monterey Bay sanctuary. | 8              |           |    |    |    | x  |             |                 |               |             |                  |               |                 |               |            |                |          |             |           |               |          |            |          |             |                     |          |               |                 |          |       |                |             | <a href="http://sanctuariesimon.org/monterey/sections/marineMammals/project_info.php?projectId=100143&amp;sec=mm">http://sanctuariesimon.org/monterey/sections/marineMammals/project_info.php?projectId=100143&amp;sec=mm</a> |     |   |







| I<br>D | Project<br>Name  | Project Description   | Charact. ID # | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |          |  |  |  |  |  |   |
|--------|--|---|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|----------|--|--|--|--|--|---|
|        |  |   |               |    |    |    |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             | NO4, PO4 |  |  |  |  |  |   |
| 1<br>1 | MBARI<br>cruise<br>data  | Monterey Bay Aquarium Research Institute (MBARI) vessels continuously record oceanographic variables.   | 1             |    |    |    |    | x  |             |              |               |             |          |               |               |               |            |        |          |             |           |              | x        | x       |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |          |  |  |  |  |  |   |
| 1<br>2 | Land/Ocean<br>Biogeochemical<br>Observatory in<br>Elkhorn Slough<br>(LOBO)                       | The LOBO project uses in situ chemical sensors to determine chemical fluxes into, within, and out of Elkhorn Slough in the Monterey Bay sanctuary. The primary focus is to measure nutrients, such as nitrate, ammonium, and phosphate. Data collected since 2003.            | 2,<br>5,<br>8 |    |    |    | x  |    | x           | x            |               |             |          |               |               |               |            |        |          |             |           | x            | x        | x       | x          | x     | x        | x        | x             | x       |            |     |      |      |            |          |           |              |       |                |             |          |  |  |  |  |  | <a href="http://www.mbari.org/obo/">http://www.mbari.org/obo/</a>   |
| 1<br>3 | Structure of<br>Populations,<br>Levels of<br>Abundance and<br>Status of<br>Humpbacks<br>(SPLASH) | SPLASH conducted a dedicated sampling program of humpback whales in the entire North Pacific from 2003-2007. Subsequent analysis is determining a current estimate of overall abundance for the North Pacific (including estimates for specific wintering and feeding areas). | 15            | x  | x  | x  | x  | x  | x           |              |               |             |          |               |               |               |            | x      |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |          |  |  |  |  |  | <a href="http://www.cascadiaresearch.org/SPLASH/splash.htm">http://www.cascadiaresearch.org/SPLASH/splash.htm</a> |
| 1<br>4 | Coastal<br>Data<br>Information<br>Program<br>(CDIP)/<br>Wave<br>Rider<br>buoys                   | CDIP was established in 1975 to measure, analyze, archive and disseminate coastal environmental data including wave models and forecasts for the United States.   | 1,<br>2       | x  | x  | x  | x  | x  |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         | x          |       | x        |          |               |         |            |     |      |      |            |          |           |              |       |                |             |          |  |  |  |  |  | <a href="http://cdip.ucsd.edu/?nav=recent&amp;sub=observed">http://cdip.ucsd.edu/?nav=recent&amp;sub=observed</a> |

| ID | Project Name   | Project Description   | Charact. ID # |    |    |    |    |    |             |              |               |             |          |               |               | Project URL |               |            |        |          |             |           |              |          |         |            |       |          |               |         |            |     |      |            |          |           |   |       |   |
|----|--|---|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|-------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|---------------|---------|------------|-----|------|------------|----------|-----------|---|-------|---|
|    |  |   |               | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt |             | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Currents | Transmittance | Weather | Barometric | PAR | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type  | LIDAR | Other-physical                                    |
| 15 | Coastal Observation and Seabird Survey Team (COASST)                   | COASST, which began in 1999, uses volunteers to survey beached marine birds at selected sections of beaches in Washington and northern Oregon. Beach segments are surveyed either monthly or every two weeks.   | 8             | x  |    |    |    |    |             |              |               |             |          |               |               |             |               |            |        |          |             |           |              |          |         |            |       |          |               |         |            |     |      |            |          |           |   |       | <a href="http://coasst.org">http://coasst.org</a> |
| 16 | Network for Environmental Observations of Coastal Ocean (NEOCO)        | NEOCO, established in 2001, is a observing network that monitors coastal oceanographic conditions. Active sites are Bodega Head, La Jolla, Newport Beach, Santa Barbara, and Santa Cruz.  | 1, 2, 5, 8    |    |    | x  | x  | x  | x           | x            |               |             |          |               |               |             |               |            |        |          | x           |           |              |          |         |            |       |          |               |         |            |     |      |            |          |           | <a href="http://www.es.ucsc.edu/~neoco/instruments.html">http://www.es.ucsc.edu/~neoco/instruments.html</a>   |       |   |
| 17 | California State University Monterey Bay - Seafloor Mapping Lab (SFML) | The CSUMB-SFML specializes in high-resolution acoustic remote sensing for coastal habitats. Data collection in coastal California began in 1993.  | 4             | x  | x  | x  | x  | x  |             |              |               |             |          |               |               |             |               |            |        |          |             |           |              |          |         |            |       |          |               |         |            |     |      |            |          |           | <a href="http://seafloor.csUMB.edu/index.html">http://seafloor.csUMB.edu/index.html</a>   |       |   |
| 18 | OCNMS Habitat Mapping  | In August 2004 and May and July 2005, OCNMS imaged several regions of the sea floor in the northern OCNMS. Video from a towed camera sled, bathymetry data, sedimentary samples and side scan sonar mapping were integrated to describe geological and biological aspects of habitat. | 4             | x  |    |    |    |    |             |              |               |             |          |               |               |             |               |            |        |          |             |           |              |          |         |            |       |          |               |         |            |     |      |            |          |           | <a href="http://www.sanctuaries.noaa.gov/science/conservation/oc_mapping.html">http://www.sanctuaries.noaa.gov/science/conservation/oc_mapping.html</a> |       |   |

| ID | Project Name                                  | Project Description  | Charact. ID # | Sensors/Parameters |    |    |    |    |             |              |               |             |               |            | Project URL |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |   |   |
|----|---|--|---------------|--------------------|----|----|----|----|-------------|--------------|---------------|-------------|---------------|------------|-------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|---|---|
|    |   |  |               | OC                 | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile fish | Adult fish |             | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type  | LIDAR   |
| 19 | Cordell Bank Ocean Monitoring Program (CBOMP) | A monthly census of birds, marine mammals, krill and physical oceanographic conditions in the Cordell Bank NMS began in 2004. Data collection methods were designed so that data could be integrated with CIMT.  | 1, 14, 15     | x                  |    |    |    |    | x           | x            |               |             |               | x          | x           |        |          | x           | x         | x            | x        | x       |            |       | x        |          |               |         |            |     |      |      |            |          |           |   | <a href="http://sanctuarysimon.org/cordell/sections/openOcean/project_info.php?projectId=84&amp;sec=00">http://sanctuarysimon.org/cordell/sections/openOcean/project_info.php?projectId=84&amp;sec=00</a> |
| 20 | MBARI Monterey Bay Multibeam Survey           | In June 1998 Monterey Bay Aquarium Research Institute (MBARI) completed surveys of selected areas of the Monterey Bay sanctuary and surrounding features using a multibeam echo sounder.   | 4             |                    |    |    | x  |    |             |              |               |             |               |            |             |        |          |             |           |              | x        |         |            |       |          |          |               |         |            |     |      |      |            |          |           | <a href="http://www.mbari.org/data/mapping/monterey/default.htm">http://www.mbari.org/data/mapping/monterey/default.htm</a>   |   |
| 21 | Essential Fish Habitat (EFH)                  | The EFH data set contains physical seafloor characteristics considered important for identifying essential habitat for groundfish. Seafloor feature data sets include side-scan sonar, bottom samples, seismic data, and multibeam bathymetry. The Active Tectonics and Seafloor Mapping Lab, College of Oceanic and Atmospheric Sciences, Oregon State University developed the data for Oregon and Washington. The Center for Habitat Studies, Moss Landing Marine Laboratories developed the data for California. | 4             | x                  | x  | x  | x  | x  |             |              |               |             |               |            |             |        |          |             |           |              | x        |         |            |       |          |          |               |         |            |     |      |      |            |          |           | <a href="http://www.nmfs.noaa.gov/habitat/habitatprojection/efh/">http://www.nmfs.noaa.gov/habitat/habitatprojection/efh/</a> |   |





| I<br>D | Project<br>Name  | Project Description  | Charact. ID # | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |    |    |    |   |   |   |
|--------|--|--|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|----|----|----|---|---|---|
|        |  |  |               |    |    |    |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             | OC | CB | GF | MB  | CI  | Chlorophyll   |
| 28     | Sanctuary Ecosystem Assessment Surveys (SEAS)          | SEAS collect data on the abundance and distribution of bird, mammals, turtles, jellyfish, krill, vessel activities, harmful algal blooms, and location of surface fronts and convergent zones. 2005-2008 annual 10 day cruise  | 1, 8, 14, 15  | x  | x  | x  | x  |    | x           | x            | x             |             |          |               | x             |               |            |        | x        | x           |           |              | x        | x       | x          | x     | x        |          |               |         |            |     |      |      |            |          |           |              |       |                |             |    |    |    |   |   | <a href="http://www.sanctuaries.noaa.gov/missions/2006gfnms/welcome.html">http://www.sanctuaries.noaa.gov/missions/2006gfnms/welcome.html</a> |
| 30     | Central Coast Ambient Monitoring Program (CCAMP)       | A water quality monitoring and assessment program for the central California region that began in 1998.  | 5             |    |    |    | x  | x  |             |              |               |             |          |               |               |               |            |        |          |             | x         |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |    |    |    |   | <a href="http://www.ccamp.org/">http://www.ccamp.org/</a> |   |
| 31     | Central Coast Long Term Environmental Network (CCLEAN) | A long-term regional monitoring program for central California that began in 2000. Water quality is monitored in watersheds that flow into coastal regions, in estuarine coastal confluences, and at coastal sites. Monitoring persistent organic pollutants in water and sediment, nutrients, pathogens, and suspended sediments in rivers. | 2, 5, 6, 7, 8 |    |    | x  | x  |    |             |              |               |             |          | x             |               |               |            |        |          |             | x         | x            | x        |         | x          | x     | x        |          |               |         |            |     |      |      |            |          |           |              |       |                |             |    |    |    | <a href="http://www.amarine.com/information/cclean/clean.html">http://www.amarine.com/information/cclean/clean.html</a> |   |   |







| I<br>D | Project<br>Name  | Project Description  | Charact.<br>ID # |    |    |    |    |    |             |              |               |             |                        |            |        |          | Project URL |             |           |              |          |         |            |       |          |               |         |            |     |      |      |            |          |   |              |   |
|--------|--|--|------------------|----|----|----|----|----|-------------|--------------|---------------|-------------|------------------------|------------|--------|----------|-------------|-------------|-----------|--------------|----------|---------|------------|-------|----------|---------------|---------|------------|-----|------|------|------------|----------|---|--------------|---|
|        |  |  |                  | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile invertebrates | Adult fish | Marine | Seabirds |             | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam   | Habitat type | LIDAR   |
| 3<br>9 | EPA<br>California<br>Coastal<br>Project                            | Various projects throughout California: Sediment samples taken from 80 estuaries in 1999; sediment samples from 50 stations in SF Bay taken in 2000; Los Angeles County dredging sediment samples taken since 1997; continental shelf sediment samples taken around Southern CA bight in 1998; several others          |                  | x  |    |    |    |    |             | x            | x             | x           | x                      |            |        | x        | x           | x           | x         |              |          |         |            |       |          |               |         |            |     |      |      |            |          |   |              | <a href="http://www.sccwrp.org/">http://www.sccwrp.org/</a> |
| 4<br>0 | CDFG/C<br>INP<br>White<br>abalone<br>surveys                       | Surveys in the 1980's  | 12               |    |    |    | x  |    |             |              | x             |             |                        |            |        |          |             |             |           |              |          |         |            |       |          |               |         |            |     |      |      |            |          |   |              |   |
| 4<br>1 | Statewid<br>e Water<br>Ambient<br>Monitoring<br>Program<br>(SWAMP) | SWAMP data currently consists of field observations, discrete field measures and laboratory, bacteria indicators, and toxicity results for sediment and water samples throughout the state of California. Tissue, bioassessment (organisms and physical habitat) and time series data are being added to the database. | 5,<br>6,<br>7    |    | x  | x  |    |    |             |              | x             |             |                        |            |        | x        | x           | x           | x         |              |          |         |            |       |          |               |         |            |     |      |      |            |          | <a href="http://www.swrcb.ca.gov/water_issues/programs/swamp/">http://www.swrcb.ca.gov/water_issues/programs/swamp/</a> |              |   |

mussel tissue, bacteria

pH, sediment

| I<br>D | Project<br>Name  | Project Description  | Charact.<br>ID # | OC | CB | GF | MB | CI | Chlorophyll<br>Fluorescence | Phytoplankton | Zooplankton | Juvenile<br>Adult inverts | Ichthyoplankt<br>Juvenile fish | Adult fish | Marine<br>Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Currents | Transmittance | Weather | Barometric<br>PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |   |   |
|--------|--|--|------------------|----|----|----|----|----|-----------------------------|---------------|-------------|---------------------------|--------------------------------|------------|--------------------|-------------|-----------|--------------|----------|---------|------------|-------|----------|---------------|---------|-------------------|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|---|---|
|        |  |  |                  |    |    |    |    |    |                             |               |             |                           |                                |            |                    |             |           |              |          |         |            |       |          |               |         |                   |      |      |            |          |           |              |       |                |             |   |   |
| 4<br>2 | OCNMS<br>offshore<br>cetacea<br>n and<br>seabird<br>surveys                                | Binocular and naked-eye surveys using ship-based line transects following permanent east-west tracklines; photo ID catalogue collected. Annual surveys in late May to July since 1995.     | 15               | x  |    |    |    |    |                             |               |             |                           |                                |            | x                  | x           |           |              |          |         |            |       |          |               |         |                   |      |      |            |          |           |              |       |                |             |   |   |
| 4<br>3 | Deep<br>Sea<br>Corals  | Expeditions to inventory deep sea corals from Olympic Coast NMS (in 2006) and the Davidson Seamount (in 2002 and 2006).  | 9                | x  |    |    | x  |    |                             |               |             | x                         | x                              |            |                    |             |           | x            |          |         | x          | x     |          |               |         |                   |      |      |            |          |           |              |       |                |             | <a href="http://olympiccoast.noaa.gov/research/research_feat/welcome.htm">http://olympiccoast.noaa.gov/research/research_feat/welcome.htm</a> |   |
| 4<br>4 | Sanctuary<br>Aerial<br>Monitoring<br>and<br>Spatial<br>Analysis<br>Program<br>(SAMSA<br>P) | Aerial surveys over the Channel Islands NMS from 1999-2004 primarily for looking at vessel use/traffic of all vessel, but marine mammal sightings are also taken.                          | 15               |    |    |    |    | x  |                             |               |             |                           |                                |            | x                  |             |           |              |          |         |            |       |          |               |         |                   |      |      |            |          |           |              |       |                |             |   |   |
| 4<br>5 | Coastal<br>LIDAR<br>Collection   | Light Detection and Ranging (LIDAR) is being used by NOAA and NASA scientists to document topographic changes along shorelines. LIDAR data collected along the U.S. west coast since 1997. | 2,<br>3          | x  |    | x  | x  | x  |                             |               |             |                           |                                |            |                    |             |           |              |          |         |            |       |          |               |         |                   |      |      |            |          |           |              |       |                |             |   | <a href="http://www.csc.noaa.gov/crs/tcm/about_lidar.html">http://www.csc.noaa.gov/crs/tcm/about_lidar.html</a>     |
| 4<br>6 | USFW<br>seabird<br>colony<br>surveys   | Annual surveys of seabird colonies in the Olympic Coast sanctuary conducted by USFW.   | 15               | x  |    |    |    |    |                             |               |             |                           |                                |            | x                  |             |           |              |          |         |            |       |          |               |         |                   |      |      |            |          |           |              |       |                |             |   |   |
| 4<br>7 | USGS<br>Pacific<br>Coast<br>habitat<br>mapping<br>program                                  | Various remotely-sensed data available for download. Primarily sidescan.   | 4                | x  | x  | x  | x  | x  |                             |               |             |                           |                                |            |                    |             |           |              |          |         |            |       |          |               |         |                   |      |      |            |          |           |              |       |                |             |   | <a href="http://kai.er.usgs.gov/regional/contusa/westcoast/">http://kai.er.usgs.gov/regional/contusa/westcoast/</a> |

| ID | Project Name   | Project Description   | Charact. ID # | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |       |        |  |   |
|----|--|---|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|-------|--------|--|---|
|    |  |   |               |    |    |    |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             | algae | precip |  |   |
| 48 | Long-term Monitoring Program & Experiential Training for Students (LiMPE TS) | The LiMPE program began in 2002. Middle school, high school, and other volunteer groups monitor the rocky intertidal, sandy shore and offshore areas of the five west coast National Marine Sanctuaries.  | 10, 11        | x  |    | x  | x  | x  |             |              |               |             |          |               | x             |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |       |        |  | <a href="http://limpetsmonitoring.org/">http://limpetsmonitoring.org/</a>                                 |
| 49 | USGS Water Quality Monitoring  | The USGS collects and analyzes chemical, physical, and biological properties of water, sediment and tissue samples from across the Nation. The NWISWeb discrete sample data base is a compilation of over 4.4 million historical water quality analyses in the USGS district data bases through September 2005. 1958-present. |               | x  |    | x  | x  | x  |             |              |               |             |          |               |               |               |            |        |          |             | x         |              |          | x       | x          |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |       |        |  | <a href="http://waterdata.usgs.gov/nwis/qw">http://waterdata.usgs.gov/nwis/qw</a>                         |
| 50 | Pacific Jets Experiment (PACJET)   | The goal of PACJET was to understand land-falling winter storms and test the use of new observing systems to understand these storms and generate products to improve National Weather Service (NWS) predictions of rainfall and runoff. This project ran 3 storm seasons (2001-2003) in California and Oregon.               |               |    |    | x  | x  | x  |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       | x        |          | x             | x       |            |     |      |      |            |          |           |              |       |                |             |       |        |  | <a href="http://www.etl.noaa.gov/programs/2003/pacjet/">http://www.etl.noaa.gov/programs/2003/pacjet/</a> |

| I<br>D | Project<br>Name  | Project Description  | Charact. ID # | OC | CI | MB | GF | CB | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wave | Wind | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |      |           |   |  |  |   |
|--------|--|--|---------------|----|----|----|----|----|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|------|-----------|---|--|--|---|
|        |  |  |               |    |    |    |    |    |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             | flow | atm gases |   |  |  |   |
| 51     | Santa Barbara Coastal Long Term Ecological Research Program (SBC LTER) | The primary research objective of the SBC LTER is to investigate the relative importance of land and ocean processes in structuring giant kelp forest ecosystems. This monitoring program began in 2000.   |               |    | x  |    |    |    |              |               |             |          |               |               |               |            |        |          |             |           | x            |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |      |           | <a href="http://sbc.lternet.edu/">http://sbc.lternet.edu/</a> |  |  |   |
| 52     | Automated Surface Observing System (ASOS)                              | ASOS stations are automated weather stations designed to provide pilots and meteorologists with near real-time weather conditions. This system began data collection in 1998.  | 1             |    |    |    |    |    |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          | x        |               |         |            |     |      |      |            |          |           |              |       |                |             |      |           |   |  |  | <a href="http://www.weather.gov/ost/asostech.html">http://www.weather.gov/ost/asostech.html</a> |
| 53     | Advanced Global Atmospheric Gases Experiment (AGAGE)                   | Continuous high-frequency gas chromatographic measurements of two biogenic/anthropogenic gases and five anthropogenic gases to determine the source and circulation. The stations are located at coastal sites around the world, with one site at Trinidad Head, California. 1995-present. |               |    |    |    |    | x  |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |      |           |   |  |  | <a href="http://agage.eas.gatech.edu/">http://agage.eas.gatech.edu/</a>                         |

| ID | Project Name   | Project Description   | Charact. ID # | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |   |   |    |   |
|----|--|---|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|---|---|----|---|
|    |  |   |               |    |    |    |    |    |             |              |               |             |          |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             | human activity, dog activity, live bird and mammal counts | relevant stream conditions, tar balls   | pH |   |
| 54 | Beach Watch  | Beach Watch is a long-term shoreline monitoring project that was founded in 1993. Volunteers conduct monthly surveys of assigned beaches within the Gulf of the Farallones and Monterey Bay National Marine Sanctuaries. Data is collected on live and dead species of birds and marine mammals as well as oil pollution. | 8, 11         |    |    | x  | x  |    |             |              |               |             |          |               |               |            |        | x        | x           |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |   | <a href="http://www.farallones.org/volunteer/beach_watch.htm">http://www.farallones.org/volunteer/beach_watch.htm</a> |    |   |
| 55 | Spatial Ecological Analysis of Megavertebrate Populations (SEAMAP) | As part of Ocean Biological Information System (OBIS), SEAMAP is a digital database of marine mammal, seabird, and sea turtle distribution and abundance data. The web-based system allows the interactive display, query, and analysis of Digital Archive in conjunction with environmental data.                        | 1             | x  | x  | x  | x  | x  |             |              |               |             |          |               |               |            |        | x        | x           |           |              | x        | x       | x          | x     |          | x        |               |         |            |     |      |      |            |          |           |              |       |                |             |   |   |    | <a href="http://seamap.env.duke.edu/">http://seamap.env.duke.edu/</a>   |
| 56 | First Flush  | First Flush is a volunteer water quality sampling program run by the Monterey Bay Sanctuary Citizen Watershed Monitoring Network. Beginning in 2000, runoff has been sampled after the first rain each year at 12 different sites in the cities of Monterey, Pacific Grove and Capitola, CA.                              | 5             |    |    |    |    | x  |             |              |               |             |          |               |               |            |        |          |             | x         |              | x        |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |   |   |    | <a href="http://www.coastal-watershed.org/Programs/First_Flush/index.htm">http://www.coastal-watershed.org/Programs/First_Flush/index.htm</a> |

| I<br>D | Project<br>Name   | Project Description  | Charact. ID # | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |  |  |   |  |   |   |
|--------|---|--|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|--|--|---|--|---|---|
|        |   |  |               |    |    |    |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |  |   |  |   |   |
| 57     | Monterey Inner Shelf Observatory (MISO)                               | MISO is part of the Rapid Environmental Assessment Lab (REAL) at the Naval Postgraduate School in Monterey, California. The MISO instruments, which record nearshore oceanographic conditions, are located on shore and 600m out from the beach adjacent to the Naval Postgraduate School at the southern end of Monterey Bay. | 2             |    |    |    | x  |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |  | <a href="http://www.oc.nps.navy.mil/~stanton/miso/">http://www.oc.nps.navy.mil/~stanton/miso/</a> |  |   |   |
| 58     | Bodega Marine Laboratory Coastal Observing System (BML-COS)           | Meteorological and oceanographic conditions on the Bodega Marine Reserve and adjacent coastal waters have been continuously monitored since 1988.  | 1             |    |    | x  |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           | x            | x        |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |  |   |  |   | <a href="http://www.bml.ucdavis.edu/boon/">http://www.bml.ucdavis.edu/boon/</a> |
| 59     | Partnership for the Interdisciplinary Study of Coastal Oceans (PISCO) | PISCO conducts experiments & long-term monitoring of west coast nearshore ecosystems (e.g., rocky intertidal, kelp forest and rocky reef). Components include nearshore oceanography, larval dispersal, recruitment, physiology, ecological interactions, community structure. Began in 1999.                                  | 9, 10, 12, 14 | x  |    | x  | x  | x  |             |              |               |             | x        | x             |               | x             | x          |        |          |             |           |              |          | x       |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |  |   |  | <a href="http://www.piscoweb.org/">http://www.piscoweb.org/</a> |   |









| I<br>D | Project<br>Name                          | Project Description   | Charact. ID # | OC | GF | MB | CI | Chlorophyll<br>Fluorescence | Phytoplankton | Zooplankton | Juvenile<br>Adult inverts | Ichthyoplankt<br>Juvenile fish<br>Adult fish | Marine<br>Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Currents | Transmittance | Weather | Barometric<br>PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL   |
|--------|--|---|---------------|----|----|----|----|-----------------------------|---------------|-------------|---------------------------|--|--------------------|-------------|-----------|--------------|----------|---------|------------|-------|----------|---------------|---------|-------------------|------|------|------------|----------|-----------|--------------|-------|----------------|---|
|        |  |   |               |    |    |    |    |                             |               |             |                           |  |                    |             |           |              |          |         |            |       |          |               |         |                   |      |      |            |          |           |              |       |                |   |
| 6<br>9 | Humboldt Line                            | Monitoring of ocean structure and the spatial distribution of plankton species including egg and larval stages of fish and select invertebrate species along a 60 nautical mile cross-shelf transect off Trinidad Head. Quarterly sampling by HSU and SWFSC, starting April 2006. | 1             | x  | x  |    |    | x                           | x             |             | x                         |  |                    |             |           | x            | x        | x       |            |       |          |               |         |                   |      |      |            |          |           |              |       |                | <a href="http://www.pacoos.org">www.pacoos.org</a>                    |
| 7<br>0 | Remote Automated Weather Stations (RAWS) | There are nearly 2,200 interagency RAWS strategically located throughout the United States. These land-based stations collected meteorological data.  |               |    |    |    |    |                             |               |             |                           |  |                    |             |           |              |          |         |            |       |          |               | x       |                   | x    |      |            |          |           |              |       |                | <a href="http://www.fs.fed.us/ra_ws/">http://www.fs.fed.us/ra_ws/</a> |
| 7<br>1 | SWFSC Central California Aerial Surveys  | Aerial surveys to quantify the spatial and temporal distribution of marine mammals, seabirds and leatherback turtles in coastal waters of central California. Began in 1997.  | 15            | x  | x  | x  |    |                             |               |             |                           |  | x                  | x           |           |              |          |         |            |       |          |               |         |                   |      |      |            |          |           |              |       |                |   |

| I<br>D | Project<br>Name                  | Project Description  | Charact. ID # | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |             |  |  |  |  |  |   |
|--------|----------------------------------|--|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|-------------|--|--|--|--|--|---|
|        |                                  |  |               |    |    |    |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             | PCB, metals |  |  |  |  |  |   |
| 7<br>2 | REEF<br>Volunteer Survey Project | The Reef Environmental Education Fund (REEF) Volunteer Survey Project enlists volunteer SCUBA divers and snorkelers to collect and report information on marine fish populations (Fish Survey Project) as well as selected invertebrate and algae species (Invertebrate & Algae Monitoring Program) along the West Coast of the US and Canada. The Project was developed in 1990. Surveys are completed annually in MBNMS, OCNMS, and CINMS. | 12            | x  |    |    | x  | x  |             |              |               |             | x        |               | x             |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |             |  |  |  |  |  | <a href="http://www.reef.org/">http://www.reef.org/</a>   |
| 7<br>4 | CCSF Beach and Ocean Monitoring  | The City and County of San Francisco (CCSF) owns and operates the Oceanside Water Pollution Control Plant that discharges municipal wastewater and storm water approximately 3.75 miles offshore of Ocean Beach. Approximately 55 stations are sampled annually for sediment quality and benthic infauna community analyses (sampled since 1997). Five stations fall within the GFNMS and ten stations fall within the MBNMS.                | 13            |    |    | x  | x  |    |             |              |               |             | x        |               | x             |               |            |        |          |             |           | x            |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |             |  |  |  |  |  | <a href="http://www.mbnms-simon.org/sections/sandyFloor/project_info.php?pid=100212&amp;sec=sf">http://www.mbnms-simon.org/sections/sandyFloor/project_info.php?pid=100212&amp;sec=sf</a> |

| I<br>D | Project<br>Name  | Project Description   | Charact. ID # | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |  |  |  |  |   |
|--------|--|---|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|--|--|--|--|---|
|        |  |   |               |    |    |    |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |  |  |  |   |
| 7<br>5 | Center<br>for<br>Integrati<br>ve<br>Coastal<br>Observa<br>tion,<br>Researc<br>h and<br>Educati<br>on (CI-<br>CORE) | CI-CORE examines watershed alteration, erosion, chemical contamination, depletion of fish stocks, toxic plankton blooms, marine-borne pathogens, and non-indigenous species along the California coast.   | 2             |    |    |    | x  |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |  |  |  | <a href="http://www.cicore.org/">http://www.cicore.org/</a>   |
| 7<br>6 | Coopera<br>tive<br>Researc<br>h and<br>Assess<br>ment of<br>Nearsho<br>re<br>Ecosyst<br>ems<br>(CRANE<br>)         | CRANE, which began in 2002, is a collaborative effort to gather data for fishery management and performance of marine protected areas in central and southern California. Data collection includes wide-scale survey of fish and invertebrate populations in shallow, rocky habitats accessible to divers (Monterey to San Diego, including the Channel Islands). | 12            |    |    |    | x  | x  |             |              |               |             | x        |               |               |               |            |        |          |             |           |              |          |         |            |       |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |  |  |  | <a href="http://sanctuariesimon.org/monterey/sections/kelpForests/project_info.php?projectID=100154&amp;sec=kf">http://sanctuariesimon.org/monterey/sections/kelpForests/project_info.php?projectID=100154&amp;sec=kf</a> |

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|--------|---|---|---------------|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|--|--|--|---|--|--|---|--|
|        |   |   |               |    |    |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |  |  |   |  |  |   |  |
| 7<br>7 | Habitat<br>Characterization and Biological Monitoring of Cordell Bank | In 2001, Cordell Bank sanctuary, in partnership with the SWFSC, USGS, and CDFG, initiated a long-term study to classify habitats and monitor fishes and macro-invertebrates on and around Cordell Bank. Underwater surveys of fishes, invertebrates, and their habitats are conducted on and around Cordell Bank using direct observation and video-transect methods from an occupied research submersible (Delta). | 9,<br>12      | x  |    |    |    |             |              |               |             | x        |               | x             |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |  |  | <a href="http://www.mbnms-simon.org/other/gen/project_info.php?pid=100163&amp;proid=&amp;form=pi">http://www.mbnms-simon.org/other/gen/project_info.php?pid=100163&amp;proid=&amp;form=pi</a> |  |  |   |  |
| 7<br>8 | Love<br>Lab<br>subtidal<br>surveys                                    | Subtidal surveys at San Miguel and Santa Rosa Islands using the CRANE protocol. Includes monitoring of marine reserves. Began in 1995.  | 12            |    |    |    | x  |             |              |               |             |          |               |               |               | x          |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |  |  |   |  |  |   |  |
| 7<br>9 | Coastal<br>Ocean<br>Currents<br>Monitoring<br>Program<br>(COCMP)      | COCMP uses an integrated set of high frequency radar systems to measure and map surface currents over large areas of the coastal ocean in central and southern California. Began in 2004.   | 1             |    | x  | x  | x  |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          | x             |         |            |     |      |      |            |          |           |              |       |                |             |  |  |  |   |  |  | <a href="http://www.cocmp.org/">http://www.cocmp.org/</a> |  |

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|--------|---|---|---------------|----|----|----|----|----|-----------------------------|---------------|-------------|---------------------------|--------------------------------|------------|--------------------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|-------------------|------|------|------------|----------|-----------|--------------|-------|----------------|---|
|        |   |   |               |    |    |    |    |    |                             |               |             |                           |                                |            |                    |             |           |              |          |         |            |       |          |          |               |         |                   |      |      |            |          |           |              |       |                |   |
| 80     | Pacific Whiting Conservation Cooperative (PWCC) surveys | To improve estimates of whiting recruitment, the PWCC partners with NMFS to conduct an annual survey. Started in 1999, this cooperative survey investigates the abundance and distribution of juvenile whiting and rockfish in the California Current.  | 14            | x  |    |    |    |    |                             |               |             |                           |                                |            | x                  |             |           |              |          |         |            |       |          |          |               |         |                   |      |      |            |          |           |              |       |                | <a href="http://www.pacificwhiting.org/">http://www.pacificwhiting.org/</a>   |
| 81     | PRBO At-Sea Marine Mammal and Seabird Surveys           | Surveys in the Gulf of the Farallones to determine the distribution and abundance of marine birds and mammals, to quantify the distribution and abundance of euphausiids and other bird/mammals prey, to characterize the zooplankton community in the upper water column, and to characterize the physical oceanographic conditions. |               |    | x  | x  |    |    |                             | x             |             |                           |                                |            | x                  | x           | x         | x            | x        | x       | x          |       |          |          |               |         | x                 | x    |      |            |          |           |              |       |                | <a href="http://www.sanctuarysiemon.org/farallones/sections/marineMammals/project_info.php?projectId=91&amp;sec=mm">http://www.sanctuarysiemon.org/farallones/sections/marineMammals/project_info.php?projectId=91&amp;sec=mm</a> |
| 82     | PIER Acoustic Telemetry Monitoring                      | PIER has installed an array of acoustic receivers at Anacapa, Santa Rosa, west end of Santa Cruz Island to monitor the movement of tagged fishes (e.g., kelp bass, California sheephead). Began in 2004.  |               |    |    |    |    | x  |                             |               |             |                           |                                |            | x                  |             |           |              |          |         |            |       |          |          |               |         |                   |      |      |            |          |           |              |       |                |   |

| ID | Project Name  | Project Description  | Charact. ID # |    |    |    |    |    |             |              |               |             |          |               | Project URL |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |   |
|----|---|--|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|-------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|---|
|    |   |  |               | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts |             | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical |   |
| 83 | Pioneer Seamount Acoustic Observatory   | A hydrophone array was installed on the summit of the Pioneer seamount (998m depth) and sounds from earthquakes, weather, whales, ships, etc. were continuously recorded between June 2001 and September 2002. |               | x  | x  |    |    |    |             |              |               |             |          |               |             |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                | <a href="http://www.mbari.org/itd/retrospective/algal.html">http://www.mbari.org/itd/retrospective/algal.html</a> |
| 84 | Point Lobos Monterey Bay Time Series  | Bio-optical, physical, meteorological, chemical, and biological time series data from moorings and ships are used document annual and ENSO-related variability. Began in 1997.                                 | 1             |    |    |    | x  |    |             |              |               |             |          |               |             |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |   |
| 85 | Remote Sensing of CINMS   | Various - multibeam and LiDAR Channel Islands and southern CA  |               |    |    |    |    | x  |             |              |               |             |          |               |             |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |   |
| 86 | San Francisco Estuary Research Institute's Regional Monitoring Program (SFEI RMP) | SFEI RMP monitors contaminant concentrations in water, sediments, and fish and shellfish tissue in San Francisco Bay and Delta. Began in 1994.   | 5, 6, 7       |    |    |    | x  |    |             |              |               |             |          |               |             |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |   |

| I<br>D | Project<br>Name             | Project Description  | Charact. ID # |    |    |    |    |    |             |              |               |             |          |               | Project URL |               |               |            |        |          |             |           |              |          |         |            |       |          |               |         |            |     |      |      |            |   |           |   |
|--------|-----------------------------|--|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|-------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|---------------|---------|------------|-----|------|------|------------|---|-----------|---|
|        |                             |  |               | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts |             | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan  | Multibeam | Habitat type  |
| 8<br>7 | Shore<br>Station<br>Program | The Shore Stations Program, which began in 1916, collects and provides access to current and historical data records of sea surface temperature and salinity measurements observed at shoreline stations along the west coast of the United States. Historically, stations ranged from the southern most station in La Jolla, California, up to the northern most point on the western coast, Neah Bay, Washington. All active stations are located in California. | x             | x  | x  |    |    |    |             |              |               |             |          |               |             |               |               |            |        |          |             |           |              |          |         |            |       |          |               |         |            |     |      |      |            |   |           | <a href="http://shorestation.ucsd.edu/">http://shorestation.ucsd.edu/</a> |
| 8<br>8 | Mussel<br>Watch<br>Program  | The NOAA National Status and Trends Mussel Watch Project monitors chemical contamination in the coastal United States. Since 1986 mussels and oysters have been annually collected at more than 200 sites around the nation and chemically analyzed for a suite of chemical contaminants.  | 6,<br>8       | x  | x  |    |    |    |             |              | x             |             |          |               |             |               |               |            |        |          |             |           |              |          |         |            |       |          |               |         |            |     |      |      |            | <a href="http://www.sfei.org/camp/servlet/DisplayProgram?which=General&amp;pid=1SF01NSTMW">http://www.sfei.org/camp/servlet/DisplayProgram?which=General&amp;pid=1SF01NSTMW</a> |           |   |



| I<br>D | Project<br>Name   | Project Description   | Charact. ID # | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wave | Wind | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |   |     |   |
|--------|---|---|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|---|-----|---|
|        |   |   |               |    |    |    |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             | DNA seq   | HAB |   |
| 8<br>9 | MBARI<br>Environmental<br>Sample<br>Process<br>or (ESP) | The ESP was developed at the Monterey Bay Aquarium Research Institute (MBARI) and is designed to autonomously collect discrete subsurface water samples, concentrate microorganisms or particles, and identify and quantify the species captured. The ESP has also been used to detect the onset and development of a harmful algal bloom (HAB). One trial was conducted in Monterey Bay in 2002 and a second generation ESP was deployed in spring 2006. | 8             |    |    |    | x  |    | x           | x            |               |             |          |               |               |               |            |        |          |             |           | x            | x        | x       | x          | x     | x        |          |               |         |            |     |      |      |            |          |           |              |       |                |             | <a href="http://www.mbari.org/ESP/">http://www.mbari.org/ESP/</a> |     |   |
| 9<br>0 | ESNER<br>R bird<br>monitoring<br>programs               | The Elkhorn Slough National Estuarine Research Reserve (ESNERR) has seven distinct, volunteer-run bird monitoring projects including: Monitoring the Rookery, Monitoring the Caspian Tern Colony, Shorebird and Waterfowl Monitoring on the Reserve (and Elkhorn Slough), Monitoring Habitat Use in the south marsh.  | 15            |    |    |    | x  |    |             |              |               |             |          |               |               |               |            |        | x        |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |   |     | <a href="http://www.elkhornslough.org/research/biomonitor_bird.htm">http://www.elkhornslough.org/research/biomonitor_bird.htm</a> |

| I<br>D | Project<br>Name                                | Project Description  | Charact. ID # | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wave | Wind | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |       |               |   |
|--------|--|--|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|-------|---------------|---|
|        |  |  |               |    |    |    |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             | algae | wave exposure |   |
| 91     | Multi-Agency Rocky Intertidal Network (MARINE) | MARINE monitors sites along the Pacific Coast using two different approaches - target assemblage monitoring (biannually at 80 locations in California and Oregon), and biodiversity community monitoring (less frequent at 91 locations from Alaska to Mexico). Sites are selected to provide data about different rocky habitats, different exposure variables, different public uses.  | 10            |    |    | x  | x  | x  |             |              |               |             |          | x             |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |       |               | <a href="http://www.marine.gov">http://www.marine.gov</a>                   |
| 92     | ESNER elasmobranch monitoring programs         | Elkhorn Slough National Estuarine Research Reserve (ESNERR) has been monitoring the elasmobranch assemblage in Elkhorn Slough since 2002. The general focus is to investigate the affect of tides on elasmobranch assemblages and abundances at various points along the Elkhorn Slough. These sampling sites included the main channel at the mouth of the slough and several of the tidal creeks and lagoons throughout the reserve. | 11            |    |    |    |    | x  |             |              |               |             |          |               | x             |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |       |               | <a href="http://www.pelagic.org/slough/">http://www.pelagic.org/slough/</a> |



| I<br>D | Project<br>Name                       | Project Description  | Charact. ID # | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |  |   |  |   |
|--------|---------------------------------------|--|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|--|---|--|---|
|        |                                       |  |               |    |    |    |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |   |  |   |
| 9<br>5 | PRNS<br>Intertidal<br>Monitoring      | The Point Reyes National Seashore (PRNS) intertidal monitoring program began in 1996. Sites are surveyed twice a year, usually around November and May, during a low tide series. Surveys are conducted on the rocky intertidal in three locations. The objective of this monitoring is to create a system for long-term tracking of the Point Reyes intertidal environment integrity.   | 10            |    |    | x  |    |    |             |              |               |             |          |               | x             |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  | <a href="http://www.nps.gov/archive/pore/science_current_resmgt.htm">http://www.nps.gov/archive/pore/science_current_resmgt.htm</a> |  |   |
| 9<br>6 | PRBO<br>Snowy<br>Plover<br>monitoring | PRBO Conservation Science has two monitoring projects for Snowy Plover, one in Monterey Bay and one at Point Reyes. Since 1976, the Monterey project has monitored Snowy Plovers nesting in coastal habitats of Santa Cruz and Monterey counties. Since 1996, the Point Reyes project has been protecting and monitoring nesting Snowy Plovers within the Point Reyes National Seashore. | 11            |    |    |    | x  | x  |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |   |  | <a href="http://www.prbo.org/cms/index.php?mid=126">http://www.prbo.org/cms/index.php?mid=126</a> |



| I<br>D | Project<br>Name                          | Project Description   | Charact. ID # | OC | CB | GF | MB | CI | Chlorophyll | Fluorescence | Phytoplankton | Zooplankton | Juvenile | Adult inverts | Ichthyoplankt | Juvenile fish | Adult fish | Marine | Seabirds | Other - bio | Nutrients | Dissolved O2 | Salinity | Density | Water temp | Depth | Air temp | Currents | Transmittance | Weather | Barometric | PAR | Wind | Wave | Aerial/sat | Sidescan | Multibeam | Habitat type | LIDAR | Other-physical | Project URL |  |   |  |  |   |
|--------|--|---|---------------|----|----|----|----|----|-------------|--------------|---------------|-------------|----------|---------------|---------------|---------------|------------|--------|----------|-------------|-----------|--------------|----------|---------|------------|-------|----------|----------|---------------|---------|------------|-----|------|------|------------|----------|-----------|--------------|-------|----------------|-------------|--|---|--|--|---|
|        |  |   |               |    |    |    |    |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |   |  |  |   |
| 99     | ESNER R invertebrate monitoring programs | The Elkhorn Slough National Estuarine Research Reserve (ESNERR) is monitoring crabs and large burrowing invertebrates (e.g., clams, fat innkeeper worms, ghost shrimp) - two groups of large, relatively easy to identify invertebrates. The goals are to detect dramatic changes in abundance, species diversity, and distribution.  | 11            |    |    |    | x  |    |             |              |               |             |          |               |               |               |            |        |          |             |           |              |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  | <a href="http://www.elkhornsloUGH.org/research/biomonitor_invert.htm">http://www.elkhornsloUGH.org/research/biomonitor_invert.htm</a> |  |  |   |
| 100    | Snapshot Day                             | Each years since 2003 watershed groups from across the state participate in the California Coast-Wide Snapshot Day, with the goal of collecting important information about the health of coastal waters flowing into the Pacific Ocean. Snapshot Day volunteers collected water samples at 565 creeks, rivers, wetlands, and beaches from the Oregon border to Ensenada, Mexico. | 5,6           |    |    | x  | x  | x  |             |              |               |             |          |               |               |               |            |        |          |             |           | x            |          |         |            |       |          |          |               |         |            |     |      |      |            |          |           |              |       |                |             |  |   |  |  | <a href="http://www.mbnms-simon.org/other/gen/project_info.php?pid=100142&amp;query=snapshot&amp;form=kw">http://www.mbnms-simon.org/other/gen/project_info.php?pid=100142&amp;query=snapshot&amp;form=kw</a> |

PO4, NO3



## **Appendix 2 – Background Information on IEA Efforts in CCE**

### **Atlantis Model for CCE**

Atlantis is a simulation modeling approach developed by Commonwealth Scientific and Industrial Research Organization (CSIRO) scientists in Australia (Fulton 2004, Fulton et al. 2005). In Atlantis, ecosystem dynamics are represented by spatially-explicit sub-models that simulate hydrographic processes (light- and temperature-driven fluxes of water and nutrients), biogeochemical factors driving primary production, and foodweb relations among functional groups. The Atlantis approach has been adapted to the California Current Ecosystem by scientists at the Northwest Fisheries Science Center (Brand et al. 2007). Currently, the Northwest Fisheries Science Center is creating an Atlantis ecosystem model at the Central California sub-regional scale. The central California model is including additional sub-regional scale data and monitoring information. The modeling team has built a network of collaborators and has identified management scenarios and data outputs that will be relevant to the management needs of their state and federal collaborators.

The CCE and central California Atlantis models are intended as a strategic management tools that will allow the identification of trade-offs and to identify direct and indirect effects of management policies. The Atlantis framework will be used in management strategy evaluation, in which management policies and assessment methods are tested against simulations that represent a real ecosystem and its complexities. The ecosystem model can serve as a filter to identify which policies (e.g., marine protected areas placement and monitoring) and methods (e.g., stock assessment techniques) are promising and which are flawed or likely to be ineffective. In addition the model can be used to develop a range of scenarios that consider tradeoffs and benefits of the multi-agency management of the fisheries (state, fisheries council, and National Marine Sanctuaries). Within the context of IEAs, the model will be used for performance testing of indicators, development of ecologically-based management targets, monitoring strategy evaluation, and possibly for semi-quantitative risk assessment.

### **Module I, CCE (Sydeman and Elliott 2008)**

The Module I California Current Ecosystem IEA by Sydeman and Elliot (2008) takes a biological indicator approach to developing an IEA. They have compiled time-series data sets of both physical oceanography and key biological organisms. Key biological organisms include forage species (e.g., krill, plankton) top-level vertebrate predators of significant management concern, such as salmon and seabirds. The objectives of this effort are used to determine trends in the abundance of indicator species to understand both recent and long-term changes in the ecosystem. An additional goal of this initial effort was to identify gaps in knowledge. Module I does not include socio-economic data and other human-related data, though this type of data may be included in subsequent



modules. Module I did not forecast future conditions, but this is a likely direction for subsequent modules.

### **NCEAS CCME Human Impact Assessment (Halpern et al. 2009)**

This project aims to understand and map how human activities are affecting marine ecosystems in the California Current, a region defined in this study as the coastal marine area between the U.S.-Canada border and central Baja, Mexico. The project builds upon previous work by collaborators from the National Center for Ecological Analysis and Synthesis (NCEAS) and Stanford University, which mapped human impacts on marine ecosystems globally. One objective of this study is the synthesis of spatial data on the distribution and intensity of human activities and the overlap of their impacts on marine ecosystems. The authors identified anthropogenic drivers of ecological change for 18 marine ecosystems in the California Current and then determined the availability of data sets to model the impacts of those drivers (Table 5). This project aims to help determine how to allocate conservation and management resources, to implement ecosystem-based management, and to inform marine spatial planning, education, and basic research.

### **ONMS SWiM Condition Reports**

Each site in the Office of National Marine Sanctuaries (ONMS) is in the process of developing, reviewing and issuing their condition reports. The reports are part of the ONMS System-Wide Monitoring framework that facilitates the development of effective, ecosystem-based monitoring programs that address management information needs using a design process that can be applied in a consistent way at multiple spatial scales and to multiple resource types. The condition reports are developed based on a Pressure-State-Response framework (PSR) – they provide a summary of natural and anthropogenic pressures on resources in the National Marine Sanctuaries, the current status and trends of resource conditions, and management responses to the anthropogenic pressures affecting resources. The PSR framework allows managers to both prioritize management actions and evaluate their effectiveness in meeting conservation or restoration goals.

The “state” section of the condition reports centers on a set of questions used as evaluation criteria to assess resource conditions and trends within each sanctuary. The questions derive from the Office of National Marine Sanctuaries mission and a system-wide monitoring framework. Resource status relating to each question is rated on a scale from good to poor and trends in the status of resources are also reported. In order to address the set of questions and thereby evaluate the status and trends of resources, sanctuary staff selected and consulted outside experts familiar with water quality, living resources, habitat, and maritime archaeological resources.

The ONMS condition reports may be accessed from the ONMS Web site:  
<http://sanctuaries.noaa.gov/science/condition>.

## **Background Information on MBCORC Report Card and Virtual Monterey Bay**

The mission of the Monterey Bay Crescent Ocean Research Consortium (MBCORC) is to promote the scientific understanding of coastal and marine systems and to facilitate the application of that knowledge for public policy, environmental awareness, and decision making. MBCORC achieves its objectives by creating, coordinating, promoting, and endorsing research, education, and outreach activities, using the Monterey Bay as a natural laboratory. This group meets periodically to discuss projects of joint regional effort. Two of those projects are:

- **Monterey Bay Ecosystem Report Card:** Producing an ecosystem report card/set of ecosystem indicators for the Monterey Bay region/Central California. This effort has been focused on identifying indicators of interest and determining the availability of associated monitoring data for the Monterey Bay area.
- **Oceanographic Modeling Workshop:** Conducting one or more oceanographic modeling workshops to foster sharing and transfer of knowledge and expertise among MBCORC members. The first workshop was held in 2007.

### **Appendix 3 – Acronyms and Abbreviations**

AFSC: Alaska Fisheries Science Center  
Beach COMBERS: Coastal Ocean Marine Mammal & Bird Education and Research Surveys  
CalCOFI: California Cooperative Oceanic Fisheries Investigations  
CBNMS: Cordell Bank National Marine Sanctuary  
CBOMP: Cordell Bank Ocean Monitoring Program  
CCAMP: Central Coast Ambient Monitoring Program  
CCE: California Current Ecosystem  
CCLEAN: Central Coast Long Term Environmental Network  
CCSF: City and County of San Francisco  
CIMT: Center for Integrated Marine Technologies  
CINMS: Channel Islands  
CINP: Channel Island National Park  
COASST: Coastal Observation and Seabird Survey Team  
COCMP: Coastal Ocean Currents Monitoring Program  
CRANE: Cooperative Research and Assessment of Nearshore Ecosystems  
CRFS: Recreational Fisheries Survey  
CSUMB: California State University, Monterey Bay  
DPSIR: Driver, Pressure, State, Impact, Response  
DFO: Department of Fisheries and Oceans Canada  
EAM: Ecosystem Approach to Management  
EFH: Essential Fish Habitat  
EPA: Environmental Protection Agency  
FAO: Food and Agriculture Organization of the United Nations  
GFNMS: Gulf of the Farallones National Marine Sanctuary  
HABs: Harmful Algal Blooms  
IEA: Integrated Ecosystem Assessment  
IOOS: Integrated Ocean Observing System  
LOBO: Land/Ocean Biogeochemical Observatory  
MARINE: Multi-Agency Rocky Intertidal Network  
MBARI: Monterey Bay Aquarium Research Institute  
MBCORC: Monterey Bay Crescent Ocean Research Consortium  
Monterey Bay Time Series (MBTS) Program  
MBNMS: Monterey Bay National Marine Sanctuary  
MEI: Multivariate El Niño Index  
MOOS: MBARI Ocean Observing System  
NCCE: Northern California Current Ecosystem  
NCEAS: National Center for Ecological Analysis and Synthesis  
NDBC: National Data Buoy Center  
NERR: National Estuarine Research Reserve  
NGDC: National Geophysical Data Center  
NMFS: National Marine Fisheries Service  
NMS: National Marine Sanctuary

NOAA: National Oceanic and Atmospheric Administration  
NODC: National Oceanographic Data Center  
NWFSC: Northwest Fisheries Science Center  
OCNMS: Olympic Coast National Marine Sanctuary  
ONMS: Office of National Marine Sanctuaries  
ORHAB: Olympic Region Harmful Algal Blooms  
PaCOOS: Pacific Coast Ocean Observing System  
PDO: Pacific Decadal Oscillation  
PISCO: Partnership for the Interdisciplinary Study of Coastal Oceans  
PnB: Plumes and Blooms  
POES: Polar Operational Environmental Satellites  
PRBO: Point Reyes Bird Observatory  
PSR: Pressure-State-Response  
SCCWRP: Southern California Coastal Water Research Project  
SEAS: Sanctuary Ecosystem Assessment Surveys  
SECRET: Studies of Ecological and Chemical Responses to Environmental Trends  
SF-BEAMS: San Francisco Bay Environmental Assessment and Monitoring Station  
SFML: Seafloor Mapping Laboratory  
SIO: Scripps Institution of Oceanography  
SWAMP: Statewide Water Ambient Monitoring Program  
SWFSC: Southwest Fisheries Science Center  
SWiM: System-Wide Monitoring  
USGS: United States Geological Survey  
USFW: United States Fish and Wildlife  
WCObs: West Coast Observatories  
WOCE: World Ocean Circulation Experiment

## ONMS CONSERVATION SERIES PUBLICATIONS

To date, the following reports have been published in the Marine Sanctuaries Conservation Series. All publications are available on the Office of National Marine Sanctuaries website (<http://www.sanctuaries.noaa.gov/>).

Reconciling Ecosystem-Based Management and Focal Resource Conservation in the Papahānaumokuākea Marine National Monument (ONMS-09-04)

Preliminary Comparison of Natural Versus Model-predicted Recovery of Vessel-generated Seagrass Injuries in Florida Keys National Marine Sanctuary (ONMS-09-03)

A Comparison of Seafloor Habitats and Associated Benthic Fauna in Areas Open and Closed to Bottom Trawling Along the Central California Continental Shelf (ONMS-09-02)

Chemical Contaminants, Pathogen Exposure and General Health Status of Live and Beach-Cast Washington Sea Otters (*Enhydra lutris kenyoni*) (ONMS-09-01)

Caribbean Connectivity: Implications for Marine Protected Area Management (ONMS-08-07)

Knowledge, Attitudes and Perceptions of Management Strategies and Regulations of FKNMS by Commercial Fishers, Dive Operators, and Environmental Group Members: A Baseline Characterization and 10-year Comparison (ONMS-08-06)

First Biennial Ocean Climate Summit: Finding Solutions for San Francisco Bay Area's Coast and Ocean (ONMS-08-05)

A Scientific Forum on the Gulf of Mexico: The Islands in the Stream Concept (NMSP-08-04)

M/V *ELPIS* Coral Reef Restoration Monitoring Report Monitoring Events 2004-2007 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-08-03)

CONNECTIVITY Science, People and Policy in the Florida Keys National Marine Sanctuary (NMSP-08-02)

M/V *ALEC OWEN MAITLAND* Coral Reef Restoration Monitoring Report Monitoring Events 2004-2007 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-08-01)

Automated, objective texture segmentation of multibeam echosounder data - Seafloor survey and substrate maps from James Island to Ozette Lake, Washington Outer Coast. (NMSP-07-05)

Observations of Deep Coral and Sponge Assemblages in Olympic Coast National Marine Sanctuary, Washington (NMSP-07-04)

A Bioregional Classification of the Continental Shelf of Northeastern North America for Conservation Analysis and Planning Based on Representation (NMSP-07-03)

M/V *WELLWOOD* Coral Reef Restoration Monitoring Report Monitoring Events 2004-2006 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-07-02)

Survey report of NOAA Ship McArthur II cruises AR-04-04, AR-05-05 and AR-06-03: Habitat classification of side scan sonar imagery in support of deep-sea coral/sponge explorations at the Olympic Coast National Marine Sanctuary (NMSP-07-01)

2002 - 03 Florida Keys National Marine Sanctuary Science Report: An Ecosystem Report Card After Five Years of Marine Zoning (NMSP-06-12)

Habitat Mapping Effort at the Olympic Coast National Marine Sanctuary - Current Status and Future Needs (NMSP-06-11)

M/V *CONNECTED* Coral Reef Restoration Monitoring Report Monitoring Events 2004-2005 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-06-010)

M/V *JACQUELYN L* Coral Reef Restoration Monitoring Report Monitoring Events 2004-2005 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-06-09)

M/V *WAVE WALKER* Coral Reef Restoration Baseline Monitoring Report - 2004 Florida Keys National Marine Sanctuary Monroe County, Florida (NMSP-06-08)

Olympic Coast National Marine Sanctuary Habitat Mapping: Survey report and classification of side scan sonar data from surveys HMPR-114-2004-02 and HMPR-116-2005-01 (NMSP-06-07)

A Pilot Study of Hogfish (*Lachnolaimus maximus* Walbaum 1792) Movement in the Conch Reef Research Only Area (Northern Florida Keys) (NMSP-06-06)

Comments on Hydrographic and Topographic LIDAR Acquisition and Merging with Multibeam Sounding Data Acquired in the Olympic Coast National Marine Sanctuary (ONMS-06-05)

Conservation Science in NOAA's National Marine Sanctuaries: Description and Recent Accomplishments (ONMS-06-04)

Normalization and characterization of multibeam backscatter: Koitlah Point to Point of the Arches, Olympic Coast National Marine Sanctuary - Survey HMPR-115-2004-03 (ONMS-06-03)

Developing Alternatives for Optimal Representation of Seafloor Habitats and Associated Communities in Stellwagen Bank National Marine Sanctuary (ONMS-06-02)

Benthic Habitat Mapping in the Olympic Coast National Marine Sanctuary (ONMS-06-01)

Channel Islands Deep Water Monitoring Plan Development Workshop Report (ONMS-05-05)

Movement of yellowtail snapper (*Ocyurus chrysurus* Block 1790) and black grouper (*Mycteroperca bonaci* Poey 1860) in the northern Florida Keys National Marine Sanctuary as determined by acoustic telemetry (MSD-05-4)

The Impacts of Coastal Protection Structures in California's Monterey Bay National Marine Sanctuary (MSD-05-3)

An annotated bibliography of diet studies of fish of the southeast United States and Gray's Reef National Marine Sanctuary (MSD-05-2)

Noise Levels and Sources in the Stellwagen Bank National Marine Sanctuary and the St. Lawrence River Estuary (MSD-05-1)

Biogeographic Analysis of the Tortugas Ecological Reserve (MSD-04-1)

A Review of the Ecological Effectiveness of Subtidal Marine Reserves in Central California (MSD-04-2, MSD-04-3)

Pre-Construction Coral Survey of the M/V Wellwood Grounding Site (MSD-03-1)

Olympic Coast National Marine Sanctuary: Proceedings of the 1998 Research Workshop, Seattle, Washington (MSD-01-04)

Workshop on Marine Mammal Research & Monitoring in the National Marine Sanctuaries (MSD-01-03)

A Review of Marine Zones in the Monterey Bay National Marine Sanctuary (MSD-01-2)

Distribution and Sighting Frequency of Reef Fishes in the Florida Keys National Marine Sanctuary (MSD-01-1)  
Flower Garden Banks National Marine Sanctuary: A Rapid Assessment of Coral, Fish, and Algae Using the AGRRA Protocol (MSD-00-3)  
The Economic Contribution of Whalewatching to Regional Economies: Perspectives From Two National Marine Sanctuaries (MSD-00-2)  
Olympic Coast National Marine Sanctuary Area to be Avoided Education and Monitoring Program (MSD-00-1)  
Multi-species and Multi-interest Management: an Ecosystem Approach to Market Squid (*Loligo opalescens*) Harvest in California (MSD-99-1)