Office of National Marine Sanctuaries
National Oceanic and Atmospheric Administration

CHANNEL ISLANDS NATIONAL MARINE SANCTUARY

National Marine Sanctuaries

CONDITION REPORT 2016

CHANNEL ISLANDS

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Cover photo: Biologist Jessie Altstatt conducting a species-habitat survey at Santa Cruz Island. Robert Schwemmer/NOAA

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OFFICE OF NATIONAL MARINE SANCTUARIES

The Office of National Marine Sanctuaries (ONMS), part of the National Oceanic and Atmospheric Administration (NOAA), serves as the trustee for a system of underwater parks encompassing more than 620,000 square miles of ocean and Great Lakes waters. The 13 national marine sanctuaries and two marine national monuments within the National Marine Sanctuary System represent areas of America's ocean and Great Lakes environment that are of special national significance. Within their waters, giant humpback whales breed and calve their young, coral colonies flourish, and shipwrecks tell stories of our maritime history. Habitats include beautiful coral reefs, lush kelp forests, whale migration corridors, spectacular deep-sea canyons, and underwater archaeological sites. These special places also provide homes to thousands of unique or endangered species and are important to America's cultural heritage. Sites range in size from less than one square mile to more than 582,000 square miles and serve as natural classrooms, cherished recreational spots, culturally significant areas, and home to valuable commercial industries.

CHANNEL ISLANDS NATIONAL MARINE SANCTUARY

Designated in 1980 by the National Oceanic and Atmospheric Administration (NOAA), Channel Islands National Marine Sanctuary (CINMS) spans 1,470 square miles surrounding five of the Channel Islands: San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara. The sanctuary supports a rich and diverse range of marine life and habitats, unique and productive oceanographic processes and ecosystems, and culturally significant resources. For current and future generations, the sanctuary serves to conserve, protect, and enhance the biodiversity, ecological integrity, and cultural legacy of these extraordinary resources using education, conservation, science, and stewardship. The sanctuary provides protection to these resources so that nature can thrive, historic shipwrecks and artifacts remain respectfully in place, cultural connections remain strong, and careful public use and enjoyment can be sustained.

FRAMEWORK FOR CONDITION REPORTS

Sanctuary condition reports are tools employed by NOAA to assess the condition and trends of national marine sanctuary resources. Condition reports provide a standardized summary of resources in NOAA's sanctuaries; drivers and pressures on those resources; current conditions and trends for resources and ecosystem services; and describe existing management responses to the pressures that threaten the integrity of the marine environment. Condition reports include information on the status and trends of water quality, habitat, living resources and maritime archaeological resources, and the human activities that affect them. They present responses to a set of questions posed to all sanctuaries (Appendix A). The reports also rate ecosystem service status and trends. Resource and ecosystem service status are rated on a six-point scale from good to poor, and the timelines used for comparison vary from topic to topic. Trends in the status of resources and ecosystem services are also reported, and are generally based on observed changes in status since the prior condition report, unless otherwise specified.

Sanctuary condition reports are structured around two frameworks: 1) a series of questions posed to all national marine sanctuaries; and 2) a management-logic model called the Driving forces (Drivers)-Pressure-State-Ecosystem Services-Response (DPSER) Framework (detailed below). The first stems from the generic structure of an ecosystem, and is used as the logic framework for the reports, while the second defines the structure of the condition reports themselves.

Although the National Marine Sanctuary System's 13 sanctuaries and two marine national monuments are diverse in many ways, including size, location, and resources, condition reports allow ONMS to consistently analyze the status and trends of the abiotic and biotic factors in each ecosystem for purposes of informing place-based management. To that end, each sanctuary is asked to answer the same set of questions, located in Appendix A, in the preparation of each condition report. Additional details about how the condition report process has evolved overtime are below.

Driving forces (Drivers)-Pressure-State-Ecosystem Services-Response (DPSER) Framework

The first generation of sanctuary condition reports (2007–2015) were structured on a Pressure-State-Response (PSR) framework. The PSR framework assumes that human activities exert pressures on the environment, which can induce change in the condition, or state, of the environment (e.g., the quality and quantity of natural resources). The human responses to these changes (e.g., environmental and economic policies) are aimed at preventing, reducing, or mitigating undesirable changes. Accordingly, all first generation condition reports included a section devoted to each portion of the PSR framework.

Beginning in 2016, the second generation of condition reports have and will use an expanded framework, the DPSER Model, that adds two concepts that better incorporate humans into the ecosystem and the report itself (Mangi et al. 2007, Levin et al. 2008, Atkins et al. 2011, Tscherning et al. 2012). First, a discussion of Drivers brings an additional understanding of the forces behind the pressures, based on various societal values, and how changes in those societal values affect the pressures. Drivers are the ultimate cause of changes in ecosystems, and can be biophysical, human, or institutional in nature. In addition, Drivers also provide a forward looking perspective to inform policy and management decisions (as described in the Response Section). By integrating past trends and future forecasts of Drivers, decision-makers can be informed as to the scale and scope of key activities in designing management responses for needed protection and/or restoration of sanctuary resources.

Second, is the addition of an Ecosystem Services section. For purposes of this report, ecosystem services are defined as "benefits that humans desire from the environment" (e.g., recreation or food). Ecosystem services are a link between humans and the ecosystem and can be goods or services (e.g., food is a good and coastal protection is a service); are valued in different ways by various types of users; and can be regulated directly by the environment, or managed by controlling human activities or ecosystem components (e.g., restoring habitats). Whether or not specific services are rendered can be evaluated based on attributes of the natural ecosystem that people care about. For example, recreational SCUBA divers care about water clarity and visibility in kelp forest and rocky reef ecosystems. These attributes can be measured and assigned status and trend ratings, which allows tracking of the specific ecosystem services to which they pertain.

ABOUT THIS REPORT

The purpose of a condition report is to use the best available science and most recent data to assess the status and trends of various parts of the sanctuary's ecosystem. The first condition report for Channel Islands was released in 2009 (ONMS 2009a); this condition report marks a second comprehensive update to describe the status and trends of sanctuary resources.

Framework

Condition reports use a Driving forces (Drivers)-Pressures-State-Ecosystem Services-Response framework (DPSER). Information provided in the State section covers the status and trends in water quality, habitat, living resources, and maritime archaeological resources from 2009–2016, unless otherwise noted. The content in the Ecosystem Services section focuses on: food supply, consumptive and non-consumptive recreation, education, science, maritime heritage, and sense of place. The Ecosystem Services section also includes an independently-prepared report authored by Chumash community contributors. The Response section of this report provides a summary of activities and management actions that sanctuary staff have led or coordinated to help address the main issues and human activities described in the Driving Forces and Pressures section of this report. This condition report helps identify gaps in current monitoring efforts, as well as causal factors that may require monitoring and potential remediation through future management actions. The data discussed will not only enable ONMS and stakeholders to identify/understand and have a shared perspective on prior changes in resource status, but will also inform management efforts to address challenges stemming from pressures, such as increasing coastal populations and climate change.

Process

In order to rate the status and trends associated with the resources and human activities, the Office of National Marine Sanctuaries (ONMS) consulted with over 80 external subject matter experts[1] familiar with the resources and with knowledge of previous and current scientific research in CINMS (Appendix B). Evaluations of status and trends were based on the interpretation of quantitative and, when necessary, qualitative assessments, together with the observations of scientists, resource managers, and sanctuary users.

Improvements

It is important to note two changes that have been made to the condition report process since 2009 due to feedback received from the CINMS Research Activities Panel (RAP). The RAP is a working group of the CINMS Advisory Council. The primary purpose of the RAP is to review research priorities related to management of CINMS; to promote, encourage, and review research projects in the sanctuary; and to provide scientific advice to the advisory council. In 2008, the RAP provided feedback on the draft condition report, including a critique that the ability of the document to provide science-based support for management of the sanctuary was limited, largely due to the omission of the degree of confidence that

[1] The independently-contributed section on ecosystem values contributed by the Chumash community was not peer reviewed.

was applied to each rating. As a result of this feedback, this updated report presents uncertainty differently in order to enhance clarity. In the 2009 condition report, inferences were drawn from the text regarding level of confidence for each status and trend rating. The new approach incorporates this information into the symbols used for those ratings and is available for every question. The determination of uncertainty is based on both an evaluation of the data utilized to determine the rating (e.g., peer-reviewed literature, expert opinion) as well as the level of agreement across experts (Appendix B).

In 2008, the RAP also suggested that in making rating judgments, there was no articulated decision-support model or benchmark for performance provided. To improve the approach to determine status and trend ratings in this updated report, ONMS used the National Oceanic and Atmospheric Administration's (NOAA) Integrated Ecosystem Assessment (IEA) framework (see Appendix G). This framework takes a literature-based approach to developing indicators for key components of the ecosystem. Status and trend assessments can then be made of the selected indicators over time such that the expert community has quantitative data representative of core ecosystem components available to them as they contribute to assessment ratings. These indicators continue to be tracked over time and any subsequent assessment can be made employing updated time series data.

Ratings reflect the collective interpretation of the status of local issues of concern among CINMS and outside experts based on their knowledge and perception of local problems; however, it is important to note that CINMS determined the final ratings. This report has been peer reviewed and complies with the White House Office of Management and Budget's peer review standards, as outlined in the Final Information Quality Bulletin for Peer Review.

As stated, the previous CINMS condition report was completed in 2009. Since then, CINMS has undertaken several standalone research and monitoring collaborations including support for the study of Channel Islands marine reserves and conservation areas, voluntary and incentive-based vessel speed reduction programs, high resolution seafloor mapping, acoustic tracking of vertebrates, and non-native species surveys, to name a few.

California Current Integrated Ecosystem Assessment (CCIEA)

The California Current Integrated Ecosystem Assessment (CCIEA), a cross-NOAA initiative led by the National Marine Fisheries Service's (NMFS) Northwest and Southwest regional science centers, provides a process and analytical tools for examining the condition of, and implementing management in, the California Current ecosystem. CCIEA seeks to better understand the web of interactions that drive patterns and trends in ecosystem components and forecasts how changing environmental conditions and management strategies affect the status of these components. For more information about CCIEA, visit https://www.integratedecosystemassessment.noaa.gov/regions/california-current-region/index.html.

EXECUTIVE SUMMARY

In 1980, National Oceanic and Atmospheric Administration (NOAA) designated Channel Islands National Marine Sanctuary (CINMS) located off the coast of Santa Barbara and Ventura counties in California. The sanctuary encompasses 1,470 square miles surrounding five of the Channel Islands: San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara. The sanctuary's remote, isolated position at the confluence of two major ocean currents supports remarkable biodiversity and productivity. The mingling of cool, nutrient-rich waters from the north with warm currents from the south form a dynamic transition zone that is home to a myriad of sea life from microscopic plankton to blue whales. Many valuable commercial and recreational activities, such as fishing, shipping, and tourism, occur in the sanctuary. The sanctuary is a special place for sensitive habitats and living resources, shipwrecks, other maritime heritage artifacts, and living Chumash culture.

The purpose of a condition report is to use the best available science and most recent data to assess the status and trends of various parts of the sanctuary's ecosystem. The first condition report for Channel Islands was released in 2009 (ONMS 2009a); this report marks a second comprehensive update to describe the status and trends of sanctuary resources. In addition, the new condition report includes the status and trends of ecosystem services or how humans either derive benefit from or accrue costs from different ecosystem attributes that people care about for their lives and livelihoods. Ecosystem services evaluated in this report include: food supply-commercial fishing; consumptive recreation-recreational fishing; non-consumptive recreation-wildlife viewing, SCUBA diving, snorkeling, and boating; sense of place-passive economic use value; maritime heritage; education; and science. The Ecosystem Services section of this report also includes an independently-prepared contribution from Chumash community authors that describes Chumash history connected to the northern Channel Islands and surrounding sanctuary waters, indigenous community values linked to the ecosystem, related traditional knowledge and practices, and historical trauma.

The findings in this condition report document status and trends in water quality, habitat, living resources, and maritime archaeological resources, and ecosystem services from 2009–2016, unless otherwise noted. The report helps identify gaps in current monitoring efforts, as well as causal factors that may require monitoring and potential remediation through future management actions. The data discussed will not only enable ONMS and stakeholders to acknowledge and have a shared perspective on prior changes in resource status, but will also inform management efforts to address challenges stemming from pressures, such as increasing coastal populations and climate change.

The findings in this condition report also provide critical support for identifying high priority sanctuary management actions, specifically helping to inform updates to the CINMS Management Plan. The management plan helps guide future work and resource allocation decisions at CINMS by describing strategies and activities designed to address priority issues and advance core sanctuary programs. The next update to the sanctuary management plan will build on the 2009 management plan, which contains a number of actions to address sanctuary issues and concerns (NMSP 2009). The 2009 plan stresses an ecosystem-based approach to management, which requires consideration of ecological interrelationships not only within the sanctuary, but also within the larger context of the California Current ecosystem. The next management plan review process is projected to begin in 2019. The process will involve significant opportunities for public input and consultations with federal, state, and local agencies, and compliance with environmental laws, regulations, and policies. Depending on the complexity of actions proposed to be included in the management plan, the entire process may take one to three years to complete.

The below provides summaries of the findings of this condition report. In summary, much of the sanctuary appears healthy and stable, including eutrophic conditions, water quality that is safe for swimming and recreation, the general condition of shoreline and seafloor habitat, many fish species, overall native sanctuary biodiversity, and the condition of maritime archaeological resources.

Human Activities

The sanctuary is adjacent to metropolitan Los Angeles — one of the largest U.S. population centers — and is therefore impacted by a large range of human activities and pressures. Due to its offshore location, human activities in the Channel Islands face different driving pressures than inshore or mainland activities. Driving forces behind these pressures can aid in predicting the direction and extent of future pressures. The majority of driving forces (resulting factors that lead to pressures) are increasing, such as population, per capita income, Gross Domestic Product (GDP) of trading partners, vessel traffic, and visitor use to the Channel Islands. Additionally, gasoline prices have been stable and relatively low making boat access to the sanctuary more affordable. The direction of these drivers indicate that pressures will continue to increase within the sanctuary.

Water Quality

While coastal nutrient runoff rarely reaches sanctuary waters, some persistent pollutants have been detected in sanctuary sediments and mussel tissues, and may be accumulating over time. Pollutants can reach the sanctuary through periodic transport by local currents, by animals, or via sediment transport. Over time, oil production has declined in the region around the sanctuary and has been fairly stable since 2012. While oil spills are rare, in 2015, a broken land pipe at Refugio Beach spilled crude oil into coastal waters, which may have reached the sanctuary. Marine debris enters the sanctuary from both water and land-based activities, and it is likely accumulating in the water column and benthic habitats. Consequences of marine debris include accidental lethal ingestion by organisms, animals becoming entangled, and/or toxic bioaccumulation up the food chain.

Fishing practices in the vicinity of the sanctuary have generally shifted over time from bottom trawls and nets to traps and hook and line, meaning overall gear interactions with seafloor habitats have been reduced; however, trap loss is an issue of concern. No-take and restricted-take marine zones established in the sanctuary in 2004 and 2007 have had measurable benefits to fished populations and habitats. Visitation to the sanctuary has increased since 2009 and in turn, pressures like anchoring damage, non-native species introductions, and vessel grounding risks are also increasing. Some of the busiest shipping lanes in the world pass through a portion of the sanctuary and produce concerning amounts of noise. Increased ambient noise levels can impair the hearing and ability of marine mammals, fishes, and invertebrates to communicate and locate prey. Both small and large vessels can strike and harm or kill large whales, and this remains an ongoing management challenge. Global climate change has affected water quality, urchins, deep-water corals, and other habitat-forming species, and it will be crucial to better understand how these changes may impact the sanctuary's living resources and habitats over time.

Habitat

The physical and biological oceanographic characteristics of the CINMS region are unique. Two major currents meet at the east-west oriented northern Channel Islands, making it a transition zone where surface temperatures shift from warm in the east, to cool in the west. There is notable seasonal variation of surface temperatures, currents, nutrients, pH, and dissolved oxygen levels. These factors combine to support one of the most productive and biologically diverse marine ecosystems in the world.

Marine researchers are also drawn to the CINMS region, and therefore many long-term datasets exist, including for water quality. Compared to coastal areas, the water quality of the sanctuary is good. A disruption to normal conditions occurred with a warm water event, unprecedented in size and duration that began in 2013 and lasted through much of 2016. During this event, the Southern California Bight experienced anomalously warm surface waters, reduced mixing and surface nutrients, and low productivity. Impacts reverberated throughout regional food webs, and how the system rebounds will be a topic of continued research. Such marine heat waves are believed to be related to climate change, and this potential correlation should also be tracked over time.

Climate drivers are currently the most concerning aspect of water quality, as the 2016 status and trend has been reduced to fair and worsening. In addition to ocean warming and marine heat waves, other impacts of climate change that are the focus of ongoing study include ocean acidification, reductions in dissolved oxygen, and the intensity, frequency, and duration of harmful algal blooms (HABs). HABs are increasing in frequency and extent along the U.S. West Coast. While typical in the CINMS region, some researchers believe the onset and severity of HABs may be influenced by ocean warming and/or anomalous spikes in sea surface temperature. Continued monitoring will produce the necessary temporal and spatial data to better discern the factors that influence HABs and describe their ecosystem impacts.

The sanctuary is comprised of a highly diverse patchwork of habitats ranging from intertidal rocky habitat and sandy beaches, inshore kelp forests, soft bottom habitats and rocky reefs, and deep-sea coral gardens. Sanctuary habitats are defined both by abiotic (e.g., sediment/bottom type, depth, rugosity) and biogenic (e.g., kelp, algae, mussels, deep-sea corals) features that contribute to overall habitat quality, structure, and function. While data on change in abiotic habitat is limited, recent monitoring data shows a decline in the health or abundance in many species that create biogenic habitat from their growth (e.g., corals) or activities (e.g., burrowing). For example, critical habitat creators, such as giant kelp, mussels, deep-sea corals, and seagrass, are all experiencing declines in health, condition, or abundance. These trends appear to be the norm beyond the sanctuary's boundaries as well, suggesting that impacts are widespread across the Southern California Bight. Conversely, trends are spatially variable with temperature, top-down ecological controls, pH, conservation measures, and changes in fishing pressure; this variability also influences habitat quality among islands.

While information is limited, pollution impacts on habitat quality appear to vary by monitoring methodology. Contaminant concentrations in mussel tissue appear to be declining for most metals; however, infaunal surveys from deeper waters have found a change in community composition, which may be a result of the impacts of pollution. While habitat quality and pollution appear to be worsening by some metrics, experts agree these trends have not yet caused severe degradation of ecological integrity within the sanctuary. Future work should focus on understanding the ecological consequences of this potential habitat loss and forecasting the response of habitat to changing climate, emerging contaminants, and fishing activities.

Living Resources

The abundance and diversity of wildlife seen around the northern Channel Islands is remarkable compared to many parts of the world and was a main reason for sanctuary designation. Although the 2016 status and trends are quite variable across the range of species in the sanctuary, overall, the data indicate that many of the sanctuary's living resources are showing relative stability or improvement since 2009. For example, most kelp forest and seafloor-associated fishes are stable or increasing, especially inside no-take zones. Additionally, the number of native species in sanctuary habitats, which is one measure of biodiversity, appears to be stable with no known recent local extinctions; however, the island-wide drastic declines in sea stars, a keystone species in rocky shore and shallow reef habitats, coupled with the establishment of a few non-indigenous species at some island monitoring sites, contributed to worsening trends in the status of nearshore communities and raises concerns about future impacts to ecological integrity and biodiversity. In the pelagic habitats, unusual abundances and distributions of both forage species, such as squid and sardine, and their predators, including sea lions, were likely driven by an unusual warm water event that began in 2013 and lasted until 2016. Abundance of forage species typically rebounds with the return of favorable oceanographic conditions, but time is needed to better understand if there are any lasting impacts from these recent anomalies. Continued monitoring of living resources in sanctuary habitats will be essential to determine whether key species and community assemblages will return to past patterns or if new patterns are emerging in response to changing climate and other human pressures.

Maritime Archaeological Resources

Data gathered through Channel Islands National Maritime Sanctuary and Channel Islands National Park's annual Shipwreck Reconnaissance Monitoring Program indicates that since 2009, maritime archaeological resources reflect little or no unexpected disturbance or looting by divers; however, a 2011 damage assessment recorded at the Winfield Scott shipwreck site was believed to be caused by improper vessel anchoring. Damage to historic iron artifacts was recorded, but believed to be caused by a vessel's anchor tackle, not by divers' activities. The monitoring program has also contributed to new historic artifact discoveries, such as the Pelorus navigation instrument located at the Equator shipwreck site in 2016. Maritime archaeological resources will continue to go through various stages of degradation caused by natural forces, especially those resources located in shallow water and impacted by surge and swells. The diminished condition of an archaeological resource could reduce its historical, archaeological, scientific, or educational value, and is likely to affect its eligibility for listing to the National Register of Historic Places. There are no known maritime archaeological resources that pose environmental threats, although some threats may come from shipwrecks located beyond sanctuary boundaries. Since the location of the majority of deep-water wrecks is unknown, impacts to archaeological resources by offshore trawling is still unknown.

Ecosystem Services

Seven ecosystem services were evaluated in CINMS for this condition report: food supply, consumptive recreation, non-consumptive recreation, sense of place, heritage, education, and science.

The food supply ecosystem service is defined as the capacity to support market demands for nutrition-related commodities through various fisheries. Food supply status in CINMS was determined to be good/fair. Even though the trends in harvest from 2000 to 2012 were variable across species/species groups, the harvest had significant positive impacts on the economy of the local area in terms of sales/output, value-added (Gross Regional Product), income, and jobs for years 2010, 2011, and 2012. Overall, the ecological indicators do not indicate there is a decline in the natural resources related to this service; however, the trend is undetermined as there is not extensive fisheries data after 2012.

Consumptive recreation was also determined to be good/fair with an undetermined trend. Two primary consumptive recreational activities are conducted in CINMS: recreational fishing and diving, the latter of which can result in incidental damage to kelp. Data collected from commercial passenger fishing vessel (CPFV) operators show that although there is variation from year to year in CPFV hours, since the 1980s, the number of hours within CINMS has been increasing. Data on expenditures and economic impacts show that from 2010 to 2012, expenditures by CPFV passengers have been increasing, in addition to the resulting economic contributions of their spending. From 2006 to 2012, private/rental boat person-days of fishing show an increasing trend from 2010 to 2012. Additionally, expenditures by private/rental boat users and the economic contributions of this activity increased between 2010 and 2011. Fish species that support recreational fisheries have been increasing or stable' however, like food supply, the trend for is undetermined due to a lack of data for economic and non-economic indicators after 2012.

Sanctuary visitors may also participate in non-consumptive recreational activities from both private boats and "for hire" operations (e.g., whale watching boats, wildlife viewing, dive charters, etc.). The only time series data on recreational uses comes from Channel Islands National Park (CINP) where from 2012 to 2016, total visitation increased. Due to the lack of time series data for non-consumptive uses, indicators for population, real per capita income, and gas and diesel prices were used for inferring trends in use. Population, real per capita incomes, and gas and diesel prices were all favorable for increases in this service. Further, surveys show whale watching operators believe that whale watching conditions have improved over the past 10 years due to increasing food supplies leading to more sightings. Based on ratings for human activities affecting water, habitat, and living resources, there is no indication that the economic and non-economic benefits derived from this ecosystem service are reducing the quality of natural resources. Consequently, the trend and status for non-consumptive recreation were determined to be good/fair and stable, respectively.

Sense of place is the aesthetic and spiritual attraction, and level of recognition and appreciation given efforts to protect a place's iconic elements. National marine sanctuaries, CINMS included, are underwater treasures designated because of their extraordinary scenic beauty, biodiversity, historical connections, and economic productivity. In addition, CINMS has additional protections with the network of 11 marine reserves and two marine conservation areas that are within the sanctuary. Non-use or "passive economic use" value is a broad economic expression for the value people have for protecting special places, and thus are good indicators of sense of place. Studies of non-use and passive economic use values have found that real per capita income is a good predictor of people's economic values. Given the valuation numbers and trends in environmental attitudes and growth in real per capita incomes, these economic indicators suggest a status of good with an increasing trend for this service. Ecological indicators do not indicate there is a decline in the natural resources related to this service.

Maritime heritage is the recognition of historical or heritage legacy. This ecosystem service was determined to be fair with a stable trend. Studies have found that people's willingness to pay for maritime heritage increased with the expansion of the number of shipwrecks protected, the level of investments in museum exhibits, educational workshops on maritime heritage, training in maritime archaeology, and Maritime Heritage Trails, including virtual trails using video and mobile phone technology. Numerous articles have appeared in magazines, academic papers have appeared in several journals, and many papers have been presented at professional meetings about maritime heritage in CINMS. Twelve museums/visitor centers have artifacts or tell the stories of some of the shipwrecks in CINMS. In 2017, CINMS funded the RV Shearwater expedition to discover the shipwreck USCG Cutter McCulloch (located outside of CINMS), which yielded 5,200 news stories with an estimated 312 million impressions worldwide. With 30 archaeological site locations inventoried and in various stages of survey within CINMS, this ecosystem is expected to continue.

Many people of all ages study ecosystems and their importance through both formal and informal education. When people derive benefits from educational experiences or products resulting from CINMS, this is considered an ecosystem service. The education ecosystem service status was determined to be good with a stable trend. A 2017 study evaluating the Ocean Guardian School program — an ONMS education program that teaches students K-12 about ocean conservation and stewardship — determined that parents are willing to pay for their children to have hands on environmental educational experiences. Another indicator, volunteer time, increased from 2008 to 2016. During that period, the value that volunteers added to the sanctuary increased by over $200,000. Further, the number of kiosk visitors at ONMS facilities and partner exhibits increased from 2013 to 2017. Additionally, technological advances have increased access to CINMS, no longer requiring a person to be physically present in the sanctuary to experience and learn about its natural, historical, or archeological features. These indicators demonstrate the various tools used to provide educational services to CINMS visitors.

The ecosystem service of science is defined as the capacity to acquire and contribute information and knowledge and was determined to be good with a stable trend. Currently, there is an absence of information on the economic value of science and research within CINMS, as this ecosystem service has not been extensively studied; however, many non-economic indicators may be used to measure and track science within the sanctuary. In some cases, researchers apply for permits to conduct research within the sanctuary. From 2006 to 2016, both the number of permits issued (which reflects about 25% of all research occurring within the sanctuary) and the number of open permits increased. Additional indicators include the total number of research projects conducted within the sanctuary (including those that do not require a permit by CINMS), publications featuring research in CINMS, and research vessel time in the sanctuary. From 2009–2014, there were 116 research projects in CINMS resulting in 49 publications. Another indicator is the number of days spent upon NOAA research vessels, which has decreased since 2008. In general, the data support that science is occurring within the sanctuary.

Chumash Ecosystem Services Assessment

In 2018, Chumash community representatives appointed to the CINMS advisory council agreed to assist with the assessment of the sanctuary's ecosystem services by preparing an independently-authored report. The independent report focused on Chumash perspectives of ecosystem and place-based values connected to the Chumash's sacred homeland islands and surrounding ocean waters. The report reflects contributions from advisory council members Alicia Cordero and Luhui Isha Ward, the Chumash Women's Elders Council, and their consultations with a broad cross-section of individuals from the Chumash community. Their work is included within this condition report to supplement the sanctuary's ecosystem services assessment; note, this work is presented in its final form submitted to ONMS in November 2018 without any editing by NOAA or its affiliates.

Chumash perspectives about ecosystem services are often different from assessments presented elsewhere in this report. Authors of the Chumash contribution do not consider all of the ecosystem service categories used herein to be consistent with the way they perceive the relationship between humans and their surroundings. Additionally, authors of the Chumash community section help sanctuary resource managers appreciate the deep history of Chumash people in connection with the Channel Islands and surrounding marine waters, the reciprocal regenerative relationship that embodies their community-based value systems and worldview, and the effects of historical trauma on Chumash community members. Seeking to understand Chumash perspectives and experiences, sanctuary managers gain an enhanced appreciation for indigenous ways of knowing and relating to the marine environment that are built over thousands of years of history.

Response

The Response section describes actions that CINMS has taken, primarily since 2009, to help address the range of issues and human activities described in the Driving Forces and Pressures section of this report. Projects and programs that sanctuary staff have led, coordinated, or conducted with partners help address many issues and human activities, including:

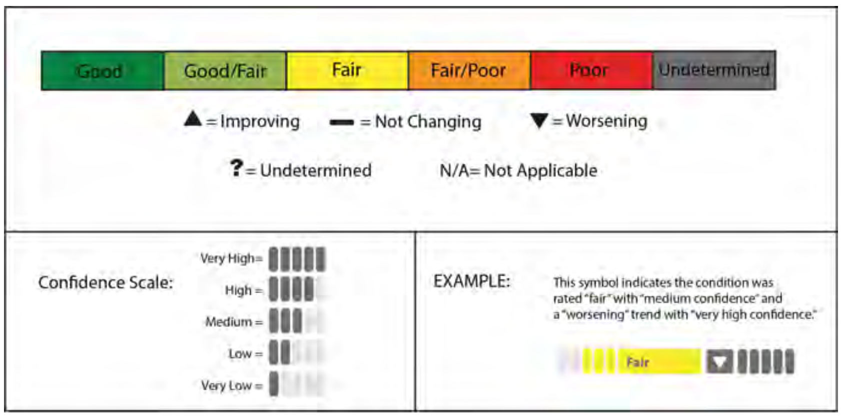
- Vessel traffic
- Ocean noise
- Non-indigenous species
- Fishing activities
- Energy development
- Pollutants
- Marine debris
- Visitor use
- Climate variability

Given the sanctuary's remote offshore setting and unique mix of human activities, effectively responding to a wide range of issues and threats requires a long-term commitment to marine conservation using a multidisciplinary, partnership-based approach. This involves the need for scientific research and monitoring studies, ongoing monitoring of conditions, enforcement of existing regulations, monitoring to identify emerging threats, community-based initiatives, and education and outreach to inspire others to care about and help protect and preserve CINMS. The dynamic and emerging nature of many issues requires that recurring assessments and adaptation are part of the sanctuary's management cycle.

CHANNEL ISLANDS NATIONAL MARINE SANCTUARY
RESOURCE CONDITION SUMMARY TABLE

The following table summarizes the various evaluations presented in this report. The first two columns list 17 questions (Issues) used to rate the condition and trends for drivers and qualities of human activities, water, habitat, living resources, and maritime archaeological resources. The Rating column displays four pieces of information: a color and term that indicates status; a symbol that indicates trend; and a shaded scale for both that indicates confidence (See Key for example and definitions). The Basis for Judgment column provides a short statement or list of criteria used to justify the rating. The Description of Findings column presents the statement that best characterizes resource status, and corresponds to the assigned color rating as described in Appendix A. The Description of Findings statements are customized for all possible ratings for each question.

Key:



#	Issue	Rating	Basis for Judgment	Description of Findings
Drivers/Pressures*				
1	Drivers	Fair ▼	Growing populations and per capita incomes in the counties adjacent to the sanctuary, in the U.S. generally, and in China, drive demand that promotes shipping and resource use; relatively low, stable fuel prices further stimulate visitation.	Selected drivers are influencing pressures in ways that cause measurable resource impacts.

2	Human Activities and Water Quality	Good/Fair ?	Some levels of human activities are decreasing, some are increasing, and some are stable. Few monitoring data sets exist. Evidence showing human activities have negatively affected water quality is sparse and inconclusive. Oil spill frequency and volume has generally decreased, apart from the 2015 Refugio Oil Spill. Short- and long-term oil spill impacts still need to be assessed. Vessel grounding impacts are localized to grounding site.	Some potentially harmful activities exist, but they have not been shown to degrade water quality.
3	Human Activities and Habitat	Fair ?	Consistent with our findings in 2009, a number of human activities have localized impacts on habitats in the sanctuary. Marine debris continues to occur, while clean-up efforts also continue. Fishing activity has remained high, although changing gear types has resulted in reduced impact to benthic habitats. Visitation to the islands remains consistent.	Selected activities have caused measurable resource impacts, but effects are localized and not widespread or persistent.
4	Human Activities and Living Resources	Fair ▼	Consistent with our findings in 2009, a number of human activities have measurable, localized impacts on living resources in the sanctuary and many of these activities are continuing at similar levels or increasing in intensity.	Selected activities have caused measurable living resource impacts, but effects are localized and not widespread or persistent.
5	Human Activities and Maritime Archaeological Resources	Fair –	Impacts to maritime archaeological resources may result from site looting, injury by divers, vessel activity, and bottom trawling. Increases in education, enforcement, and trawling closures may allow for improvement.	Selected activities have caused measurable impacts to maritime archaeological resources, but effects are localized and not widespread or persistent.

Water Quality				
6	Eutrophic Conditions	Good –	Mainland eutrophic conditions generally do not reach islands due to their distance from shore. Extreme episodic events may cause inputs to reach the islands. There are also localized inputs, such as marine mammals, seabirds, and vessel discharges. Nitrate and phosphate concentrations have gradually been increasing at depth, but have been stable in surface waters — apart from 2013-2016 when surface nutrients decreased in response to anomalous warm water and reduced mixing. Typically, chlorophyll decreases when temperatures spike seasonally.	Eutrophication has not been documented or does not appear to have the potential to negatively affect ecological integrity.
7	Human Health Risks	Good/Fair –	Presence of *Pseudo-nitzschia* is cyclic and most frequent with positive upwelling anomalies. Periods of high domoic acid have become more frequent starting in 2001. The 2015 bloom was unprecedented in abundance and spatial extent. Harmful algal blooms (HABs) are increasing in frequency and intensity. No reports of human illness; however, shellfish and crab fisheries, marine mammals, and seabirds have been negatively affected.	One or more water quality indicators suggest the potential for human health impacts, but human health impacts have not been reported.
8	Climate Drivers	Fair ▼	Sea surface temperature is increasing, as are episodic warm water anomalies. There were significant effects of the recent warm water event and El Niño, including low primary productivity. Warming has led to reduced efficiency of the biologic pump (flux of organic material to depth), which in turn has decreased dissolved oxygen (DO) in the water column. In general, DO near the surface decreases seasonally during upwelling events. Large-scale climate	Climate-related changes such as the warm water event, decreasing dissolved oxygen, and ocean acidification have caused measurable, but not severe degradation in some attributes of ecological integrity.

			oscillations can influence other water quality parameters, as well; for example, Pacific Decadal Oscillation influences HABs. Seawater pH has been steadily decreasing over time. Organisms in CINMS are accustomed to variable pH and therefore, may be less vulnerable to change, but we know little about certain habitats, such as deep sea. Some sanctuary habitats may provide buffer against pH decreases (e.g., eelgrass beds).	
9	Other Stressors	Undetermined ?	Here, “other stressors” are those that are hard to quantify in the water column and/or that have indirect impacts; therefore, there are few datasets to assess. The sanctuary's offshore location buffers it from the water quality issues experienced off the mainland; however certain wind and circulation conditions can transport contaminated coastal waters to the sanctuary. It is believed microplastics are prevalent and increasing throughout the ocean.	
Habitat				
10	Integrity of Major Habitats	Fair ▼	Monitoring programs indicate some measurable loss in many components of major habitats including kelp forests, understory kelp, algal groups, mussel beds and deep-sea corals. Kelp and deep-sea coral declines are primarily in the eastern sanctuary. Other components of major habitat are stable or improving.	Selected habitat loss or alteration has caused measurable, but not severe degradation in some attributes of ecological integrity.
11	Contaminant Concentrations	Good/Fair —	Declines in several contaminants were measured in mussel tissues, but levels remain high for others. Some infauna contaminant samples are no longer considered pristine and received a slight downgrade in rating. Sediment contaminants	Selected contaminants are suspected and may degrade some attributes of ecological integrity, but have not yet caused measurable degradation.

			are present at low levels. More data are needed to determine any impacts on habitat, marine life, and future trends.	
Living Resources				
12	Keystone and Foundation Species	Fair ▼	Severely reduced abundance of sea stars and key pelagic forage species, and reduced abundance of lobster and sheephead in areas open to harvest, may impact ecological integrity at some locations. Other keystone and foundation species are stable or increasing.	The status of keystone or foundation species suggests measurable, but not severe degradation in some attributes of ecological integrity.
13	Other Focal Species	Fair ?	Some focal species absent or substantially reduced which may reduce ecological function, but recovery happening for some species or in some locations. Trends variable across focal species; some stable or increasing while others have declined since 2009.	Selected focal species are at reduced levels, but recovery is possible.
14	Non-Indigenous Species	Fair ▼	Several non-indigenous species have been observed at one or more sites in sanctuary since 2009. *Sargassum horneri* has spread to three islands and is increasing in abundance with potentially negative consequences for native kelp communities.	Non-indigenous species have caused measurable, but not severe degradation in some attributes of ecological integrity.
15	Biodiversity	Fair ?	A few recent changes in abundance of key species may impact biodiversity; however, more time is needed to determine if they will persist. Shallow habitats, deep habitat, and pelagic habitats show different trends in biodiversity.	Selected biodiversity loss or change has caused measurable, but not severe degradation in some attributes of ecological integrity.

Maritime Archaeological Resources*				
16	Integrity of Maritime Archaeological Resources	Fair ▼	Past looting of some shallow sites and natural deterioration of all sites contribute to declining integrity; integrity of deeper wrecks is unknown, but some accidental fouling by fishing gear may have occurred.	The diminished condition of selected archaeological resources has reduced, to some extent, their historical, archaeological, scientific, or educational value, and may affect the eligibility of some sites for listing in the National Register of Historic Places.
17	Maritime Archaeological Resources Threat to Environment	Good/Fair —	Sites just outside sanctuary boundaries pose a greater threat from leaching chemicals, such as bunker fuels and cargos.	Selected maritime archaeological resources may pose isolated or limited environmental threats, but substantial or persistent impacts are not expected.

**Note that a confidence score was not assigned to the Drivers question (1) or the Maritime Archaeological Resource questions (5, 16, and 17) because subject matter experts were not consulted on these ratings. Due to a limited number of experts in these fields, and Office of National Marine Sanctuaries (ONMS) in-house experts available, ONMS internally evaluated the Driver question (1) and the Maritime Archaeological Resource questions (5, 16, and 17). Two socioeconomists with ONMS determined the Driver question rating. Two archaeological experts with the ONMS Maritime Heritage Program determined the Maritime Archaeological Resource question ratings; these subject experts have been monitoring existing archaeological sites since the 1980s, as well as recording new discoveries.*

CHANNEL ISLANDS NATIONAL MARINE SANCTUARY
ECOSYSTEM SERVICES SUMMARY TABLE

Ecosystem Service	Rating	Description of Findings	Indicators
Sense of Place	Good/Fair –	Unable to fully provide the ecosystem service due to prior or existing human activity, but performance is acceptable.	Economic indicators are positive and stable, human dimensions indicators are increasing or stable, and resource indicators do not indicate there is a decline in the natural or maritime archaeological resources related to this service.
Consumptive Recreation	Good/Fair ?	Unable to fully provide the ecosystem service due to prior or existing human activity, but performance is acceptable.	Economic indicators are positive and stable, human dimensions indicators are increasing or stable, but resource indicators do not cover many important species supporting this service.
Non-consumptive Recreation	Good/Fair –	Unable to fully provide the ecosystem service due to prior or existing human activity, but performance is acceptable.	Economic indicators are positive and stable, human dimensions indicators are increasing or stable, and resource indicators do not indicate there is a decline in the natural resources supporting this service.
Food Supply	Good/Fair ?	Unable to fully provide the ecosystem service due to prior or existing human activity, but performance is acceptable.	Economic indicators are positive and stable, human dimensions indicators are increasing or stable, but resource indicators do not cover many important species supporting this service.
Maritime Heritage	Fair –	Ability to provide this ecosystem service is compromised, and existing management would require enhancement to enable acceptable performance.	Economic indicators are positive and stable, human dimensions indicators are increasing or stable, and resource indicators do indicate there is a decline in the cultural resources related to this service, but it is not widespread.

Science	Good —	The capacity to provide the ecosystem service has been either enhanced or remained unaffected.	Economic indicators are positive and stable and human dimensions indicators are increasing or stable.
Education	Good —	The capacity to provide the ecosystem service has been either enhanced or remained unaffected.	Economic indicators are positive and stable and human dimensions indicators are increasing or stable.

* *Note that a confidence score was not assigned to the Ecosystem Service ratings because subject matter experts were not consulted in a workshop setting on these ratings.*

SITE HISTORY AND RESOURCES

Overview

Channel Islands National Marine Sanctuary is located off the coast of Santa Barbara and Ventura counties in southern California, 350 miles south of San Francisco and 95 miles north of Los Angeles.

The sanctuary encompasses 1,470 square statute miles (1,110 square nautical miles) of ocean waters surrounding San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara Islands, extending from mean high tide to six nautical miles offshore around each of these five islands (Figures SH.1, SH.2).

The sanctuary was federally designated in 1980 because of its national significance as an area of exceptional natural beauty and resources, and due to heightened concerns following the 1969 oil spill in the Santa Barbara Channel. It is administered by NOAA, within the U.S. Department of Commerce, and managed to promote ecosystem conservation, protect cultural resources, and support compatible human uses.

The sanctuary surrounds and partially overlaps Channel Islands National Park, a terrestrial and marine protected area of national and global significance. The park is administered by the Department of the Interior's National Park Service. The park consists of 250,000 acres of land on San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara Islands, and waters within one nautical mile of each island (Figure SH.1). Channel Islands National Park monitors and protects threatened and endangered species, restores ecosystems, and preserves the natural and cultural resources for current and future generations.

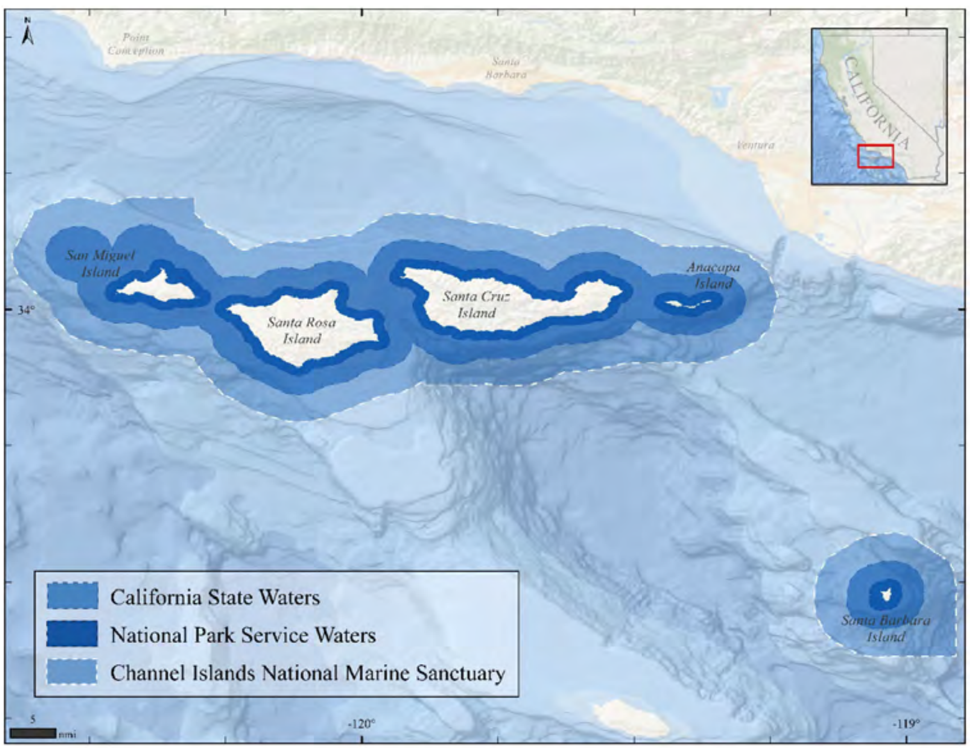


Figure SH.1. Channel Islands National Marine Sanctuary surrounds the terrestrial portion of Channel Islands National Park, overlaps with the marine portion of the park and California state waters, and also encompasses U.S. federal waters. Map: M. Cajandig/NOAA

Figure SH.2. Looking west from east Anacapa Island, one of five islands in Channel Islands National Park that is surrounded by Channel Islands National Marine Sanctuary. Photo: C. Fackler/NOAA

History

Human History of the Channel Islands

The Channel Islands and the surrounding waters have a rich human history dating back more than 13,000 years. The Chumash, or island people, are indigenous to the region surrounding the Santa Barbara Channel — the body of water separating mainland California and the Channel Islands (Watts et al. 2008).

Island Chumash were avid mariners who relied greatly on the sea for sustenance. They plied the waters of the islands, channel, and coast in tomols (i.e., redwood plank canoes) to fish and trade with mainland communities.

The maritime society of the Chumash once thrived in villages located throughout the northern Channel Islands and mainland coast. Today, no Chumash dwellings exist on the islands, but a vibrant community remains in southern California where their seafaring traditions are kept alive (Figure SH.3). For a detailed explanation of Chumash history connected to the northern Channel Islands and surrounding sanctuary waters, as well as an introduction to ongoing Chumash community values, traditional knowledge and practices, and historical trauma, see the "Chumash Ecosystem Services Assessment" that follows the Ecosystem Services section of this report.

In 1542, Spanish explorer Juan Rodriguez Cabrillo entered the Santa Barbara Channel and is believed to be the first European to land on the islands. Subsequent explorers included Sebastian Vizcaino, Gaspar de Portola, and English captain George Vancouver, who in 1793 assigned the present names to the islands on nautical charts.

Figure SH.3. Modern day Chumash paddlers in a tomol continue their seafaring traditions. Photo: R. Schwemmer/NOAA

In the early 1800s, European settlers relocated the Chumash people from the islands to mainland missions. Soon after, hunters, settlers, fishermen, and ranchers — attracted by the rich natural resources — began to populate the islands.

For the next hundred years, Russian, British, and American fur traders visited the islands and surrounding waters to hunt sea otters, and later seals and sea lions, for their prized fur and oil. Valuable fisheries for abalone and lobster thrived. Cattle and sheep ranches were established and remained active until 1998 when the last herds of cattle were removed (Livingston 2006). All of these activities were largely unregulated at the time and altered the land and ocean ecosystems.

The federal government, and in particular the military, also saw value in the Channel Islands' strategic location. In 1912, the U.S. Lighthouse Service (later the U.S. Coast Guard) began its stay on Anacapa Island and, in 1932, constructed the Anacapa Island Lighthouse (Figure SH.4) that exists to this day (Wheeler 2002). The U.S. Navy assumed control of San Miguel Island just before World War II and subsequently, the islands served an important role in southern California's coastal defenses.

The islands' waters continue to lure people. Culture, commerce, and recreation remain important influences. Federal protections of both the land and waters now recognize the area's past, present, and future cultural and ecological importance.

Figure SH.4. In 1932, the U.S. Lighthouse Service constructed the Anacapa Island Lighthouse. Photo: R. Schwemmer/NOAA

Protection of the Islands and Sanctuary Designation

Federal efforts to protect the northern Channel Islands began in 1938 when President Franklin D. Roosevelt designated Santa Barbara and Anacapa Islands as Channel Islands National Monument.

In 1976, a U.S. Navy and National Park Service agreement allowed supervised public visitation to San Miguel Island. Also in 1976, the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) Man and the Biosphere Programme designated the islands and surrounding waters as the Channel Islands Biosphere Reserve.

In 1978, the continued protection, research, and educational use of the mostly privately owned Santa Cruz Island was granted through a partnership between The Nature Conservancy and the Santa Cruz Island Company.

In March of 1980, San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara islands, and the waters within one nautical mile of each island, were designated as Channel Islands National Park, the nation's 40th national park. On October 2, 1980, NOAA designated the ocean waters from mean high tide to six nautical miles off those five islands as Channel Islands National Marine Sanctuary.

In 2003, the state of California implemented a network of marine reserves and conservation areas within the sanctuary's state waters portion. In 2006 and 2007, the network was augmented and complemented by NOAA, resulting in a total of eleven marine reserves and two marine conservation areas established within the sanctuary. In adding these zoned areas, NOAA extended the sanctuary's outer boundaries by 15 square miles, about a one percent increase to the total size of the sanctuary (Figure SH.5).

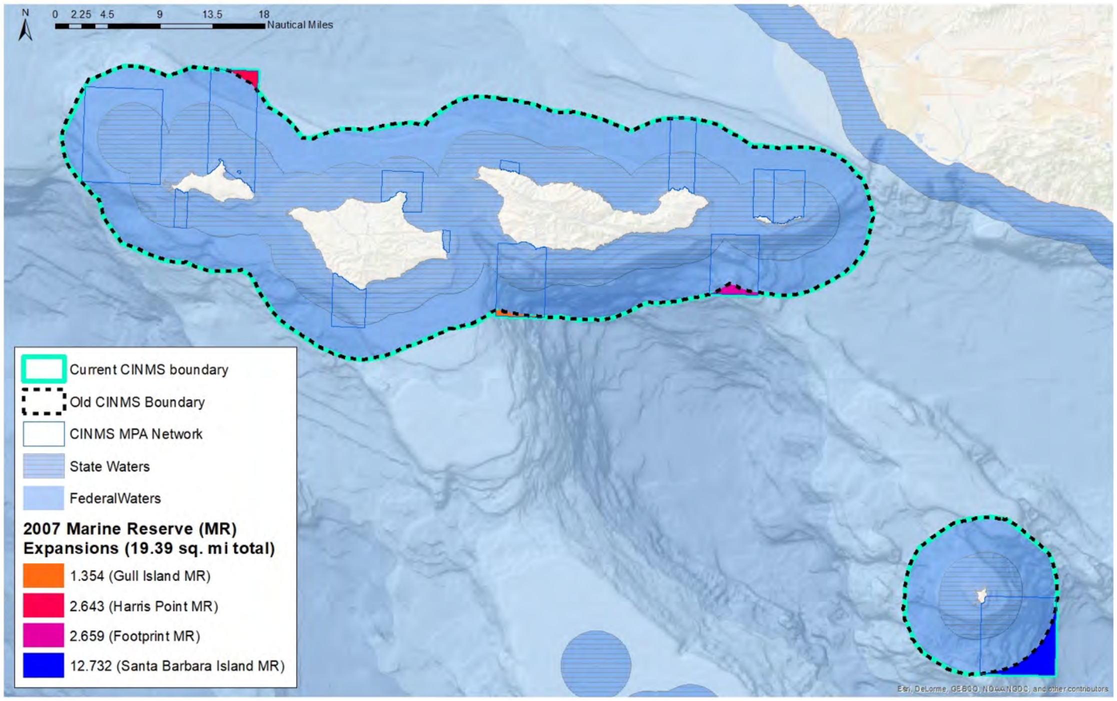
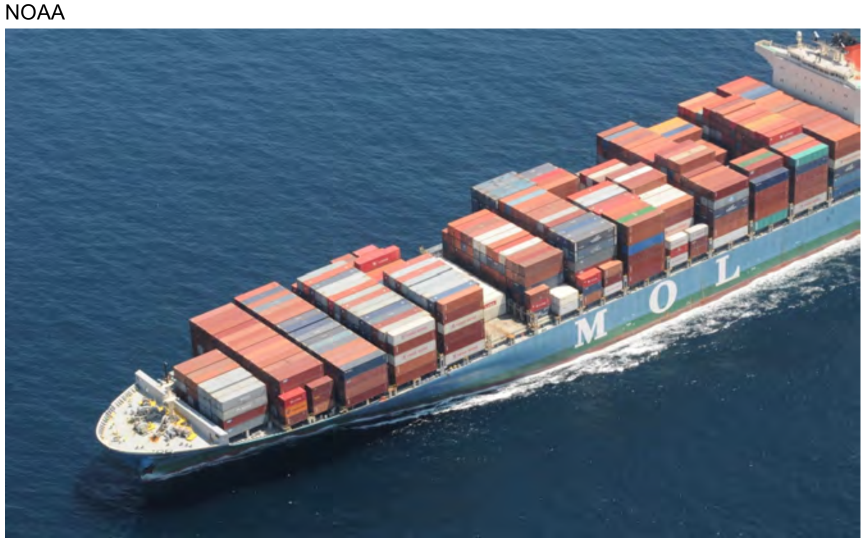


Figure SH.5. The 2007 expansion of marine reserves added about 15 square miles to Channel Islands National Marine Sanctuary. Map: E. Duncan/NOAA

Commerce

Since the days of the early coastal Chumash inhabitants, coastal waterways along southern California have been a main route of travel and supply. Ocean-based commerce and industry (e.g., fisheries and coastal shipping) continue to be important to the maritime history, the modern economy, and the social character of this region.

Figure SH.6. Large container ships regularly pass through sanctuary waters. Photo: NOAA



The expansion of the global economy over the past 50 years resulted in a substantial increase in international commercial vessel traffic through the Santa Barbara Channel. Much of this shipping traffic is to and from the Ports of Los Angeles and Long Beach, both of which consistently rank among the busiest ports in North America (NAFTA 2015).

The sanctuary is located about 70 miles northwest of these ports and about 40 miles northwest of Port Hueneme, a smaller deepwater international port. Large commercial vessels (Figure SH.6) pass through sanctuary waters just north of Anacapa and eastern Santa Cruz Islands when traveling in designated shipping lanes within the Santa Barbara Channel Traffic Separation Scheme. (Figure SH.7)

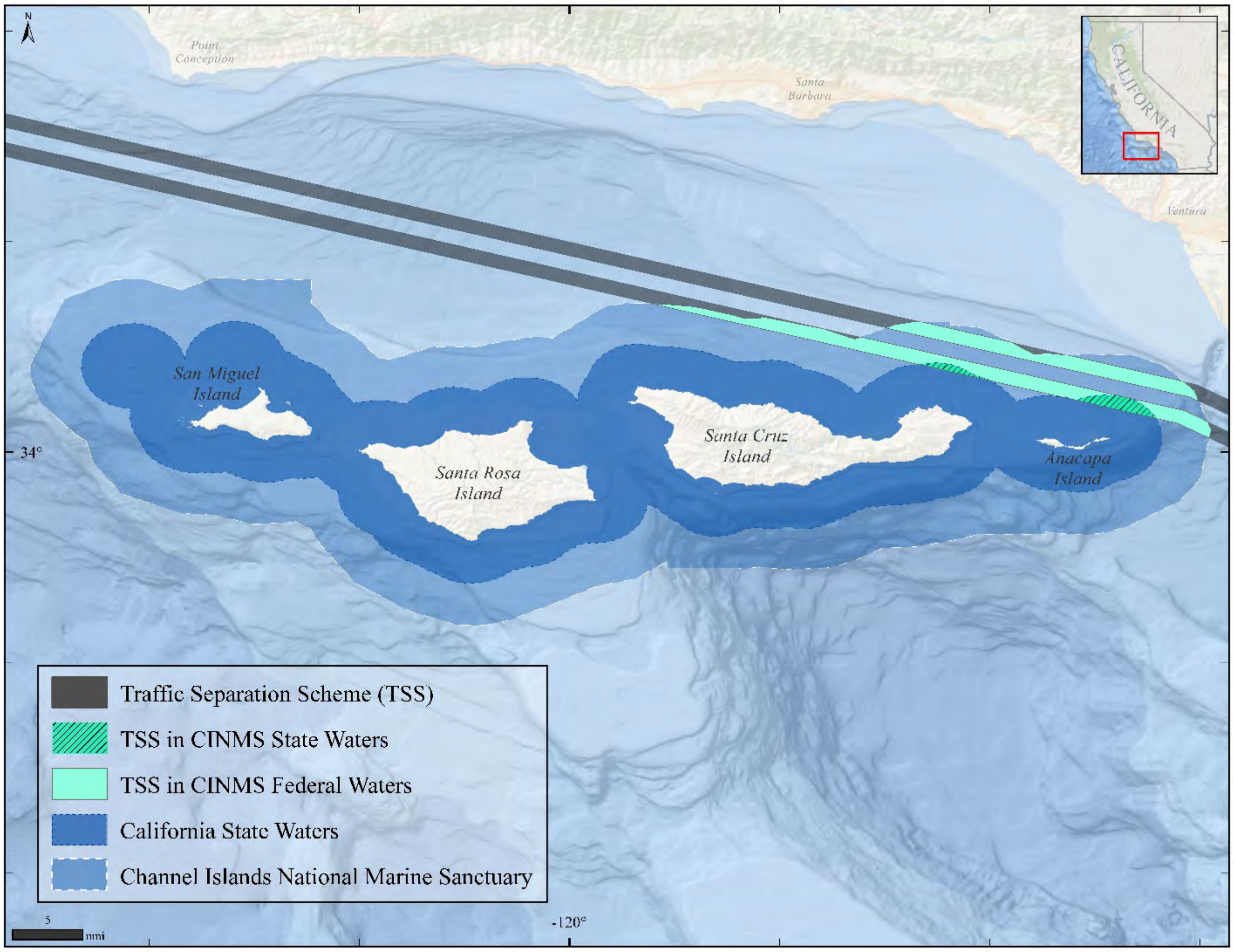


Figure SH.7. Area of overlap between CINMS and Santa Barbara Channel Traffic Separation Scheme. Map: M. Cajandig/NOAA

Smaller commercial vessels ply these waters as well. The rich fishing grounds within the sanctuary support a diverse and productive fishing industry. The Santa Barbara port complex (Santa Barbara, Ventura, Channel Islands, and Port Hueneme harbors) has the most valuable commercial landings of any port complex in California, with most of those landings coming from the waters surrounding the sanctuary (Schroeder 2016).

Recreation

Figure SH.8. Each year, endangered blue whales seasonally feed within and adjacent to sanctuary waters. Photo: J. Morton/NOAA

The waters surrounding the Channel Islands are feeding grounds for seabirds, pinnipeds, and a variety of large whales (Figure SH.8). These natural resources attract local private and charter vessels from the mainland harbors of Santa Barbara, Ventura, and Channel Islands (in Oxnard), and from further distances such as Long Beach and San Pedro harbors, who take visitors into the sanctuary for wildlife viewing, kayaking, recreational diving, and fishing trips.

Traditional and Cultural Connections

Figure SH.9. After a 17-mile journey across the Santa Barbara Channel in 2008, youth paddlers in the tomol *'Elye'wun*, or Swordfish, prepare to be welcomed by Chumash friends and family at Limuw (Santa Cruz Island). Photo: R. Schwemmer/NOAA

A vibrant Chumash culture remains closely tied to the northern Channel Islands and surrounding sanctuary waters. As a sacred homeland and place of origin, these islands and waters support cultural values and native traditions, and are honored by Chumash people and tribal organizations that work for their protection. One tradition involves an annual gathering of the Chumash community on Limuw (Santa Cruz Island) at the village site of Swaxil (Scorpion Valley) where they receive the paddlers of tomols that have journeyed 17 miles across the Santa Barbara Channel (Figure SH.9). For a detailed explanation of Chumash history connected to the northern Channel Islands and surrounding sanctuary waters, as well as an introduction to ongoing Chumash community values, traditional knowledge and practices, and historical trauma, see the "Chumash Ecosystem Services Assessment" that follows the Ecosystem Services section of this report.

Research

The sanctuary is an ecologically significant place that serves as a living lab for scientists locally and the world over. The rich biodiversity found in the sanctuary's ecosystem provides valuable opportunities for multidisciplinary research, monitoring of long-term ecological change, evaluation of resource management effects, and public education. The sanctuary, whose main office is co-located with the University of California at Santa Barbara, provides a convenient educational and research center available for year-round study. ONMS works both in partnership and independently to increase understanding of the sanctuary's natural and historic resources, and utilizes two research vessels to conduct field studies and support education (Figure SH.10).

Figure SH.10. NOAA's R/V *Shearwater* conducts conservation research off Santa Cruz Island. Photo: R. Schwemmer/NOAA

Education and Outreach

The sanctuary offers a diverse array of opportunities for the public to explore and learn from one of the most diverse and productive marine ecosystems in the world. Various organizations and institutions, working in partnership with the sanctuary, engage the public through formal and informal science, technology, engineering, and mathematical (STEM) education, outreach, conservation, and stewardship activities focused on the sanctuary's resources, history, current resource protection issues, and natural beauty. These activities support the sanctuary's mission by helping to foster a sense of place and wonder. In so doing, they raise awareness about the value of taking care of the ocean today and for the future.

Geology

The Channel Islands are located within a unique geological feature of the southern California coast. Over millions of years, large plates of the earth's crust moved along fault lines, pushing against the coastline of Mexico and California, creating today's coastal geography. During this shifting, part of the southern California coast was rotated, resulting in the Transverse Ranges — the unusual east-west axis of the California coast just south of Point Conception — and the formation of the Channel Islands archipelago (Figure SH.11).

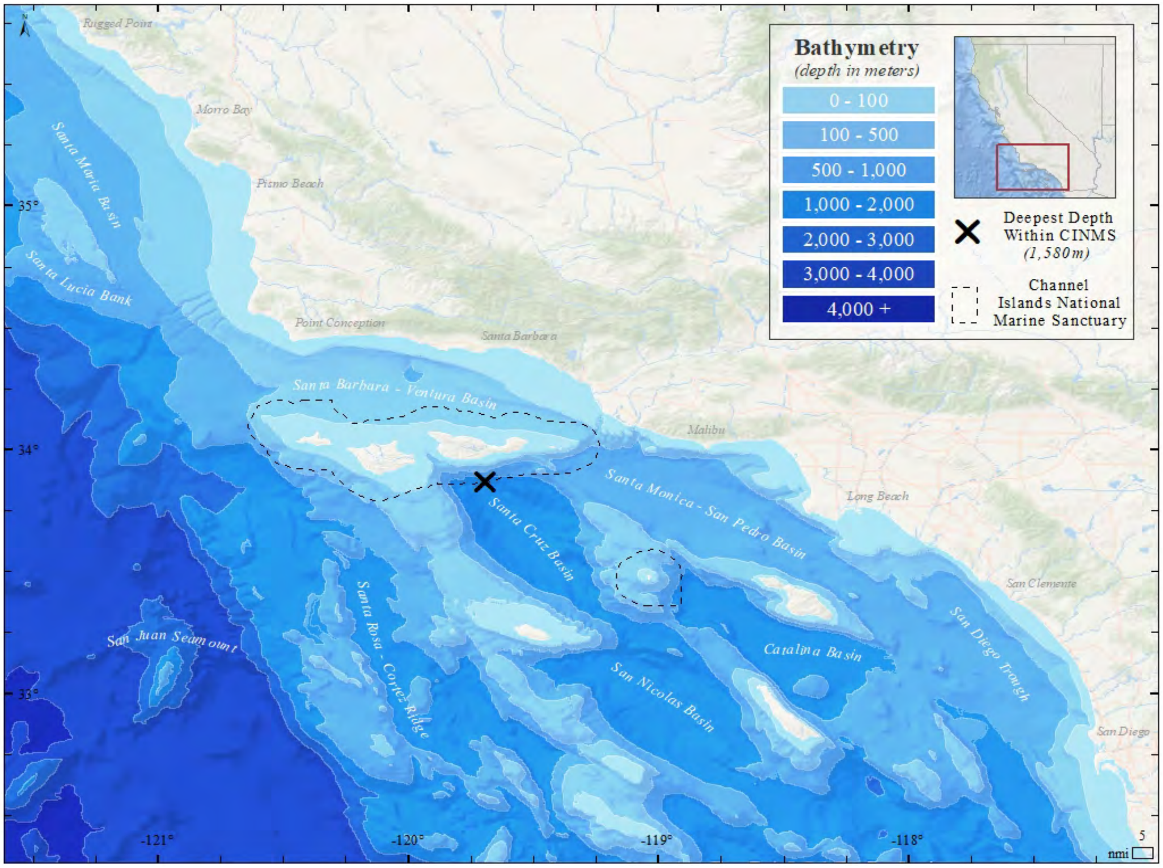


Figure SH.11. Geological processes created the unique east-west orientation of the Channel Islands. Map: M. Cajandig/ NOAA

The Continental Borderland is the offshore section of the underwater geology that forms a wide continental shelf (Norris and Webb 1990). Unlike most wide continental shelves that consist of gently sloping platforms interrupted by low banks and occasional canyons, the Continental Borderland is a region of basins and elevated ridges (Norris and Webb 1990); the Channel Islands are the portions of the ridges that rise above sea level (Figure SH.12).

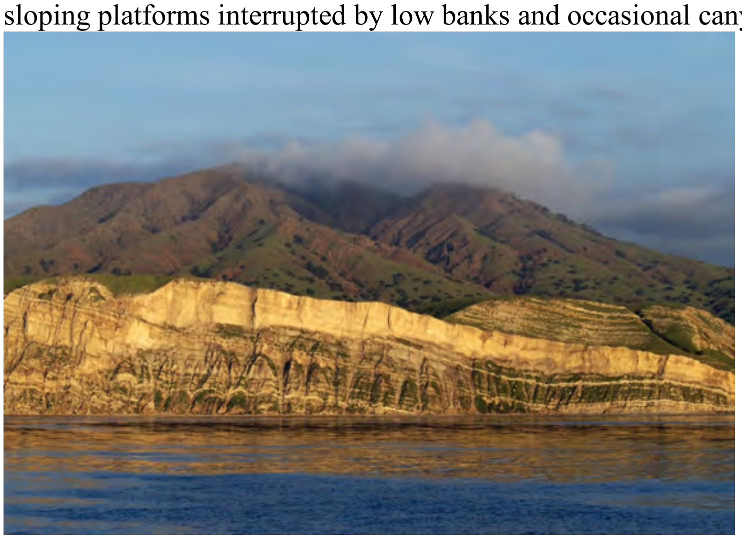


Figure SH.12. The south side of Santa Cruz Island has a rugged coastline. Photo: R. Schwemmer/NOAA

Also unique to this area are large deposits of oil and gas. More than 20 oil fields and several natural gas fields lie beneath the Santa Barbara Channel in the Santa Barbara Basin, a deep submerged geological feature just north of the sanctuary. Natural oil seeps in the area are known to have one of the highest rates of seepage in the world.

Oceanography

Water circulation around the Channel Islands is complex and highly dynamic. This pattern results from the interaction of large-scale ocean currents, local geography, and the basin and ridge topography of the ocean bottom in southern California.

The California Current flows south along the west coast of North America bringing cool water towards the equator. At the northern Channel Islands, the current mixes with the north-flowing Southern California Countercurrent, which brings warm water northwestward up the coast (Hendershott and Winant 1996).

Between the islands and the mainland, these currents create a localized cyclonic gyre that can vary in intensity seasonally based on current and wind speed (Hendershot and Winant 1996, Harms and Winant 1998, Winant et al. 2003).

The region around the islands is known as a marine transition zone because of the mixing of the warm and cool waters in the sanctuary. These varying conditions create alternate states of upwelling, where cool nutrient-rich water is brought from deeper areas to the photic (i.e., light penetrating) zone at the surface; and relaxation, when upwelling ceases (Winant et al. 2003).

Regional upwelling is wind-driven and provides the nutrients and conditions for seaweeds, phytoplankton, and zooplankton to thrive. The resulting high seasonal ocean productivity within and near the sanctuary attracts migratory species from across the Pacific Ocean, including pinnipeds, seabirds, and large baleen whales.

Habitat

There are a variety of important habitats within CINMS including sandy beach, rocky shore, kelp forest and rocky reef, shallow sandy seafloor, deep seafloor, and pelagic habitat. These habitats support a diverse group of algae, plants, invertebrates, fish, marine mammals, and seabirds (Figure SH.13).

As of 2017, about 76 percent of the sanctuary's seafloor had been characterized and mapped with high quality seafloor bathymetry data (Figure SH-14). The mix of sanctuary habitats is diverse and it is expected that the understanding of the extent of each available habitat will improve as habitat mapping continues.

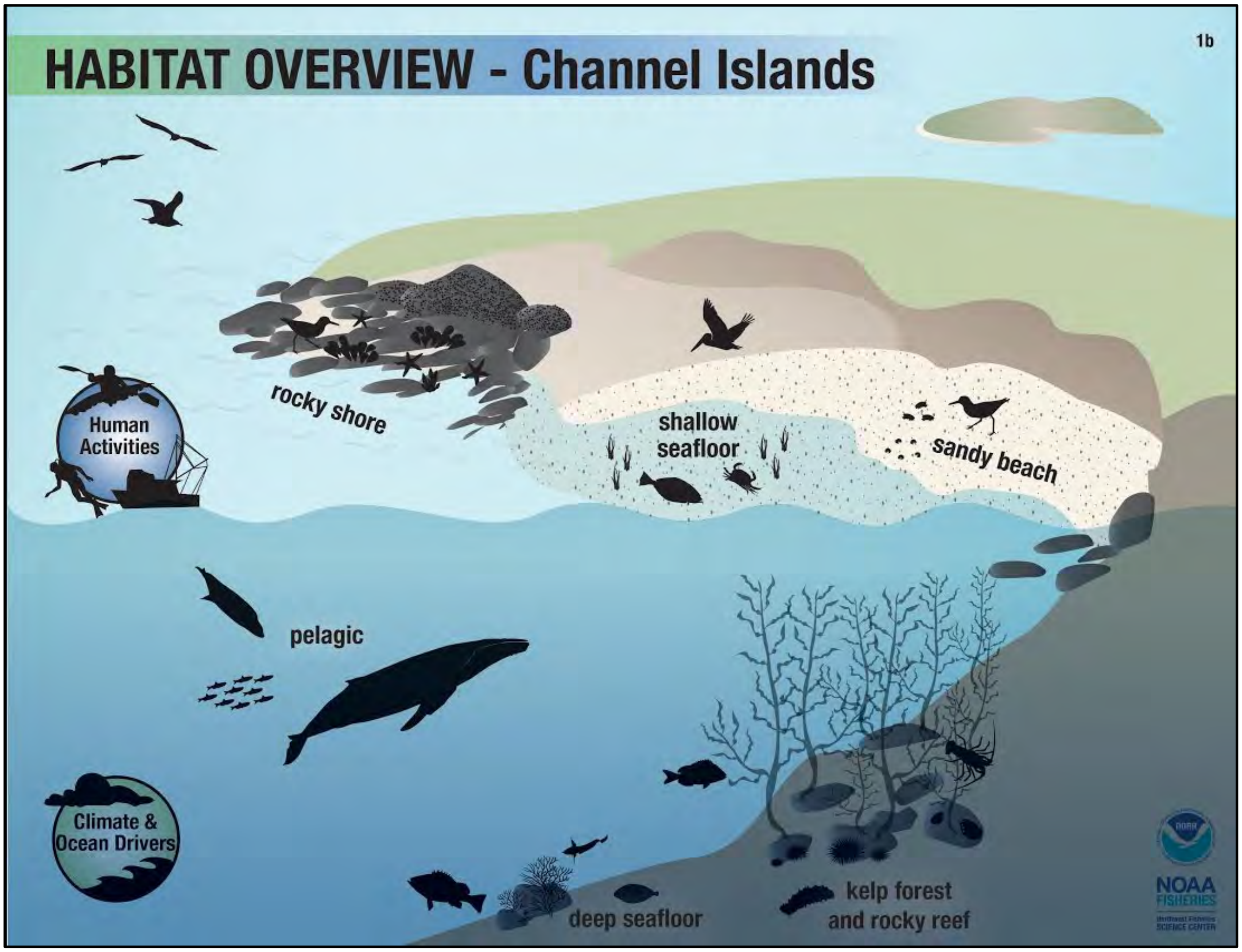


Figure SH.13. There are many diverse habitats found within the sanctuary. Figure: S. Kim/NOAA

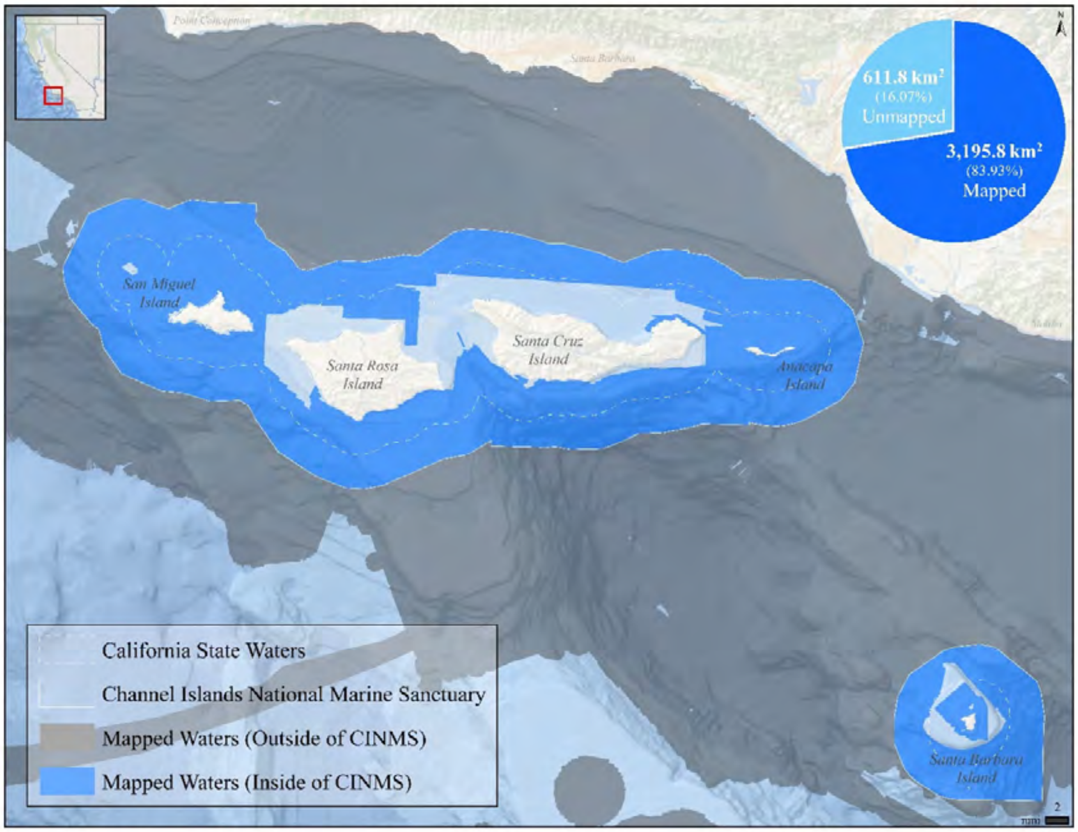


Figure SH.14. High resolution mapped seafloor areas within and adjacent to the sanctuary (as of June 30, 2017). Map: M. Cajandig/NOAA

Sandy Beach

Sandy beaches are high-energy coastal habitats that are periodically covered and uncovered by waves and daily tides — the height of the tides within the sanctuary can be more than two meters (6.5 feet). Sandy beaches are a major component (approximately 20 percent) of the intertidal region of the northern Channel Islands. Sandy beaches are used by a wide variety of species for foraging, nesting, resting, and breeding (Figure SH.15a).

Figure SH.15. Sandy beaches and rocky shores are high energy environments found throughout the Channel Islands. Photos: R. Schwemmer/NOAA

Rocky Shore

Changing tides, pounding waves, and competition for food and space are among many physical and biological factors that determine the nature of plant and animal communities along the rocky shore. Similar to the sandy beach habitat, organisms here have adapted to thrive in this harsh and changing environment where they live part of their day under water and part of their day exposed to the air (Figure SH.15b).

Shallow Sandy Seafloor

The nearshore shallow habitat extends from the surf out to waters that are approximately 30 meters deep. Waves and currents interact with the sandy seafloor in this relatively shallow zone, creating sand waves and ripples and organizing sediment particles into different group sizes (e.g., sand, gravel, cobble) (Figure SH.16).

Kelp Forest and Rocky Reef

Rocky seafloor habitats are widespread around the sanctuary. These rocky underwater reefs are often characterized by dense patches of kelp, a marine algae. One third of Southern California's kelp forests are found within sanctuary waters 2-30 meters, or more, deep, with giant kelp (*Macrocystis pyrifera*) being the largest and most prominent species.

Deep Seafloor

The deep seafloor habitat extends from about 30 meters to greater than 200 meters deep over the continental shelf and slope; the depth in some canyons may exceed 1,500 meters.

More than 90 percent of the habitat found in the deep waters off Southern California is soft bottom (Thompson et al. 1993). Many organisms live in and above the mud and sand, including clams, worms, sand crabs, sand dollars, sea stars, bottom-dwelling sharks, rays, and flatfishes (Figure SH.17).

The less common rocky seafloor is made up of low-relief reefs less than one meter in height. Higher relief pinnacles and ridges occur in some areas, such as off the northwest end of San Miguel Island. These high-relief volcanic reefs can include features such as walls, ledges, caves, pinnacles, boulders, and bedrock outcroppings. These rocky underwater environments provide habitat capable of supporting thousands of algal, invertebrate, and fish species.

Because of the difficulty in studying very deep habitats, less is known about these areas in the sanctuary; however, recent submersible work has revealed colonies of deep-sea coral, such as *Lophelia pertusa* north and south of the islands. These coral gardens support diverse fish and invertebrate communities (Etnoyer et al. 2014, Tissot et al. 2006) (Figure SH.18).

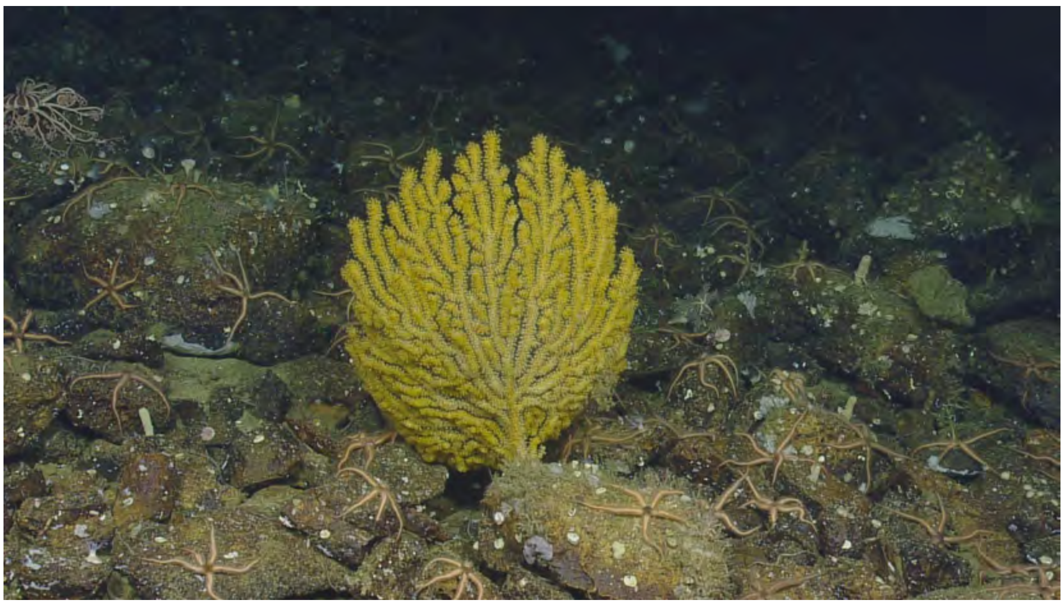


Figure SH.17. Gorgonian coral can be seen on deep rocky bottom habitat. Photo: OET/NOAA

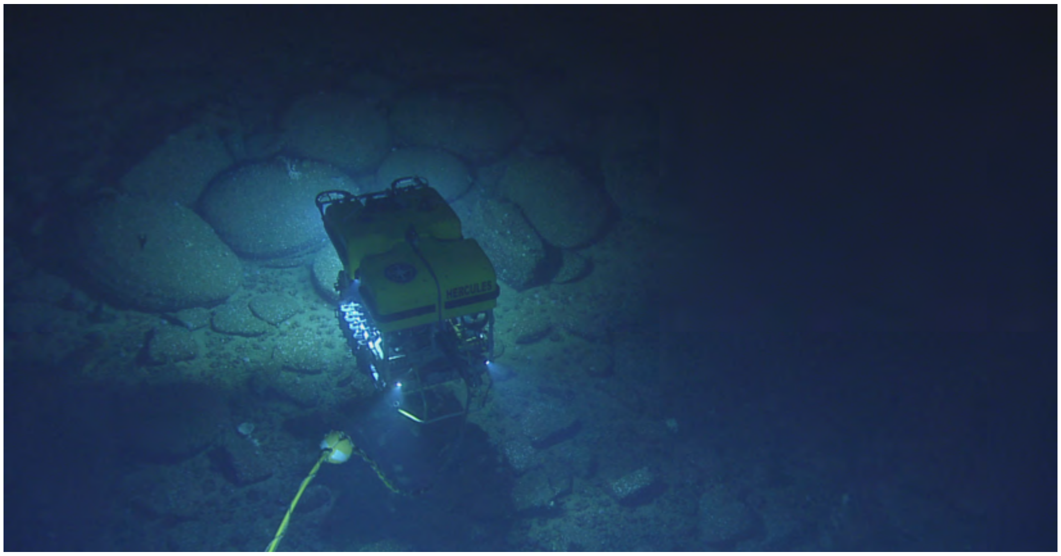


Figure SH.18. A remotely operated vehicle (ROV) explores the sanctuary's benthic habitat. Image: OET/NOAA

Pelagic Habitat

Pelagic habitat, the most extensive habitat in the sanctuary, includes the offshore oceanic water around the islands. It is divided into sub-habitats based on depth, each of which has varying degrees of light penetration, temperature, oxygen concentration, and density.

Light can penetrate the water's surface down to 200 meters, known as the photic zone. This region of the water column is also called the epipelagic, and the base of its food webs are composed almost entirely of phytoplankton — tiny plants that turn sunlight into energy via photosynthesis. Zooplankton (i.e., tiny fish larvae and invertebrates) and small schooling fishes (e.g., anchovy and sardine) that feed on phytoplankton are in turn a major food source for larger fishes, seabirds, and marine mammals.

In the midwater environment (200–1,000 meters), fishes and some invertebrates have developed special adaptations that enable them to live under higher water pressure, lower oxygen levels, and darkness. Many small midwater fishes and zooplankton feed on phytoplankton by migrating hundreds of meters to the surface layer after sunset and then returning to their midwater habitat at dawn.

Wide ranging and migratory pelagic species are inherently hard to study. To help overcome this, ONMS and local partners maintain a marine animal tracking network to better understand the habitat use and movements of tagged large vertebrates (e.g., elasmobranchs, predatory fish, marine mammals) along the West Coast. To improve understanding of mid- and deep-water habitats, ONMS and partners employ a variety of technologies, including net sampling, manned submersibles, and remotely operated vehicles.

Living Resources

The abundance and distribution of marine life in the sanctuary is driven on a large scale by the oceanographic conditions around the islands, specifically the mixing of the warm Southern California Countercurrent from the south and the cooler California Current from the north creating localized gyres and upwelling patterns.

The varied oceanographic conditions and the transition between them, the diversity of habitats (ranging from sheltered embayments to exposed open coasts), and the relatively undisturbed location support a wide variety of invertebrates, fish, sea turtles, seaweed, marine plants, marine mammals, and seabirds.

Sanctuary waters around Santa Barbara Island, the most southern island, are inhabited mainly by warmer water, southern species. Anacapa and Santa Cruz islands have both southern and northern species. The waters around Santa Rosa and San Miguel islands to the west are populated with a greater portion of cooler water, northern species. For example, garibaldi (*Hypsypops rubicunda*) are found mainly in warm water around Santa Barbara and Anacapa islands, while blue rockfish (*Sebastes mystinus*) are more abundant in the colder waters off San Miguel Island.

Plankton

A diverse planktonic community forms the base of the sanctuary's food web. The abundance and species richness of plankton varies greatly in both space and time and is dependent upon environmental factors, such as nutrients and temperature. Short-term blooms of phytoplankton often occur in association with upwelling. These blooms subsequently support zooplankton populations. Zooplankton, in turn, are preyed upon by small schooling fish that then provide food for larger fish, seabirds, and marine mammals.

Macroalgae and Plants

Macroalgae (i.e., seaweed) and marine plants (i.e., seagrasses) are habitat-forming primary producers that grow in intertidal and shallow subtidal waters, generally less than 30 meters deep, where enough light penetrates for photosynthesis.

The islands support a rich array of benthic algae and seagrasses. In southern California, there are at least 492 species of algae and four species of seagrasses known to occur from among the 673 total species described for California (Abbott and Hollensberg 1976, Murray and Bray 1993).

These algae and marine plants are critical to the life history of many of the invertebrates, fishes, seabirds, and marine mammals found in the sanctuary. For example, giant kelp forms extensive underwater forests on rocky substrates at shallow subtidal depths (Figure SH.19). These impressive kelp forests are characteristic features of southern California nearshore marine environments, including the nearshore zone adjacent to the sanctuary, and are important not only ecologically, but also for recreational and commercial activities including fishing, diving, and tourism.

Kelp beds are highly productive habitats and serve as important nursery habitat for juvenile fishes in the upper canopy (Carr 1994). They also provide food, attachment sites, and shelter for a diverse assemblage of invertebrates and other species of algae on the benthos, throughout the water column, and in the root-like structure called the holdfast (Dayton 1985, Graham 2004).

Figure SH.19. Giant kelp forests are characteristic of the sanctuary's nearshore marine environment. Photo: NOAA

There are two types of marine flowering plants found in the sanctuary. Surfgrass (*Phyllospadix* spp) is found in rocky intertidal and shallow subtidal areas. Eelgrass (*Zostera marina*) is found in soft bottom subtidal areas. These plants form productive and complex habitats that provide food and refuge for a wide variety of marine species, including recreational and commercially important fish and invertebrates (den Hartog 1970, Orth et al. 1984, Hemminga and Duarte 2000) (Figure SH.20).

Seagrass beds provide nursery habitat (reviewed in Heck et al. 2003) and are important for nutrient cycling (Costanza et al. 1997) and substrate stabilization (Fonseca and Fisher 1986). Recent efforts have focused on restoring eelgrass beds at Anacapa Island. Eelgrass beds are also found at Santa Cruz and Santa Rosa islands.

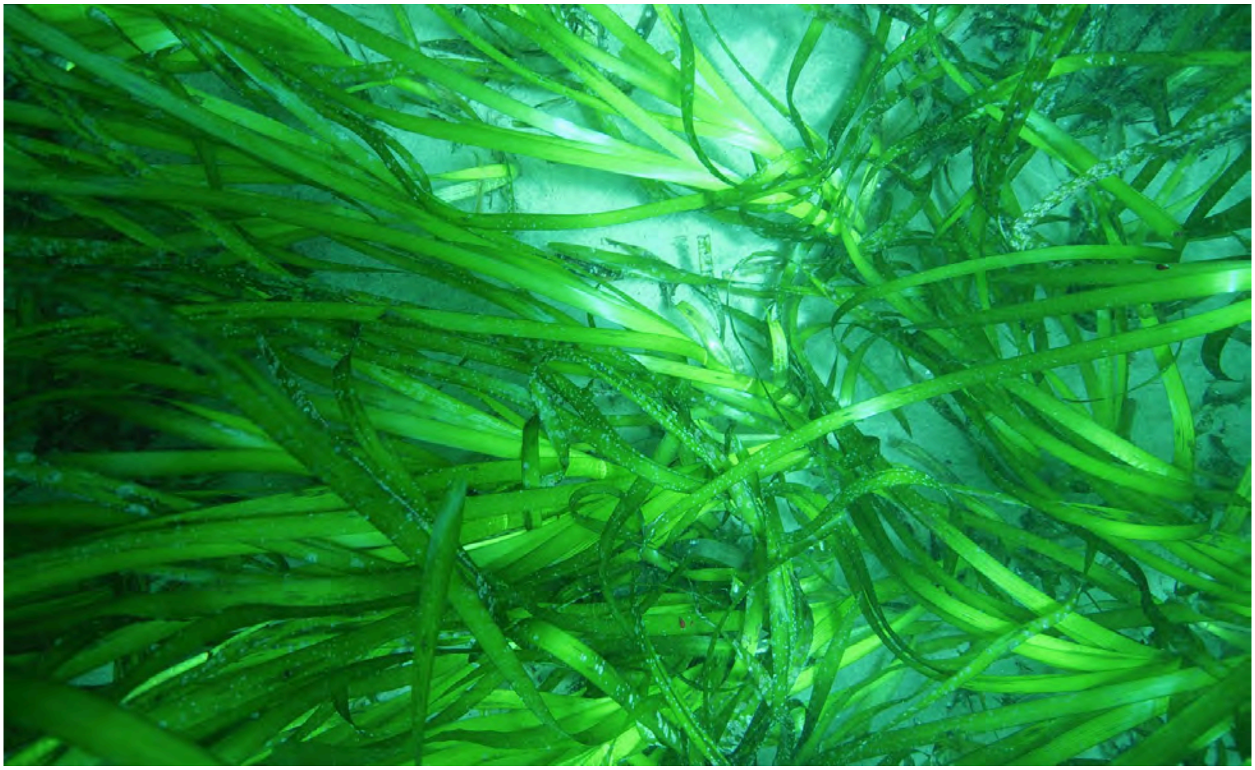


Figure SH.20. Seagrass, like this eelgrass at Santa Cruz Island, provides food and refuge for a variety of marine species. Photo: R. Schwemmer/NOAA

Invertebrates

The total number of invertebrate species in southern California may be in excess of 5,000, not including micro-invertebrates (Smith and Carlton 1975, Straughan and Klink 1980). Common and ecologically important invertebrates in the sanctuary include: abalone, anemones, barnacles, clams, corals, crabs, jellyfish, mussels, nudibranchs, prawns, salps, scallops, sea cucumbers, sea slugs, sea stars, sea urchins, snails, spiny lobster, squid, tunicates, and worms (Figure SH.21).

Figure SH.21. Bat star (*Patiria miniata*) can be found in the sanctuary's intertidal zone. Photo: C. Fackler/NOAA

Fish

More than 400 species of fish have been documented in the sanctuary, which constitutes a greater species richness than nearby coastal regions along the southern California mainland. Fish diversity on nearshore reefs is related to the presence or absence of kelp and substrate topography (Figure SH.22).

Figure SH.22. Hundreds of fish species reside in the sanctuary, often in kelp forest habitats. Photo: R. Schwemmer/NOAA

Some of the common nearshore kelp bed and rocky reef-associated fishes in the sanctuary include: giant sea bass, kelp bass, garibaldi, and California sheephead. Common important groundfish found within sanctuary waters include: bank rockfish, bocaccio, cowcod, chilipepper rockfish, Dover sole, English sole, sablefish, and widow rockfish (Figure SH.23).

Figure SH.23. These juveniles of two species of rockfish live in the sanctuary. Photo: NOAA

Coastal pelagics and highly migratory fish species include: California barracuda, Pacific bonito, white sea bass, yellowtail, albacore, blue shark, jack mackerel, northern anchovy, opah, Pacific mackerel, Pacific northern bluefin tuna, Pacific sardine, shortfin mako shark, skipjack tuna, striped marlin, swordfish, thresher shark, white shark, and yellowfin tuna.

Figure SH.24. California gull chicks (*Larus californicus*) are one species of gull that can be found in the Channel Islands. Photo: NOAA

Seabirds

CINMS is located along the Pacific Flyway, a major migratory route for birds. The islands act as a stopover during the birds' northerly (i.e., April through May) and southerly (i.e., September through December) migrations. In addition, the diversity of habitats on the Channel Islands provides breeding and nesting sites for many resident species, which then forage in sanctuary waters. These island sites are particularly valuable because they are free of mainland predators and immediately adjacent to the southern California's most productive waters (Figure SH.24).

Sandy beaches provide foraging and resting habitat for a number of shorebirds including: black-bellied plover, gulls, long-billed curlew, sanderlings, whimbrel, and willet. The upland portions of the beach provide kelp deposits that attract invertebrates, which are eaten by black and ruddy turnstones (*Arenaria melanocephala* and *A. interpres*), dowitchers, and other shorebird species. The islands' rocky caves and crevices provide nest habitat for Scripps's murrelets (*Synthliboramphus scrippsi*) and ashy storm-petrels (*Oceanodroma homochroa*), while Cassin's auklets (*Ptychoramphus aleuticus*) dig burrows in seaside cliffs. Twelve seabird species breed in the Channel Islands, eight of which are granted special protected status under federal or California state law: ashy storm-petrel, black storm-petrel, California brown pelican, California least tern, double-crested cormorant, rhinoceros auklet, Scripps's murrelet, and western snowy plover.

Sea Turtles

Four species of sea turtles have been reported in the offshore southern California region: green, leatherback, loggerhead, and olive ridley. All species of sea turtles are federally endangered and these four species are rarely sighted at the Channel Islands because of range limits (green, loggerhead, and olive ridley), decreased populations, and their migratory habits.

Whales, Dolphins, and Pinnipeds

The Channel Islands and surrounding waters support a great diversity of marine mammals, including whales, pinnipeds, and on occasion, sea otters. As in the case of the seabirds, they depend on a large volume of seasonal food resources. The abundance and distribution of marine mammals is an indication of the general health and ecological integrity of the sanctuary's marine ecosystem.

At least 33 species of cetaceans have been reported in the southern California Bight (C.J. Rennie, Santa Barbara Museum of Natural History, pers. comm., Leatherwood et al. 1987), with 18 regularly observed in the Santa Barbara Channel (Santa Barbara Coastal LTER 2006). These species include but are not limited to: blue whale, bottlenose dolphin, California gray whale, humpback whale, Pacific white-sided dolphin, Risso's dolphin, and short-beaked and long-beaked common dolphin (Figure SH.25).

The sanctuary provides vital habitat for pinnipeds, offering important feeding areas, breeding sites, and haul outs. Six species of pinnipeds have historically occurred in the northern Channel Islands: California sea lion, Guadalupe fur seal, northern fur seal, northern elephant seal, Pacific harbor seal, and Steller sea lion. The most common pinniped in the northern Channel Islands is the California sea lion, with San Miguel serving as the location for 50 percent of pup births. The least common is the Steller sea lion, for which the sanctuary is at the southern edge of its range.

Figure SH.25. Humpback whales lunge feed in the sanctuary. Photo: R. Schwemmer/NOAA

Finally, the southern sea otter (*Enhydra lutris*) is occasionally sighted at the Channel Islands, although there is currently no resident breeding population. The southern sea otter is listed as threatened under the federal Endangered Species Act and is considered depleted and protected under the Marine Mammal Protection Act. In general, the California population has been slowly increasing in recent years (Tinker and Hatfield 2016).

Maritime Archaeological Resources

Archival research suggests over 140 historic maritime archaeological resources, including ship and aircraft wrecks, may exist in the sanctuary (Morris and Lima 1996). This significant number of shipwrecks within the sanctuary can largely be attributed to prevailing currents and weather conditions, combined with natural hazards. The shipwreck remains reflect the diverse range of activities and nationalities that traversed the Santa Barbara Channel. European sailing and steam vessels, California-built ships of Chinese design called "junks," American coastal traders, vessels engaged in island commerce, and a Gold-Rush-era side-wheel steamer have all been lost in sanctuary waters; each has a story to tell about the history, technology, and society of earlier times.

Of the 140 historic ship and aircraft wrecks identified in the Channel Islands National Marine Sanctuary and National Park, only about 30 sites have been located and surveyed (Figure SH.26). Two examples of these known shipwrecks are the passenger-cargo steamer Cuba, which stranded off of San Miguel Island in 1923 (Figure SH.27), and the California Gold Rush side-wheel passenger steamer Winfield Scott, which stranded in 1853 on Anacapa Island (Figure SH.28).

The sanctuary's Shipwreck Reconnaissance Program contributes to scientific knowledge and enhancement of management practices related to underwater archaeological resources by encouraging research and monitoring efforts. Federally-certified scuba divers provide year-round monitoring of submerged sites through cooperative partnerships with Channel Islands National Park, California State Lands Commission, and Coastal Maritime Archaeology Resource organization. To date, one nearshore site, Winfield Scott, has been added to the National Register of Historic Places (Figure SH.28).

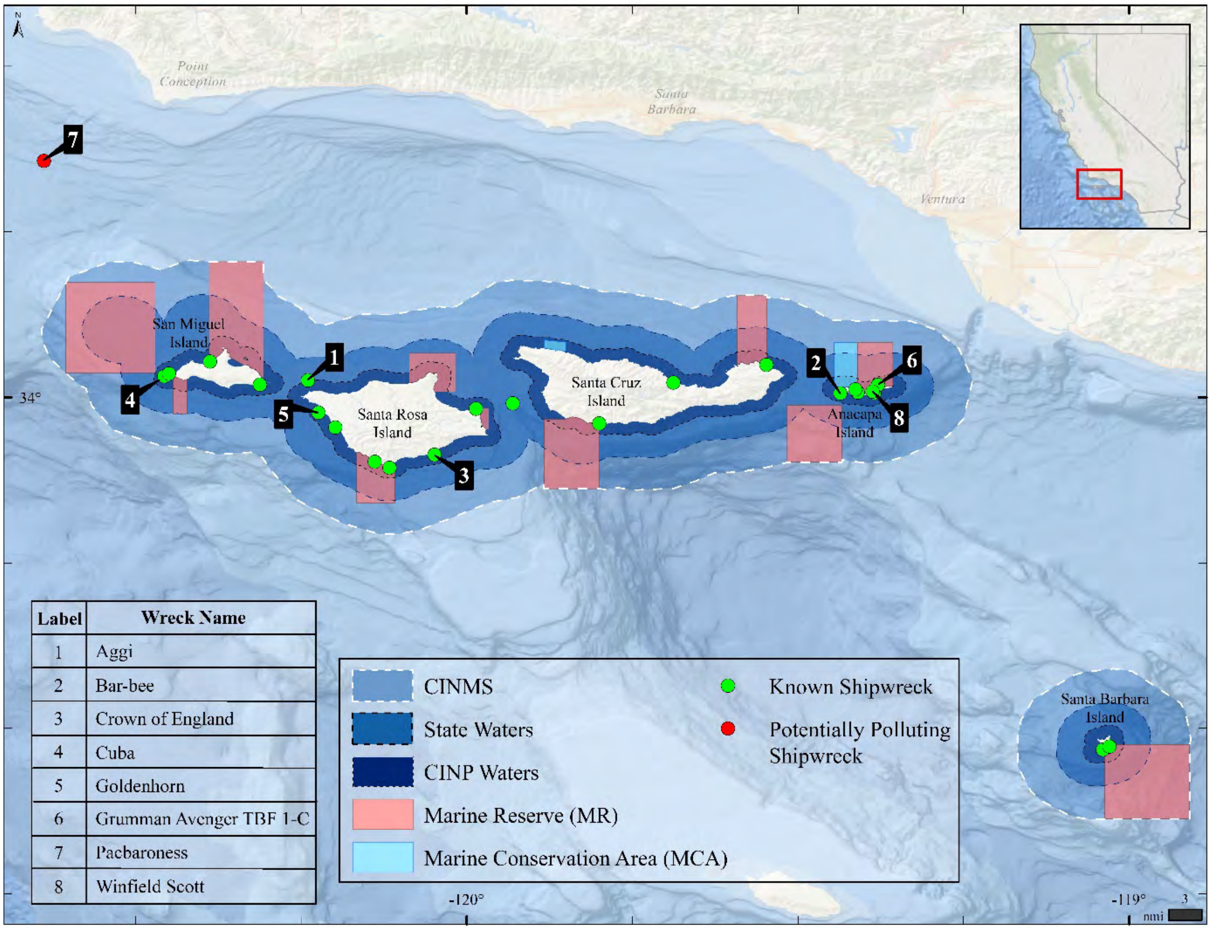


Figure SH.26. Map shows locations of some of the known shipwrecks in or near Channel Islands National Marine Sanctuary. Map: M. Cajandig/NOAA

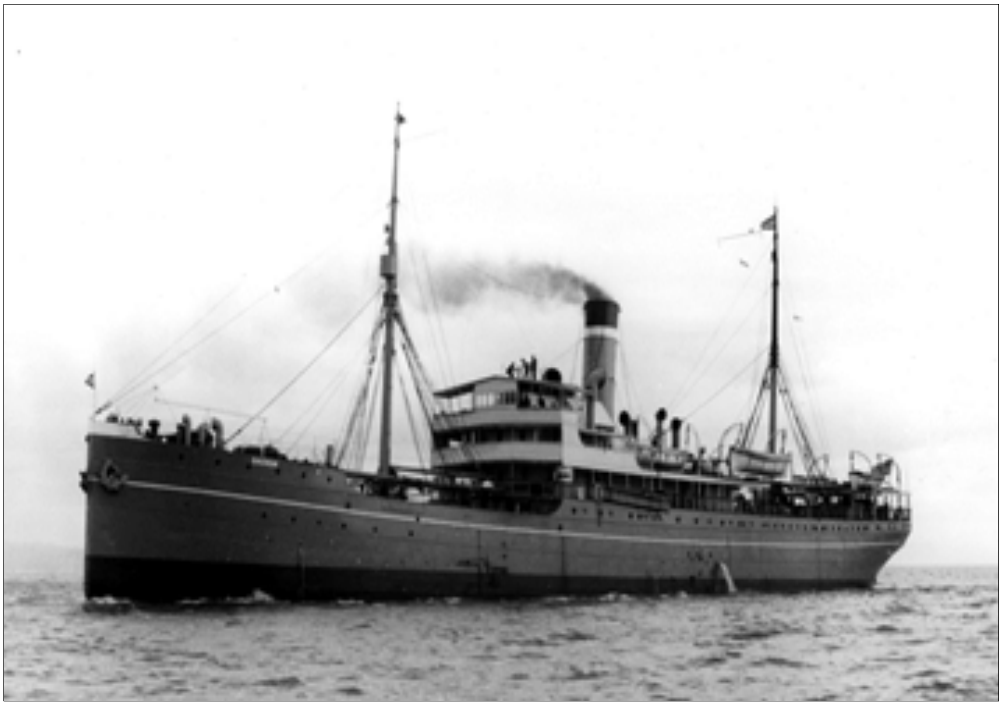


Figure SH.27. Passenger steamer *Sachem*, later renamed *Cuba*, was stranded off San Miguel Island in 1923. Photo: courtesy of M. McGarvey

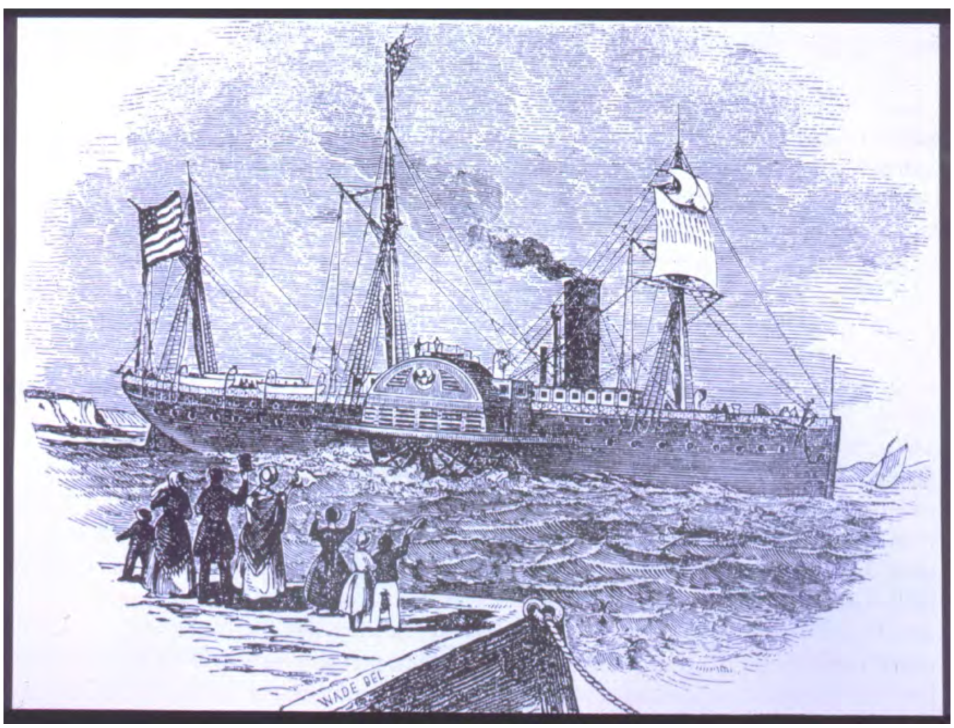


Figure SH.28. Side-wheel passenger steamer *Winfield Scott* lost at Anacapa Island in 1853 is the earliest recorded shipwreck at Channel Islands and is on the National Register of Historic Places. Photo: courtesy of R. Schwemmer/NOAA

DRIVING FORCES AND PRESSURES ON THE SANCTUARY

Human activities and natural processes affect the condition of both natural and archaeological resources in national marine sanctuaries. This section describes the general nature and extent of known pressures affecting resources in CINMS. Driving forces behind those pressures are also discussed and can aid in predicting the direction and extent of future pressures. While the trends in drivers and pressures support the assessment of sanctuary resource status and trends (i.e., the State section of this report), forecasts provide a forward-looking approach to address policy and management responses needed to protect and/or restore sanctuary resources (i.e., the Response section of this report). This section also addresses five questions about the status and trends of drivers and the human activities (i.e., pressures) influencing major sanctuary resource components — water, habitat, living resources, and maritime archaeological resource quality.

The general approach used herein is to integrate drivers with pressures in the discussions of each pressure; however, since there are several drivers that affect several different pressures, they are addressed in this introduction. Quantitative details are included in this section and are not repeated when each pressure that they affect is discussed.

Two of the most important high-level drivers of status and trends for sanctuary pressures are changes in population growth and per capita income; both operate at multiple scales ranging from local to international and affect demand for resources (e.g., food and access), and thus, levels of activity that alter conditions (e.g., development, shipping traffic, boating, pollution, noise, etc.).

The U.S. population increased 0.9% per year between 2000 and 2015 and is forecast to increase 1.0% per year through 2030 (Woods and Pool 2016). In 2010, 123 million people, or 39 percent of the nation's population lived along the coast. By 2020, NOAA predicts another ten million people will move to a coastal county.[2]

Nearly one third of California residents (about 11 million people) now live in Los Angeles, Santa Barbara, and Ventura counties, the three counties adjacent to CINMS (U.S. Census Bureau 2016, see Appendix C: Table App.C.1.2 and Figure App.C.1.1). Between 2000 and 2015, population in this three county area grew at an annual rate of 0.5 percent. California's population is projected to increase slightly between 2015 and 2030 (1.1 percent), with the three county area expected to experience an average annual population growth rate of 0.7 percent (Woods and Pool 2016, see Appendix C: Table App.C.1.4).

Meanwhile, the standard of living in the three counties has increased faster than the rest of the U.S. Between 2000 and 2015, real per capita income increased 1.3 percent in the U.S. and is forecast to increase 1.6% per year between 2015 and 2030 (Woods and Pool 2016). Between 2000 and 2015, the real per capita income increased 2.5 percent in the three counties; however, increases to real per capita income are expected to even out in the future. Specifically, projections show a 1.6 percent increase for both the

[2] National Ocean Service. What percentage of the American population lives near the coast? Retrieved from https://oceanservice.noaa.gov/facts/population.html (last updated Oct. 10, 2017).

U.S. and the three county area between 2015 and 2030 (Woods and Pool 2016, see Appendix C: Tables App.C.1.2, App.C.1.3, and Figure App.C.1.2).

Another major driver of pressures on U.S. resources in general, including those along the West Coast, is Chinese per capita income. China is one of the biggest importers of fishery products from the Channel Islands' region (NMFS 2017a). As China's per capita income increases, this is likely to result in an increased demand for all goods, including seafood and other fishery products from CINMS. As stated above, U.S. increases were 1.3% per year between 2000 and 2015. In contrast, China's Gross Domestic Product (GDP) per capita increased 10% per year between 2008 and 2016 and is forecast to increase 7% per year through 2020 (Trading Economics 2017, see Appendix C: Table App.C.1.5).

A third important and more immediate driver for many ocean activities is the price of fuel. Gas prices are an input to the production of commercial fisheries, ocean recreation and offshore gas exploration. If the price increases, this makes all commercial fishing and ocean recreation activities more costly. Gas prices, for example, declined 29 percent between 2012 and 2017, affecting levels of visitation and various uses. Lower gasoline prices may result in a lowered willingness of producers to invest in exploration and drilling around the sanctuary, as the costs of research and exploration may be prohibitive when the value of gasoline is lower. At the same time, lower gas prices make it less costly to engage in ocean recreation and to visit Channel Islands.

Vessel Traffic

Private, commercial, and military vessels may affect the sanctuary, adjacent environment, and sanctuary users in several ways, including:

- Air pollution via greenhouse gas emissions
- Discharge of oil, sewage, non-indigenous species, and non-biodegradable materials
- Increased ocean noise impacting living marine resources
- Navigational safety concerns
- Anchor damage to seafloor habitats (e.g., eelgrass, corals) or maritime heritage resources (e.g., shipwreck sites)
- Ship strikes on whales, including endangered whale species
- Changes in sanctuary wildlife behavior
- Spills, debris wreckage, and habitat degradation from vessel collisions, groundings, and sinkings

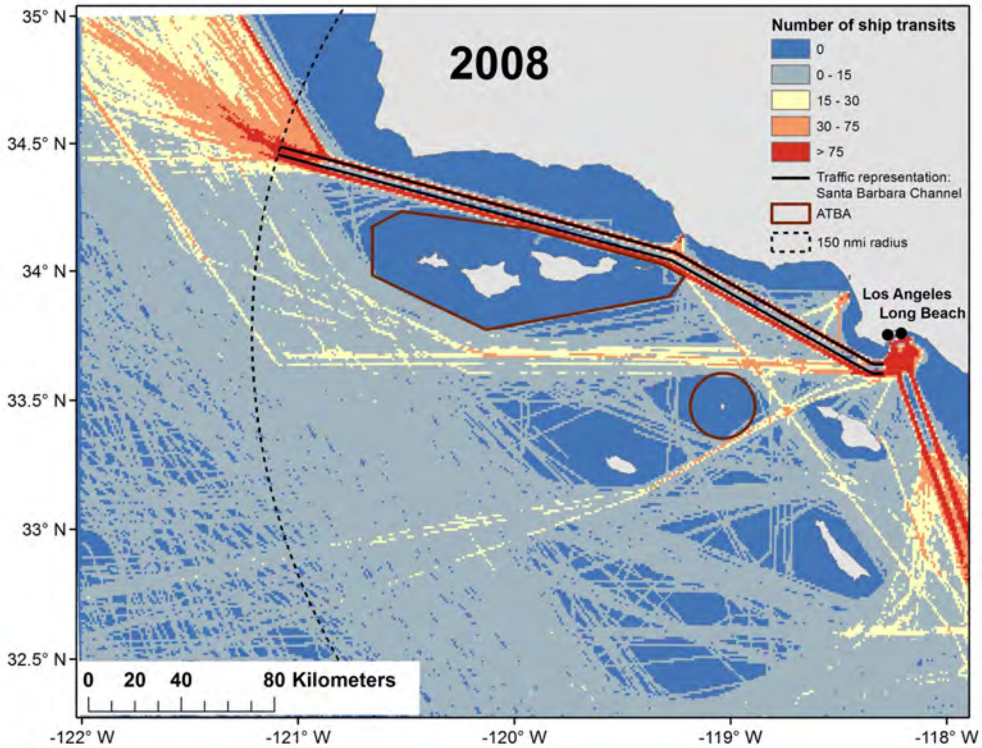
The two busiest commercial shipping ports in North America – Long Beach and Los Angeles – are located just south of the sanctuary. Nearly 9,200 ships (2017 data) annually transit into and out of the ports of Los Angeles and Long Beach, with approximately 41 percent of those transits passing through sanctuary waters (MESC 2018). The ships transit through and near the sanctuary via an internationally approved traffic separation scheme within the Santa Barbara Channel (Figure DP.VT.1). Ships also transit along the south sides of the northern Channel Islands, beyond the sanctuary's boundary.

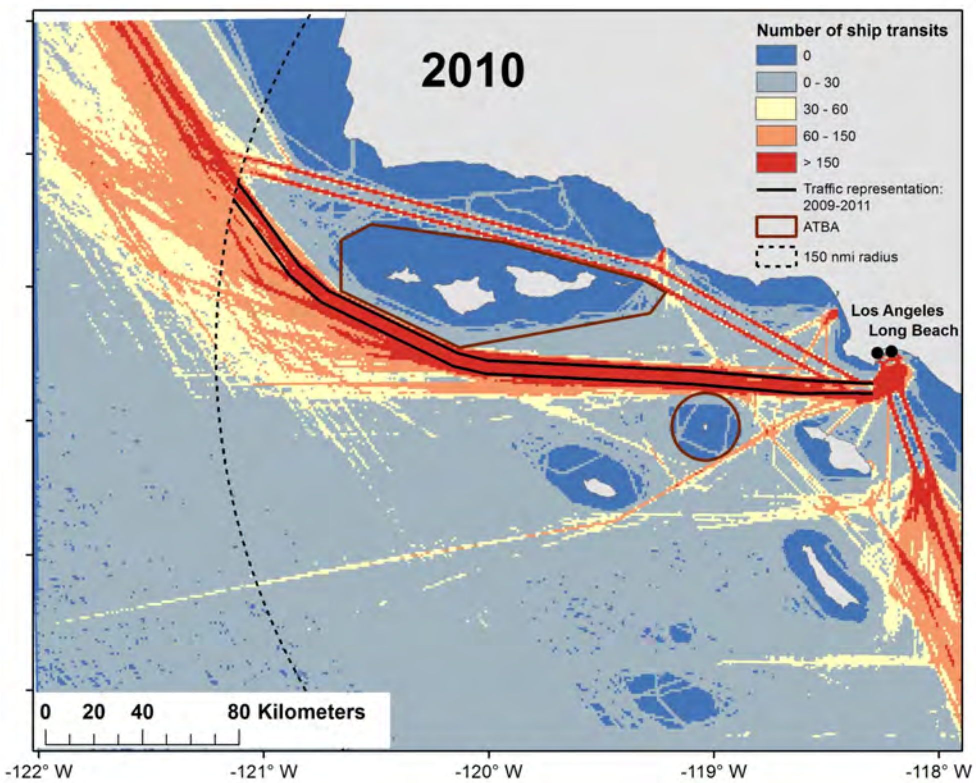
Regulatory and economic changes over time have affected the amount and pattern of shipping traffic passing through or around the sanctuary (Figure DP.VT.2). Ship traffic transiting south of the northern Channel Islands increased significantly starting in 2009 when new California state regulations required use of cleaner fuels by ships traversing within 24 nautical miles of the California coast. Since the southern route allowed ships to transit through waters mostly beyond the California Air Resource Board's (CARB) aforementioned jurisdiction, it thus became a preferred route for many shipping lines that had previously passed through the sanctuary using the traffic separation scheme in the Santa Barbara Channel. Since 2015, however, federal requirements for cleaner ship fuels have also been applied to an Emissions Control Area that extends from 24 to 200 nm offshore, thus lessening the displacement effect of the 2009 CARB fuel requirements. As of the end of 2017, the amount of ships using the Santa Barbara Channel traffic separation scheme had increased to 3,737 transits, almost twice the amount of ship traffic (2,007 transits) traveling just south of the northern Channel Islands (MESC 2018).

Smaller commercial and recreational vessels are also prevalent in the sanctuary. Harbors near the sanctuary contain thousands of recreational, commercial, and research vessels. In turn, these vessels provide year-round opportunities for diving, fishing, sailing, whale watching, and wildlife viewing (Figure DP.VT.3).

Major driving forces of large vessel traffic are population and per capita incomes in the U.S. and China, as these are the main sources of demand for imports and exports through the Ports of Los Angeles and Long Beach. Cargo volume through the two ports increased 18% per year between 1995 and 2007, declined between 2007 and 2009 during the recession, and is forecast to increase at about 5.5% per year for the years 2010 to 2020 and 4.7% per year between 2020 and 2030 (The Tioga Group, Inc. 2009, see Appendix C: Table App.C.1.6). Pressure from both large vessel traffic and small boat use are likely to continue, given forecasted trends for the drivers.

Figure DP.VT.1. A large container ship transits past Anacapa Island. Photo: R. Schwemmer/NOAA


2008
Number of ship transits
0
0 - 15
15 - 30
30 - 75
> 75
Traffic representation: Santa Barbara Channel
ATBA
150 nmi radius
Los Angeles
Long Beach
0 20 40 80 Kilometers
35° N
34.5° N
34° N
33.5° N
33° N
32.5° N
-122° W
-121° W
-120° W
-119° W
-118° W


2010
Number of ship transits
0
0 - 30
30 - 60
60 - 150
> 150
Traffic representation: 2009-2011
ATBA
150 nmi radius
Los Angeles
Long Beach
0 20 40 80 Kilometers
-122° W
-121° W
-120° W
-119° W
-118° W

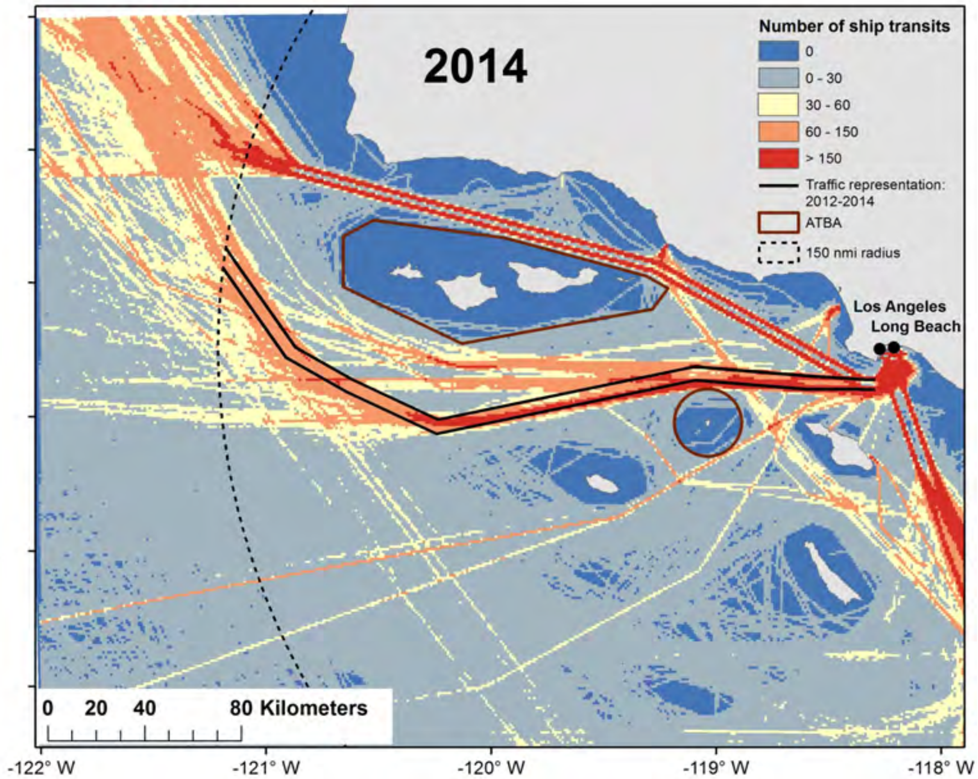


Figure DP.VT.2. Traffic patterns of large commercial vessels (cargo and tanker vessels) in the Santa Barbara Channel region for 2008, 2010, and 2014. The number of commercial ship transits is shown, using Automatic Identification System (AIS) data transmitted from ships. Vessels transiting to and from the Ports of Los Angeles/Long Beach that pass by the northern Channel Islands use either the Santa Barbara Channel Traffic Separation Scheme around the north side of the islands, or take routes south of the islands. Data source: USCG AIS data, processed by NMFS; Figure: MSWGSS 2016

Figure DP.VT.3. Santa Barbara Harbor is one of several convenient points of departure for smaller commercial and recreational vessels visiting the sanctuary. Photo: R. Schwemmer/NOAA

Non-indigenous Species

The National Marine Sanctuaries Act, which provides for the designation and management of national marine sanctuaries, states that all national marine sanctuaries are intended to maintain “the natural marine assemblages that inhabit the area.” Non-indigenous species are plants and animals living outside their endemic, or native, geographical range. Some non-indigenous species may be benign; however, many become “invasive” species if they cause ecological or economic harm in their newly inhabited environment.

Invasive marine species are those marine non-indigenous species that are capable of causing declines, extirpations, or extinctions of native plants and marine life, reducing biodiversity by competing with native organisms for limited resources, and altering habitats. These changes may result in economic impacts and fundamental disruptions of both the local sanctuary ecosystem and beyond.

Marine non-indigenous species may be introduced to the sanctuary by traveling on the hulls of oceangoing ships and on the hulls, propellers, or trailers of small private and commercial boats. In addition, they may be released in or near the sanctuary in ballast water, the release of aquarium specimens or bait, accidental release from aquaculture operations, and other means. Increasing levels of international trade and associated vessel traffic needed to move cargo for growing populations throughout the world, such as in the U.S. and China, are the primary drivers affecting the original introduction of marine non-indigenous species in California marine waters.

Figure DP.NIS.1. A NOAA diver holds up an invasive *Undaria pinnatifida* sub-adult during a 2017 algae survey dive at Channel Islands National Marine Sanctuary and Channel Islands National Park. Photo: J. Altstatt/UCSB and NOAA

Several algal species are appearing in southern California and have proliferated at Santa Catalina Island and other areas (Miller et al. 2011) (Figure DP.NIS.1). *Sargassum horneri* is present along the mainland from Baja California to Santa Barbara and at three of the five Channel Islands (i.e., Anacapa, Santa Cruz, and Santa Barbara) (Marks et al. 2015b). *Undaria pinnatifida* has been found in Santa Barbara and Ventura Harbors, and in 2016, was discovered at Anacapa Island by the National Park Service (Kushner 2016). The invasive bryozoan *Watersipora* spp. has been observed on many oil platforms in the Santa Barbara Channel and at some natural reefs and pier pilings in the sanctuary. The Asian red alga *Caulacanthus ustulatus* has been observed at one site at Anacapa Island.

The increased presence of non-indigenous algal species within the sanctuary, particularly *Sargassum horneri* and more recently *Undaria pinnatifida*, raise concerns about potential adverse ecological impacts; such effects within the sanctuary, especially for newly discovered *Undaria pinnatifida*, are largely unknown at present (Diaz et al. 2018).

Ocean Noise

Increasing human activity in the ocean has also meant increasing levels of noise. Anthropogenic noise can affect marine animals and their habitats in complex ways, ranging from interfering with communication to various forms of physical harm. The nature and degree to which resources are impacted depends on the interaction of noise intensity, duration, timing, and frequency, among other factors.

It is difficult to measure the consequences of long-term noise exposure on the well-being of individual animals, especially for long-lived animals like whales. That said, scientists have documented higher stress loads in whale populations exposed to chronically louder conditions. Thresholds of impact vary depending on their location, species, activity, and health (Gedamke et al. 2016).

In addition, there are studies focused on the effects of ocean noise on shorter-lived and more laboratory-friendly species, such as fish and marine invertebrates. These studies show that when animals are exposed to noise, they are more susceptible to predation, less likely to find prey, and less able to navigate to areas where they can survive and reproduce (Gedamke et al. 2016).

Research shows anthropogenic ocean noise has increased significantly in southern California over the past several decades (Andrew et al. 2002, McDonald et al. 2006, Buxton et al. 2017). Some examples of activities or types of man-made sound that may have the potential to adversely impact marine life acutely or chronically include: vessel noise, sonar and other military activities, construction, oil and gas production, and non-lethal acoustic deterrents used in fisheries; these all may contribute to creating a noisy acoustic "soundscape" for the sanctuary's marine life (Figure DP.ON.1).

Shipping is an important source of ocean noise. Recent risk assessment modeling suggests that while part of the sanctuary is predicted to have relatively lower shipping traffic noise compared to other areas within southern California, the portion of the sanctuary that intersects the Santa Barbara Channel Traffic Separation Scheme may be a degraded acoustic environment for blue, fin, and humpback whales (Redfern et al. 2017) (Figure SH.7).

Figure DP.ON.1. Whales and dolphins, including this blue whale, use sound to communicate, orient themselves, and navigate through their environment. Increasing man-made noise from shipping and other industrial activities has the potential to interfere with their activities. Photo: J. Calambokidis/Cascadia Research

Commercial and Recreational Fishing

The sanctuary's rich and productive ecosystem supports myriad fish and invertebrate species. This diversity attracts commercial fishing operators, recreational anglers, and divers to the sanctuary. Fisheries within the sanctuary are carefully managed for sustainability and, where needed, for recovery and species protection under rules set cooperatively by NOAA, the Pacific Fishery Management Council, and the State of California. Fisheries regulations along with stable fuel prices and increases in population and per capita income are drivers affecting fishing pressure within the sanctuary. Stable fuel prices, increases in population and per capita income are all drivers that are likely to increase fishing pressures within the sanctuary.

Commercial and recreational fishing can affect sanctuary resources in varied ways, including:

- Catch and removal of fish and invertebrates
- Bycatch and release mortality
- Ecosystem effects (e.g., predator-prey relationships, behavior changes, reduced biomass)
- Entanglement of marine mammals or other non-target species
- Explosive deterrents that irritate or harm nuisance species
- Habitat disturbance from bottom gear
- Lost or discarded fishing gear that continues to catch or otherwise impact marine life

Commercial Fishing

The Santa Barbara Channel is the most important commercial fishing region in the State of California. Based on a Bureau of Ocean Energy Management (BOEM) analysis of state fishery landings data from 2005 to 2015, the Santa Barbara Channel ranked first in the state in total value of landings and second in total weight (Schroeder 2016) (Figure DP.CF.1).

Figure DP.CF.1. A commercial fishing vessel transits through the Santa Barbara Channel near Channel Islands National Marine Sanctuary. Photo: C. Fackler/NOAA

NOAA has estimated that approximately 250 commercial vessels regularly fish in the sanctuary, with the majority of catch being market squid, spiny lobsters, red urchins, crab, prawns, shrimp, and sea cucumbers (Leeworthy et al. 2014a and b). Most of these vessels concentrate their fishing activity within one mile of the Channel Islands' shorelines (Senyk et al. 2008) (Figure DP.CF.2).

Figure DP.CF.2. Commercial fishermen collect their traps near San Miguel Island in the sanctuary. Photo: R. Schwemmer/NOAA

The effects of drivers on trends in commercial fishing were evaluated by Leeworthy et al. (2014a) for CINMS from 2000 to 2012. In 2012, the top seven species/species groups (listed above) accounted for 93.3 percent of the landing weight and 89.8 percent of its value to the fishermen in the Channel Islands. Market squid and spiny lobster, two of the sanctuary's most sought-after commercial species, are in high demand as exports to China (NMFS 2017a). Particularly considering forecast increases in China's population, GDP, and GDP per capita, we can expect increasing pressure on commercially fished sanctuary resources.

Recreational Fishing

The sanctuary provides quality recreational fisheries for the public. Up to 100,000 trips per year land over a half million fish off Santa Barbara and Ventura Counties alone, and this represents nearly a tenth of annual angler trips statewide (RecFIN 2017a and 2017b). Most recreational fishing trips in the sanctuary take place in the eastern half, which lies within easy boating distance to the mainland and the harbors of Santa Barbara and Ventura (Figure DP.RF.1).

Anglers can access a range of nearshore and offshore areas within the sanctuary (Figure DP.RF.2). They may fish from private and for-hire boats and may fish from above or below the water. Anglers use hook-and-line and spear guns to catch bottom and mid-water fish species. Recreational fishers may use hoop nets and diver-based hand-removal techniques to target invertebrates.

In 2016, nearly a tenth of angler trips statewide (about 100,000) took place off Santa Barbara and Ventura counties, landing about 585,000 fish (RecFIN 2017a and 2017b). Measured in person-days using 2004–2012 data from the California Department of Fish and Wildlife, 9.2 percent of fishing in California from commercial passenger fishing vessels and 2.5 percent of private/rental boat fishing occurred in CINMS (Leeworthy and Schwarzmann 2015).

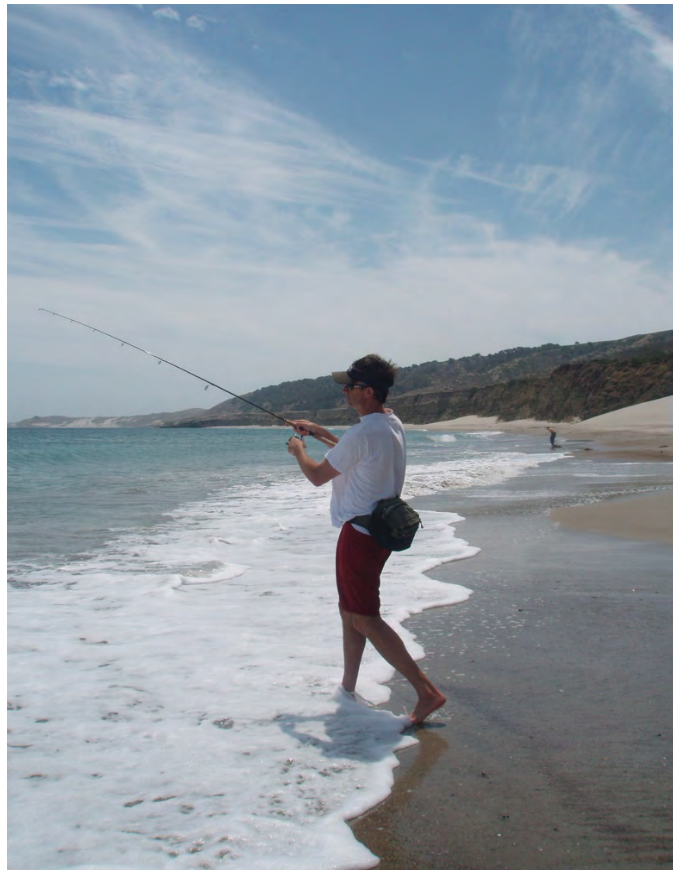


Figure DP.RF.1. Recreational anglers can enjoy the solitude of fishing at Santa Rosa Island in Channel Islands National Marine Sanctuary and Channel Islands National Park. Photo: C. Fackler/NOAA

Figure DP.RF.2. Recreational anglers can fish in over 80 percent of sanctuary waters. Photo: M. McIntosh/NOAA

For recreational fishing, the trends of primary drivers — increasing population and per capita incomes for the U.S., California, and the previously stated three-county area, and relatively constant gas prices — suggest continued increases of this activity.

Energy Development Activities

California has rich energy resources, both on land and offshore. While offshore production of oil and gas has declined steadily over the past 20 years, the state still accounts for about six percent of all U.S. crude oil production and about one percent of domestic natural gas production. California is pivoting to energy efficiency and implementation of alternative technologies. The state is a leader in electricity generation from renewable energy sources (U.S. Energy Information Administration 2016b).

As the population increases, domestic oil and gas prices remain stable, and demand for clean energy grows, it is likely that energy development and production will continue to be a steady pressure affecting waters adjacent to the sanctuary (U.S. Energy Information Administration 2016a and b).

Offshore Oil and Gas

While there has been a moratorium on new offshore oil and gas leasing in state waters since 1988, and current (2017-2022) enacted federal leasing plans withdraw federal waters off California from new leasing (BOEM 2016), there are 39 existing developed or active leases dotting the southern California coast. Oil and gas exploration and production occurs at 14 offshore oil platforms, seven of which are located in the Santa Barbara Channel (Figure DP.EDA.1). None of the offshore platforms are located within sanctuary boundaries, but adjacent activities could potentially impact sanctuary resources.

Marine fracking and other oil well stimulation activities have occurred at one platform in the Santa Barbara Channel. The extent and impact of fracking activities in the ocean are not well documented or understood.

Spill response contingency plans and improved platform and pipeline technologies and practices have reduced the risks over time of a spill damaging sanctuary resources; however, threats to sanctuary resources remain from: 1) spills and discharges from oil platforms, pipelines, and ships operating close to sanctuary boundaries; and 2) effects of oil production.

Figure DP.EDA.1. Platform Gail is one of several offshore oil and gas platforms that lie just beyond sanctuary boundaries. Photo: R. Schwemmer/NOAA

Oil and chemical spills in the sanctuary region can result from accidents associated with oil production and could range from small, localized spills to large events that span hundreds of kilometers of coastline. While rare, a large spill could have a major impact on wildlife, habitat, and human uses, such as fishing and tourism.

In 1969, a spill released approximately 200,000 gallons of oil into the Santa Barbara Channel fouling mainland and island waters and shorelines. More recently, on May 19, 2015, an oil pipeline ruptured near Refugio State Beach on the mainland. The event released an estimated 21,000 gallons of crude oil into the Pacific Ocean. Based on several reports, some of this oil may have dispersed across the Santa Barbara Channel into the sanctuary. Efforts are ongoing to assess and describe the impact on marine resources.

Renewable energy advances have contributed to declines in hydrocarbon production. In 2009, renewable energy supply in the U.S. was 7.04 quadrillion British thermal units (BtU) and has steadily increased since then. In 2018, the projected supply of renewable energies is 10.08 quadrillion BtUs, a 43.5 percent increase in U.S. supply. (See Appendix C: Table App.C.1.7).

In general, offshore oil production has declined 7.5 percent annually in Santa Barbara County since 1996, though there were slight increases (9.9 percent and 12.8 percent) in 2013 and 2014. In 2015, however, production declined by 39.8 percent — a 19-year-low at 11.9 million barrels. This compares to 59.6 million barrels produced in 1996. Offshore gas production followed similar annual trends, and has decreased 6 percent annually since 1996 in Santa Barbara County. Both offshore and onshore gas production experienced steep declines in 2015 of 49 percent and 16 percent, respectively (UCSB Economic Forecast Project 2016). Drivers of offshore energy development, including population growth, changing demand for domestic production, growing demand for clean energy, and projected flat U.S. retail prices for gas and diesel through 2018 (U.S. Energy Information Administration 2016a) suggest steady pressure.

Renewable Sources of Ocean Energy

California's offshore resources hold renewable energy potential (Musiel et al. 2016). In 2016, BOEM and the State of California created an Intergovernmental Renewable Energy Task Force to evaluate opportunities for offshore renewable energy development, in particular the possibility of offshore wind turbines.

Potential impacts on sanctuary resources or users from offshore renewable energy development could include:

- Seafloor habitat destruction
- Ocean noise impacting living marine resources
- Wind turbine blades killing seabirds or disrupting their movement or migratory patterns

Conflicts with other ocean uses seeking to operate in the same space above, on or below the water

Projections for substantial increases in both demand and supplies of energy from renewable sources suggest that these pressures could increase as well in the future.

Pollutants

Eighty percent of pollution to the marine environment comes from the land. One of the biggest sources is nonpoint source pollution, which results from runoff from the land. Population growth and associated coastal development in the three county area will result in runoff that will continue to drive this sanctuary pressure.

Land-based pollution may reach the eastern portion of the sanctuary (Anacapa and Santa Cruz islands) infrequently via stormwater plumes during major runoff events from the Ventura and Santa Clara rivers (Engle 2006, SBCK and Engle 2010) (Figure DP.P.1). Because pollutants can be carried to the sanctuary by ocean currents, or transported through the food chain, the issue of water quality impacts encompasses a much greater area than the sanctuary itself.

In 2010, a comprehensive assessment found water quality in the sanctuary could be affected by:

- Contaminated sediments
- Discharge from large and small vessels
- Dredged materials
- Harmful algal blooms
- Marine debris
- Pollution from offshore oil and gas production facilities
- Runoff from land-based sources

The assessment identified other potential threats including new energy production projects in the Santa Barbara Channel, pharmaceuticals, personal care products discharged in sewage effluent, and open ocean aquaculture (SBCK and Engle 2010).

Whatever the source, poor water quality can affect the health of both people and wildlife. It can cause illness or disease, impair condition and reproductive capacity, and decrease productivity in a variety of marine organisms.

As population for the three-county area is projected to continue to increase through 2030, its development footprint will continue to increase pressures on CINMS resources.

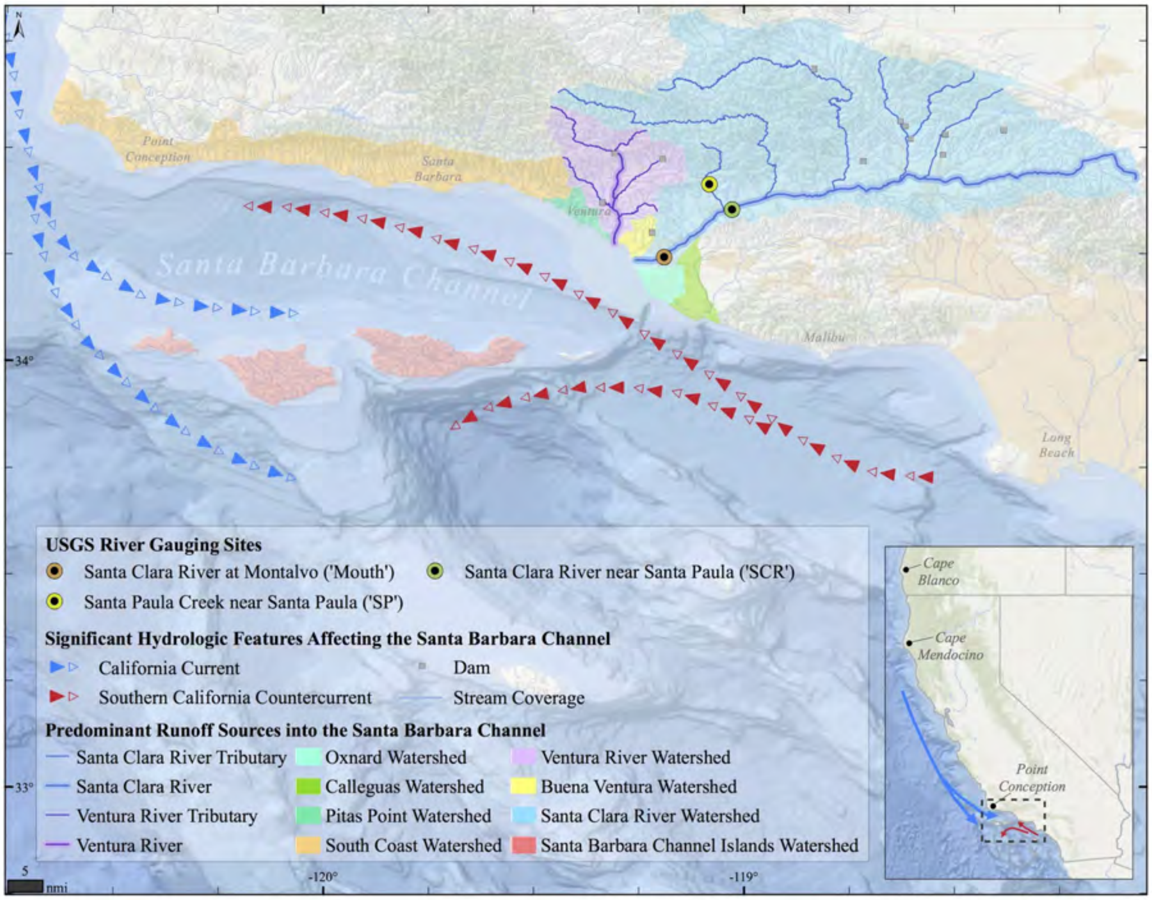


Figure DP.P.1. Major watersheds and ocean currents transport pollutants into and within the Santa Barbara Channel. Map: M. Cajandig/NOAA

Marine Debris

According to the definition utilized by NOAA's Marine Debris Program, the federal lead for addressing marine debris, marine debris is any persistent, manufactured, or processed solid material that is directly or indirectly, intentionally or unintentionally, disposed of, or abandoned in, the marine environment. Marine debris can include a wide variety of objects (e.g., lost fishing gear, lost vessel cargo, plastics, metal military debris) from multiple sources (e.g., stormwater runoff, landfills, recreational and commercial activities, military activities) (Keller et al. 2010).

Plastic is the most prevalent type of marine debris found in the ocean. Plastic debris can come in all shapes and sizes, but those that are less than five millimeters in length are called "microplastics." Recent research suggests these microplastics can accumulate in seafood, particularly shellfish (Avio et al. 2017).

Many types of marine debris exist in the sanctuary and collect at various places around the Channel Islands (Figure DP.MD.2). The prevalence of debris within the sanctuary is affected by both natural forces (e.g., currents) and human drivers including population growth and increasing coastal development.

Figure DP.MD.1. Volunteers conduct a marine debris clean-up on Santa Cruz Island. Photo: C. Fackler/NOAA

Marine debris threatens the marine environment, human health, and safe navigation. For example, ingestion of or entanglement in marine debris may lead to death in animals like sea turtles, marine mammals, birds, and benthic organisms (Marine Debris Program 2014a,b). Entanglement may result in drowning, starvation, physical trauma, systemic infections, or increased susceptibility to other threats, such as ship strikes (Figure DP.MD.2). Marine debris also can alter the condition and structure of habitats (Marine Debris Program 2014a, b, 2016). For example, lost or discarded fishing gear can continue to catch and kill marine life for years.

Projected increases in vessel traffic, including private vessels undertaking recreational activities, commercial and recreational fisheries, and the population of the three-county area and associated development, is expected to continue to increase pressures from marine debris.

Figure DP.MD.2. A humpback whale entangled in crab pot gear in Monterey Bay was freed on May 15, 2014 off the coast of Santa Barbara thanks to specially trained and authorized volunteers with the Whale Entanglement Team (WET), assisted by CINMS and the NOAA *R/V Shearwater*. Photo: NOAA, MMHSRP Permit 932-1489

Visitor Use

Figure DP.VU.1. Kayakers enjoy recreating in the sanctuary. Photo: C. Fackler/NOAA

The sanctuary exists to promote both public enjoyment and protection of special places. The public visits the sanctuary to fish, boat, dive, surf, kayak, and view wildlife (Figures DP.VU.1-4). These types of recreational activities in the sanctuary are encouraged as sustainable or responsible use when visitors follow required laws, policies, and best practices, like maintaining minimum setback distances when viewing marine mammals. Adherence to rules and guidelines allows visitors to have minimal impacts on sanctuary resources while still deriving several benefits, such as recreation, education and outreach. In comparison, irresponsible visitor use that does not adhere to rules and guidelines or responsible practices at times can result in potential adverse impacts such as:

- Disrupting ecosystem processes
- Disturbing shipwrecks or other protected heritage resources
- Disturbing wildlife
- Littering
- Polluting
- Trampling or disturbing sensitive habitats

Due to its offshore location and multiple points of entry (e.g., CINMS does not have a prescribed entrance, as with most terrestrial national parks), it is difficult for ONMS to routinely track visitor use in the sanctuary. There are two sources of data, from the National Park Service and Island Packers, that could provide possible indicators for the trends in recreational visitor use in the sanctuary. First, the National Park Service keeps many details about annual visitation to Channel Islands National Park, including estimates of those going ashore to the islands and observations of private boats at various island anchorages. In addition, many visitors to the sanctuary and Channel Islands National Park are transported by Island Packers, the primary contract concessionaire service currently authorized by the National Park Service to ferry visitors from the mainland to the Channel Islands. In 2012, Island Packers brought 67,804 passengers to the islands. Five years later, visitation rose to 87,491, a 37 percent increase in the number of people visiting the park (NPS 2017). It is possible these figures reflect a broader trend of increasing visitor use within the sanctuary as well.

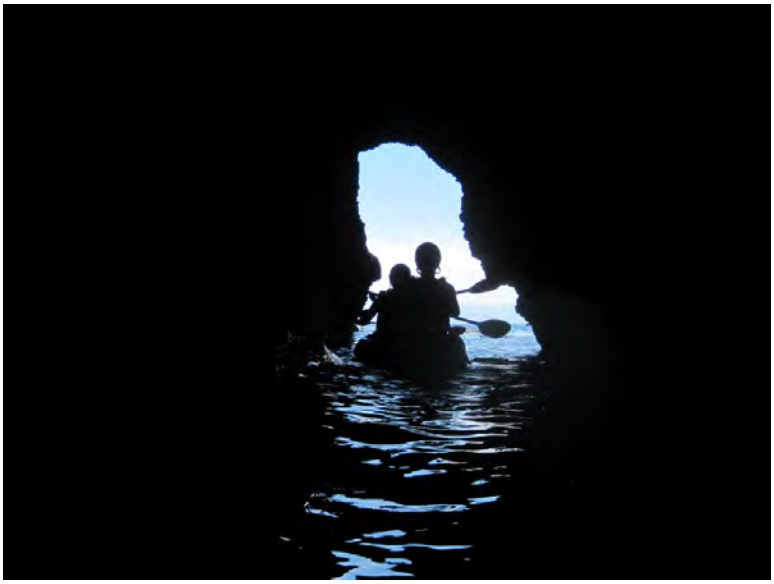


Figure DP.VU.2. Kayakers explore one of the many sea caves around the Channel Islands. Photo: C. Fackler/NOAA

Figure DP.VU.3. Recreational divers exploring the sanctuary's abundant kelp forests. Photo: R. Schwemmer/NOAA

NPS estimates of visitor use are highly variable over time, with opposite trends for boating visitors at anchor and visitors going ashore. Recreating visitors to Channel Islands National Park that go ashore increased from 41,486 in 2000 to 86,683 in 2016, a 109 percent increase. For visitors on boats, there were 168,387 in 2000 and this declined to 44,330 in 2016, a 74 percent decline (NPS 2017, see Appendix C, Table App.C.1.8 and Figure App.C.1.4). It is uncertain whether the park's boating visitor estimates are a good indicator of sanctuary visitor use.

A third potential indicator for visitor use can be population, per capita incomes, and gas prices, particularly for demand for boating measured as boat registrations (Bell and Leeworthy 1987, Leeworthy 2013). California registrations for boats larger than 26 feet in length (which are needed to traverse to CINMS) decreased by roughly 10% per year between 2013 and 2016 (NMMA 2017). Private boating use was estimated for the 2006-07 period for the survey of private boaters by LaFranchi and Pendleton (2008) using the former CINMS Sanctuary Aerial Monitoring and Spatial Analysis Program (SAMSAP) (Leeworthy 2013). Pooling data for 2001 to 2009 by season and type of day (weekdays and weekend/holidays), there were an estimated total of 3,680 private boat days for recreation in CINMS in 2007.[3]

Figure DP.VU.4. Island Packers' vessels bring visitors to the national park and sanctuary. Photo: R. Schwemmer/NOAA

In summary, visitor use within the sanctuary specifically is tracked neither comprehensively nor routinely; there are no reliable estimates for all the ways people may visit the sanctuary or how often. Nevertheless, visitor use is driven broadly by population growth, per capita income, and fuel prices. All these drivers suggest visitor use will continue to be a persistent and likely growing pressure on the sanctuary for the foreseeable future.

Climate Variability

Natural Climate Oscillations

The climate off the California coast is influenced primarily by two natural phenomena: the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). These phenomena, along with irregular climate shocks like marine heat waves, affect weather and oceanographic conditions in complex ways along the entire West Coast, of which the Channel Islands are a part.

ENSO is known for its alternating warm (El Niño) and cold phases (La Niña), interspersed among

[3] For more information on this analysis, see Leeworthy 2013. SAMSAP stopped in 2009; more recent data are not available.

"neutral" conditions. El Niño and La Niña episodes, which originate in the equatorial Pacific, are infrequent and relatively short-lived, typically lasting nine months to a year. The PDO, originating over the North Pacific, also has warm and cold phases, but operates on much longer time scales, sometimes persisting decades.

The environmental changes characteristic of these natural phenomena can have large-scale and long-term impacts on ocean processes, weather, and climate. For example, higher sea surface temperatures during an El Niño phase can affect ocean processes, like wind-driven upwelling, that lead to decreased productivity and changes in species distribution; the opposite can be true during cooler La Niña years.

It is unclear if and how the timing and severity of these natural climate cycles are interacting with climate change; this is a topic of interest for current and future research efforts in and around the sanctuary.

Climate-driven Sea Level Rise

The effects of global sea level rise may be magnified along California's coast due to melting ice and the Earth's rotation and gravitational pull on waters. According to a California Ocean Protection Council report in 2017, "for every foot of global sea-level rise caused by the loss of ice on West Antarctica, sea-level will rise approximately 1.25 feet along the California coast" (Griggs et al. 2017). Rising sea levels could increase coastal erosion and impact infrastructure both on the Channel Islands and mainland. The rising waters could also affect the sanctuary's living marine resources by flooding and submerging shoreline habitats and reducing the amount of light reaching marine algae and plants. Recent work by the U.S. Geological Survey and partners using a Coastal Storm Modeling System for Southern California (CoSMoS 3.0) provides tools to help managers predict possible shoreline flooding areas, including at the Channel Islands, given various future sea level rise and storm intensity scenarios (USGS 2018).

Climate-driven Ocean Acidification

Large scale changes in ocean chemistry, specifically pH and concentrations of carbonate, are recognized as a threat to ecosystem integrity. Ocean acidification refers to a reduction in the pH of the ocean over an extended period of time, caused primarily by the uptake of anthropogenic carbon dioxide (CO_2) from the atmosphere.

Calcifying organisms, such as oysters, clams, sea urchins, shallow-water corals, deep-sea corals, and calcareous plankton, are particularly vulnerable to changes in ocean chemistry (Figure DP.CV.1). A lower ocean pH decreases the availability of carbonate ions, the building blocks of shells and corals. These organisms are habitat engineers and/or prey species, so a decrease in their abundance, distribution, or health could cause cascading effects throughout the ecosystem (Marshall et al. 2017).

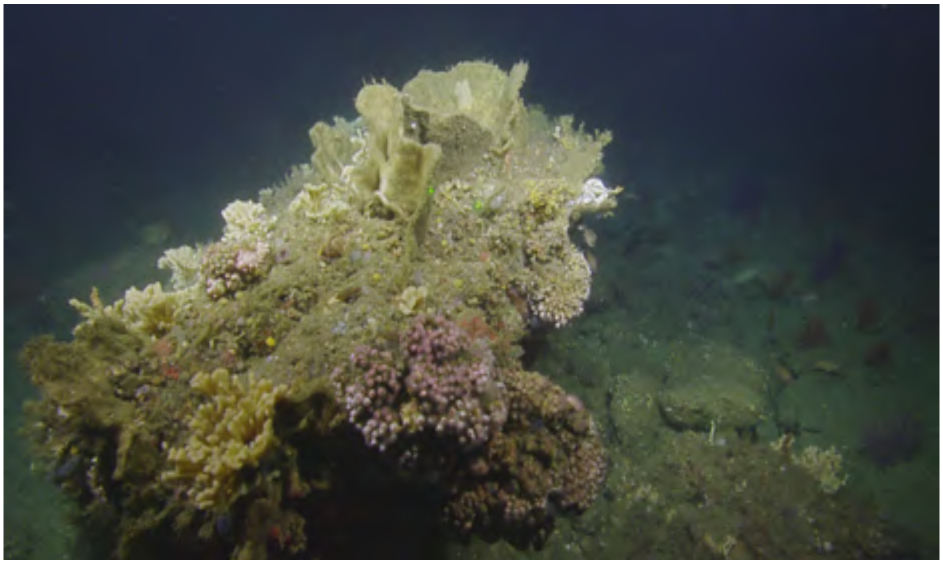


Figure DP.CV.1. Changes to ocean chemistry and temperature can have widespread impacts on sanctuary resources like these deep-sea corals. Photo: NOAA

Waters in the Santa Barbara area have experienced a decline in pH over the past three decades (Turi et al. 2016); however, Kapsenberg and Hofmann (2016) found that so far, ocean acidification rates are slower around the Channel Islands than in nearby coastal waters. It is unknown how ocean acidification will affect deep-water sanctuary habitats (i.e., depths greater than 40 meters), which is important habitat for vulnerable corals and invertebrates

STATE OF DRIVERS AND PRESSURES

Below are answers to questions related specifically to the drivers and pressures discussed above. The status and trends of sanctuary resources are addressed in the next section.

Driver Rating (Question 1)

Driving forces help to explain the origins of pressures on resources and understand the future trends of those pressures. Drivers include societal values and demographic and economic factors that result in pressures on the resources.4 More specifically, drivers describe the effect of societal values, demographic and economic forces on different ecosystem uses. Societal values may include levels of conservation awareness, political leanings, or changing opinions about the acceptability of specific behaviors (e.g., littering, fishing). Other driving forces may include specific changes in the demographics of an area (e.g., age structure, population, etc.), demand for ocean products, economic situations, industrial development patterns or business trends. An overall rating for the status and trends of drivers is made in the following question (Question 1).

1. What are the states of influential human drivers and how are they changing?

The status of drivers was not addressed in the 2009 condition report. This question was added as part of the expansion of the reporting model to consider drivers and ecosystem services, both of which are critical elements of the Drivers-Pressure-State-Ecosystem Services-Response (DPSER) model used as the framework for this report. Selected drivers, principally population and per capita income increases in the U.S. and China, in addition to stable prices for fuel, which promotes visitation, are influencing pressures in ways that cause measurable resource impacts; therefore, this question is rated as Fair with a worsening trend that reflects ongoing and projected increases in both population and income.

The projected continued growth of population and per capita income nationally, regionally, and within the three counties adjacent to CINMS are the most important drivers affecting pressure on sanctuary resources. These directly affect demand for resources (primarily food and access) that in turn, alter the activity levels of known sanctuary pressures, such as shipping traffic, recreational use, pollution, and noise. This can result in resource impacts such as collisions with marine mammals, the spread of non-indigenous species to the sanctuary, and the release of marine debris. As explained above, the fact that fuel prices have stabilized in recent years is, to a lesser extent, an important additional driver that affects the levels of certain activities within and adjacent to the marine sanctuary (e.g., vessel traffic and visitation).

Pressure Ratings (Questions 2–5)

Questions 2-5 address the levels of pressures and their potential effects on sanctuary resources. On May 31, 2016, ONMS convened an expert workshop to discuss available data on human activities taking place in and around the sanctuary (Appendix B). Experts provided opinions on the current status and trend for

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[4] Drivers related to external climate forcing is addressed in Question 8: *Have recent changes in climate altered water conditions and how are they changing?*

each question, and rated their confidence in each assessment. Supporting information was taken from academic, private, and public sources.

Human activities that adversely impact water quality are the focus of Question 2. These include oil and gas exploration and extraction, and shipping and vessel groundings. The 2015 Refugio Oil Spill is described, although due to limited data availability at the time of assessment, impacts on water quality, habitats, and living resources are not discussed in detail.

Question 3 covers human activities that may adversely influence habitats. Human activities often have structural impacts (e.g., the removal or mechanical alteration) to habitats. Fishing gear that physically disrupts the seafloor, anchoring, marine debris, and trampling of intertidal habitats are all examples of structural impacts. In addition, this question tracks human activities that indirectly impact habitat quality, including chemical impacts or disruption of ecological processes affecting the abundance of biogenic habitat. Examples of these activities include discharge of engine fluids as a result of vessel groundings and oil spills.

Human activities that have the potential to negatively impact living resources are the focus of Question 4. These include activities that remove plants or animals as well as activities that have the potential to injure or degrade the condition of living resources. Activities that can facilitate the introduction or spread of non-indigenous species are also applicable to this question.

Activities that influence archaeological resource quality are the subject of Question 5. These include activities that diminish resource quality either intentionally or inadvertently. Of importance, maritime cultural artifacts are non-renewable; once degraded or destroyed, their archaeological value is lost forever.

2. What are the levels of human activities that may adversely influence water quality and how are they changing?

In 2009, the rating of the levels of human activities that may adversely influence water quality was good and not changing. This rating was given because although several human activities have the potential to affect water quality, anthropogenic impacts to sanctuary water quality were considered low or negligible. Currently, anthropogenic water quality impacts in the region include contamination and risks from oil and gas production and transport, vessel groundings, and noise. In this assessment, experts rated adverse water quality impacts from human activities as good/fair (medium confidence) with an undetermined trend (medium confidence). The rating is good/fair (rather than good) with an uncertain trend because in recent years, unprecedented events have occurred and emerging threats have appeared including the 2015 Refugio Oil Spill, persistent local drought conditions since 2012 and the 2013–2016 warm water event. Despite the severity of these events, there is limited associated data regarding sanctuary water quality impacts. Some levels of activities appear to be decreasing, others increasing. The following provides updated information on the status of measurable human activities that may affect sanctuary water quality.

In southern California, oil and natural gas slowly seep from over 2,000 hydrocarbon cracks in the ocean floor. At least 38 seeps are located in the Santa Barbara Channel, and the most active seeps are directly south of Coal Oil Point. It is estimated that 3,500–7,100 gallons (100–170 barrels) of oil and ~75 tonnes (100,000 cubic meters) of natural gas seep every day in the Santa Barbara region (UCSB Hydrocarbon Seeps Project 2000). In addition to these natural sources, oil and gas exploration and production occurs at

14 offshore oil platforms, seven of which are located in the channel, with pipelines running along the coast and inland (see Appendix C: Figure App.C.2.1). With the exception of two lease units established prior to CINMS designation that partially overlap a small portion of the sanctuary's outer boundary, none of these oil and gas activities, including oil rigs themselves, occur within sanctuary boundaries. However, adjacent activities could potentially impact sanctuary resources. A steady decrease in southern California offshore oil and gas activity began in the mid-1990s and then stabilized in 2012 (see Appendix C: Table App.C.2.2). According to the Bureau of Ocean Energy Management (BOEM) and others, the volume of oil spilled at sea (from platforms and/or tankers) is small compared to oil naturally seeped in the region (see Appendix C: Table App.C.2.2).

There are important differences between the hydrocarbons introduced into the marine environment from natural seeps and oil spilled from platforms, tankers, or pipes, so comparing volume alone is an inadequate assessment of impacts (SBC 2002). Seeps steadily and gradually introduce large amounts of hydrocarbons across large areas of the marine environment at variable rates and compositions (e.g., methane), and can dissolve in the water column, bubble to the atmosphere, sink, or end up as balls of tar along the coast (see Appendix C: Figure App.C.2.2). Natural seeps affect both water and air quality, and are thought to result in a background water pollution level with sub-lethal effects on organisms. Withdrawal from reservoirs (e.g., offshore oil production) has been shown to influence both decreases (Kvenvolden and Cooper 2003) and increases in seepage rates over time (SBC 2002). The oil produced off Santa Barbara is medium to heavy crude and thus, it floats in seawater when spilled, but may sink after weathering.

In contrast, offshore vessels or tankers might spill other types of heavier crude or petroleum products. In addition to crude oil, pipes can contain produced water, diesel, and/or anti-corrosion compounds. Spills release concentrated oil from a point source in a short time and range in volume (and number) from tiny (thousands of events) to catastrophic (rare events), as do their water quality impacts. Once in the marine environment, particularly the water column, spilled oil is difficult to contain and recover. While tiny spills blend into background pollution levels, major spills can have dramatic impacts on water quality, habitats, and living resources. Spilled oil impacts on the marine environment are more intense and qualitatively different than seeped oil (SBC 2002). For example, plankton communities are not affected by background hydrocarbon levels; however major spills can decimate zooplankton communities and larvae. Zooplankton can rebound quickly, but the disturbance may reverberate throughout the food chain, including through bioaccumulation. Larvae recover less quickly, which can affect population growth post-spill.

Discharges from offshore oil platforms operating in federal waters were reported from 1996, 2000, and 2005. In sum, solid and drilling mud discharges have decreased since a peak in new well drilling (n=31) in 1996, and are currently at or lower than 2,313 metric tonnes of cuttings, which was the estimate in 2000 (BSEE and BOEM 2016). Produced water is a mixture of oil, natural gas, formation water, and well chemicals (additives, e.g., corrosion inhibitors). Although produced water is brought to the surface during oil and gas production and generally increases over an offshore oil field's lifetime, it currently appears to be in decline. Total volume from all platforms in 2005 was 9.4 billion liters, and the latest estimate from 2014 was 5.2 billion liters produced water discharges per year (Houseworth and Stringfellow 2015). Both produced water discharges and chemical constituent concentrations (see Appendix C: Table App.C.2.3) are below permitted values (EPA 2013). High concentrations of constituents, such as heavy and trace metals, could adversely impact surrounding habitats and water quality. A 2013 study by Love et al. concluded that 21 trace elements did not occur in higher concentrations in whole-fish samples at oil platforms compared to at natural areas, and found only the Pacific sanddab showed a risk of ingesting/bioaccumulating pollutants at oil platforms.

Marine fracking acidization and other well stimulation activities have occurred in the Santa Barbara Channel (e.g., Platform Gail) and other oil platforms in the region, nonetheless, the extent and impact of fracking activities in the ocean are not well documented. Updated and more comprehensive time-series data are needed to identify current effects of oil and energy production and/or fracking on local water quality including oil mixtures and bi-products, contaminants, metals, nutrients, produced water, and freshwater use.

On May 19, 2015, an estimated 142,000 gallons (3,400 barrels) of crude oil were released when a corroded onshore pipeline ruptured near Refugio State Beach. An estimated 105,000 gallons (2,500 barrels) reached the beach and 21,000 gallons (50 barrels) was estimated to have entered coastal waters (see Appendix C: Figure App.C.2.3). NOAA and the California Department of Fish and Wildlife (CDFW) oil spill response teams, the Southern California Coastal Ocean Observing System (SCCOOS), academic researchers, and Santa Barbara community members worked together to clean up the oil spill, track the oil's trajectory, and monitor the effect of oil on habitats, animals, and water quality. The week of May 19, 2016 was characterized by strong offshore winds and oil was predicted to travel across the Santa Barbara Channel, towards the west and north shores of the northern Channel Islands (see Appendix C: Figure App.C.2.4). Transport models based on sea surface current data suggested oil reached the sanctuary as early as May 22, 2015, and the northwest coastlines of Santa Rosa and Santa Cruz Islands on May 23 (Figure S.P.2.1). Channel Islands National Park confirmed concurrent oil sightings on various coastal locations of Santa Cruz Island, but the origin of the tar collected at that time was not confirmed.

Ongoing research from the University of Santa Barbara (UCSB) (PIs: Valentine, Passow, Carlson, Washburn, Iglesias-Rodriguez), NOAA, SCCOOS, and associated institutions are continuing to describe the effects of the Refugio Oil Spill on the Santa Barbara Channel region. Due to ongoing natural resource damage assessment and associated legal processes between agencies and the responsible party, existing data were largely unavailable at the time of the expert workshops and the effects of the Refugio Oil Spill will be revisited in future reports. Data from large crude oil spills in other locations (e.g., Alaska, Gulf of Mexico) indicate that impacts can persist for several months or even years. Residual impacts include the presence of introduced chemical oil dispersants (sometimes more toxic than the oil itself) in the water column, deposition of crude oil in the sanctuary, and long-term impacts of contaminants on living resources. Spatial and temporal severity of impacts from oil spills are dependent on the amount spilled, response times, local weather, sea conditions, oceanographic processes, and the sensitivity and resiliency of exposed species and communities.

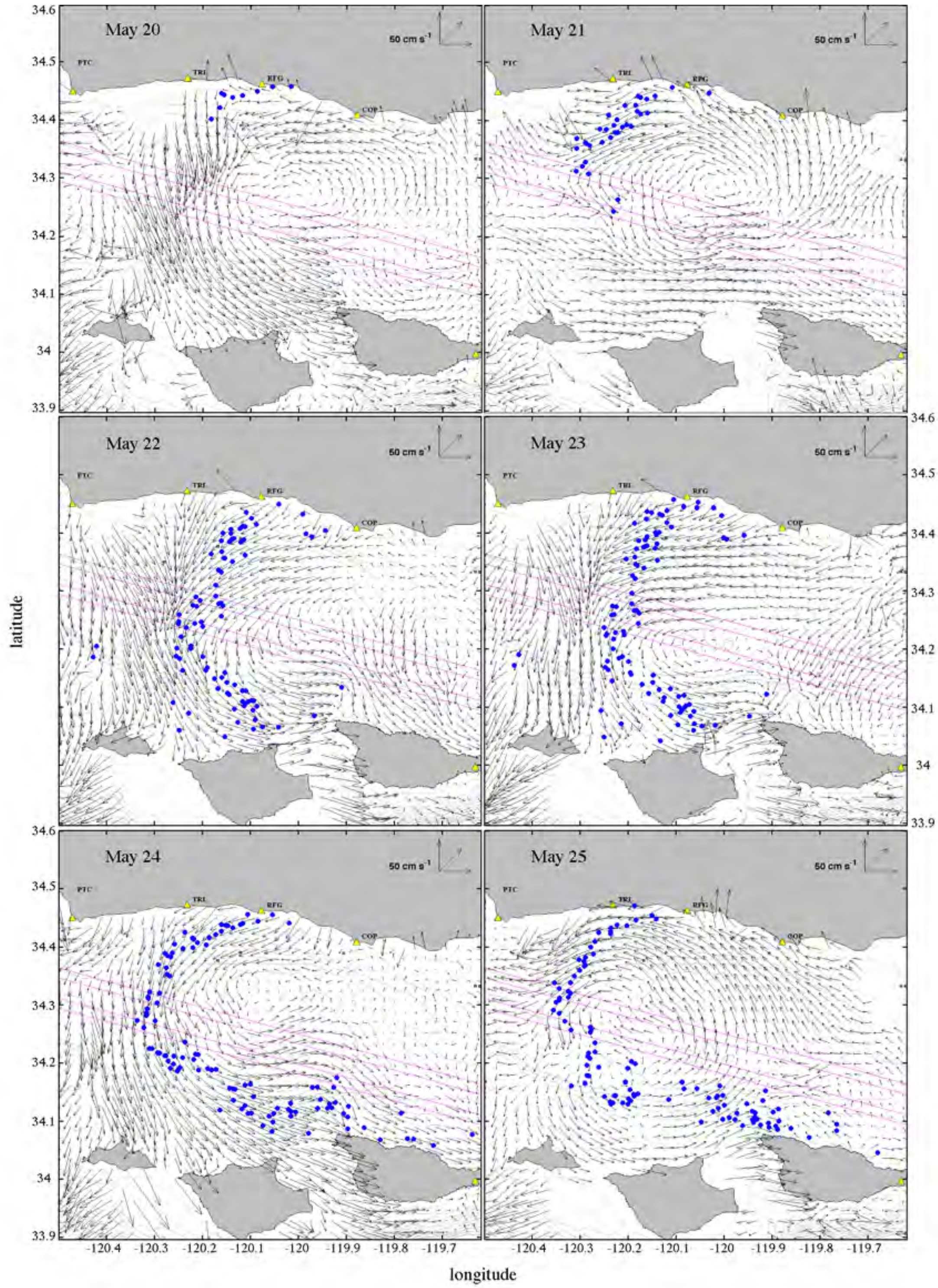


Figure S.P.2.1. Daily snapshots of oil transport simulations (blue dots) based on near-real time sea surface current direction and speeds (black arrows) from May 20 to 25, 2015, the days just after the Refugio Oil Spill. Yellow triangles represent SCCOOS high frequency (HF) radar observation stations. PTC = Point Conception; RFG = Refugio State Beach; COP = Coal Oil Point. Not pictured is a HF station at Gaviota, which was temporarily installed for one and half months following the spill (currently no longer active, see http://washburnlab.msi.ucsb.edu/mtu1) to address local data gaps. Not labeled is the yellow triangle/HF Radar station on Santa Cruz Island. Pink lines indicated commercial shipping lanes. The full oil transport model simulation can be viewed online: http://sccoos.org/about/news/2015-refugio-state-beach-oil-spill/. Figure: B. Emery and L. Washburn/UCSB

Another important water quality concern for the sanctuary is degradation of pelagic habitat via noise pollution. For example, the nearby Ports of Long Beach and Los Angeles are two of the busiest in the U.S. Faster, large ships transiting to and from these ports and high ship density translate to louder introductions of noise into the marine environment, particularly in shipping lanes (Moore et al. 2018, Redfern et al. 2017, see Appendix C: Figures App.C.2.6 and App.C.2.7). Anthropogenic noise has been documented to affect the behavior of large cetaceans, and the distribution of teleosts and marine mammals (EDC 2004, McKenna et al. 2015, MSWGSS 2016). Evaluating and mitigating ocean noise has become a major focus for NOAA and an emerging focus for CINMS (Gedamke et al. 2016). The Santa Barbara Channel shipping lanes have served and continue to act as an ongoing case study for ambient and low frequency anthropogenic noise research. Up until 2009, the vast majority of cargo ships coming to and from the ports of Long Beach and Los Angeles passing by the northern Channel Islands did so via the Traffic Separation Scheme (shipping lanes) established within the Santa Barbara Channel, a route between the northern Channel Islands and mainland Santa Barbara that crosses through a portion of the sanctuary. In 2008, shipping noise in the channel decreased by 15 percent because of an economic recession that lowered the overall amount of ship traffic (McKenna et al. 2012). In 2009, the majority of the channel ship traffic shifted to areas south of the northern Channel Islands in order to avoid new California air quality controls requiring the use of low-sulfur emitting fuels within 24 nautical miles of shore. With this shift, there was a 70 percent decrease in shipping noise in the channel. Then in 2013, federally-required fuel use and emissions controls were expanded to 200 nautical miles from shore, which re-distributed ship traffic again to the majority of traffic occurring in the channel's shipping lanes (see Appendix C: Figure App.C.4.12). Subsequently, shipping noise in the channel elevated again, but has remained below ambient noise levels recorded in 2009 (see Appendix C: Figure App.C4.13). In 2017, it was estimated that for shipping traffic from the Ports of Los Angeles and Long Beach that pass by the northern Channel Islands, 65 percent used the Santa Barbara Channel shipping lanes and 35 percent transited south of the islands (MESC 2018). Some resident passive acoustic listening stations are established in and around the sanctuary to monitor ocean noise, including from shipping (see Appendix C: Figure App.C2.8). Continued and new ocean noise research would improve ONMS's ability to characterize sanctuary soundscapes and assess impacts on sanctuary resources, particularly for species, including marine mammals, and some fish and invertebrates, that rely on acoustic communication to forage, socialize, and navigate.

In addition to direct habitat impacts (see Question 3), there are short- and long-term water quality concerns associated with vessel groundings, including oil and/or other discharges (e.g., diesel, debris). The number of groundings vary annually; the largest number recorded was in 2015 (n=7). Generally, potential impacts from vessel groundings are thought to be localized to the grounding site.

3. What are the levels of human activity that may adversely influence habitats and how are they changing?

In the 2009 condition report, the impact of human activities on habitat quality was rated fair with an improving trend. Commercial and recreational opportunities abound in the sanctuary and while human activities result in many benefits for the sanctuary, they can also impact sanctuary resources. Sanctuary habitats were observed to be affected by fishing impacts (both direct and indirect), marine debris, vessel discharges, and anchoring. At the time, habitat condition was improving and this trend was associated with the State and NOAA establishment of Channel Islands marine reserves and conservation areas in 2004, 2006 and 2007, as well as other management measures.

In 2016, the status rating for human activities adversely affecting habitat quality remained fair (medium confidence); however the trend has been changed to undetermined (medium confidence). Limited time-series data exist on human activities and their associated impact on habitat quality; however, available data show increasing levels of fishing, and concerns regarding associated gear impacts are considered in this report. Additional data regarding boating activity and marine debris abundance would be required to inform a thorough impact assessment. The following provides updated information on the status of human activities that had the most influence on the rating. Further information on human activities is presented in Appendix C: Drivers and Pressures.

The Channel Islands region has historically been and continues to be essential to local fisheries. Across California, the region is recognized as one of the most important in terms of total landings and value of catch (Schroeder 2016). Over the last three decades, fishing pressures have changed dramatically in the sanctuary as a result of regulations, consumer demand, and economics. CDFW landings data show that by the early 2000s, bottom contact nets and trawls for halibut and groundfish, which can cause benthic habitat damage, had become negligible due in part to fisheries management measures (i.e., nearshore gillnet ban, Rockfish Conservation Areas, federal groundfish closures, and no-take Marine Reserves) (Figure S.P.3.1). For this reason, habitat damage in rocky and reef ecosystems from these gear types are likely negligible during the assessment period for this report. There is some limited trawl effort for

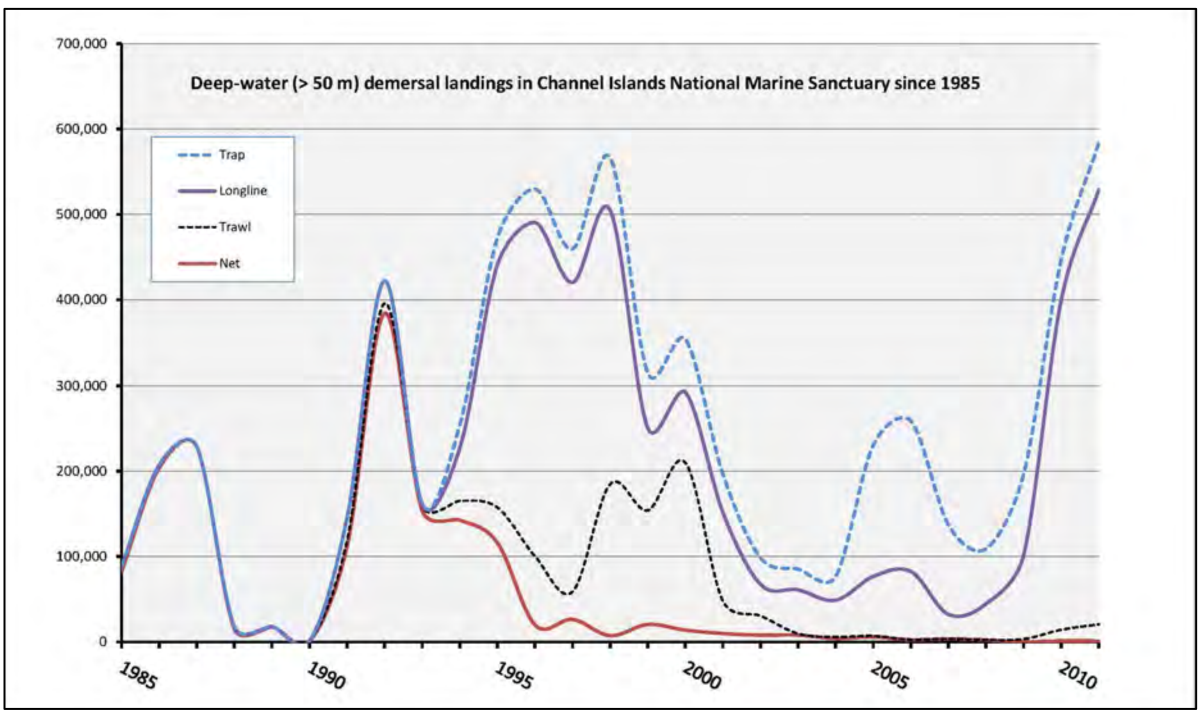


Figure S.P.3.1. Landings (in pounds) of demersal fishes and invertebrates fished from deep-water habitats (> 50 meters) in Channel Islands National Marine Sanctuary since 1985, symbolized by bottom contact gear type. Traps are blue, longlines are purple, trawl nets are black, and set nets are red. Landings have changed over time as a result of changing regulations, economic conditions, and consumer demand. Since 2002, there have been relatively few landings from gillnets and trawls. Landings from longlines and traps were also relatively low compared to the mid-1990s. Landings from traps and bottom longlines (i.e., fixed gear) have increased substantially since 2008, approaching peak levels. Data Source: CDFW; Figure: P. Etnoyer/NOAA invertebrates (e.g. sea cucumbers), but these trawls are smaller than those used for fish, and impacts to soft bottom habitat are likely not as persistent or harmful compared to trawl effects on hard bottom habitats. Since 2008, traps (e.g., spiny lobster and crab) and bottom longline fishing gear have increased dramatically due to economic changes and a shift in effort away from other bottom contact gear (Schroeder et al 2016; Etnoyer, unpub. data). This shift over time in bottom contact gear types (Figure S.P.3.1) has likely resulted in a switch from wide-scale to smaller-scale and more localized impacts on benthic habitat during this assessment period. In addition, lost traps have the potential to continue to cause fishing mortality (e.g., ghost-fishing), and can damage or remove sensitive species, such as seagrasses, as traps drag across the seafloor.

In addition to disturbance from fishing, there have been 64 reported vessel groundings within sanctuary boundaries, including recreational vessels, fishing vessels, and a drug smuggling panga (i.e. modest-sized, open, outboard-powered, fishing boat) since 2000 (Figure S.P.3.2); however, short- and long-term impacts to habitats from vessel groundings cannot be quantified because some groundings go unreported and the discharge of oil, diesel, and vessel debris has not been quantified for many of the recorded groundings. Groundings have occurred at all sanctuary islands, with the majority reported at Santa Cruz Island (Figure S.P.3.3). While groundings vary annually, there was a spike in 2015 (n=7) in comparison to the two preceding years during which only one (2013) and two (2014) groundings were reported, respectively (Vessel Assist, unpub. data). Generally, impacts from groundings are thought to be localized to the impact site.

Figure S.P.3.2. Vessel grounding on Santa Barbara Island. Photo: Vessel Assist

While consumer culture, economics, and policy have had an effect on marine debris, no long-term monitoring data exists to quantify the impact on sanctuary habitats; however, anecdotal evidence suggests marine debris is widespread. Many different programs and sanctuary partners, such as the SeaDoc Society, Ocean Defenders Alliance, and Santa Barbara Adventure Company, have conducted marine debris removals both underwater using SCUBA gear and onshore in coastal sanctuary habitats. Due to the difficulties associated with observing and accessing debris in deep water, an information bias exists towards shallow habitats. Between 2009 and 2013, the SeaDoc Society's California Lost Fishing Gear Recovery Project collected 33,890 pounds of gear over 58 days off the seafloor within the sanctuary and nearby region. On three trips to Frenchy's Cove, Anacapa Island, the Ocean Defenders Alliance's Operation Deep Sweep removed 900 pounds of squid net, five lobster traps, and 400 feet of polypropylene line. Santa Barbara Adventure Company estimates 1,300 pounds of trash and derelict fishing gear were collected from a two-mile section of beach at Yellowbanks on Santa Cruz Island in one day in February 2015. Microplastics (e.g., small plastic pieces that are less than five millimeters) are an emerging concern as researchers are finding they have become widespread throughout the Southern California Bight.

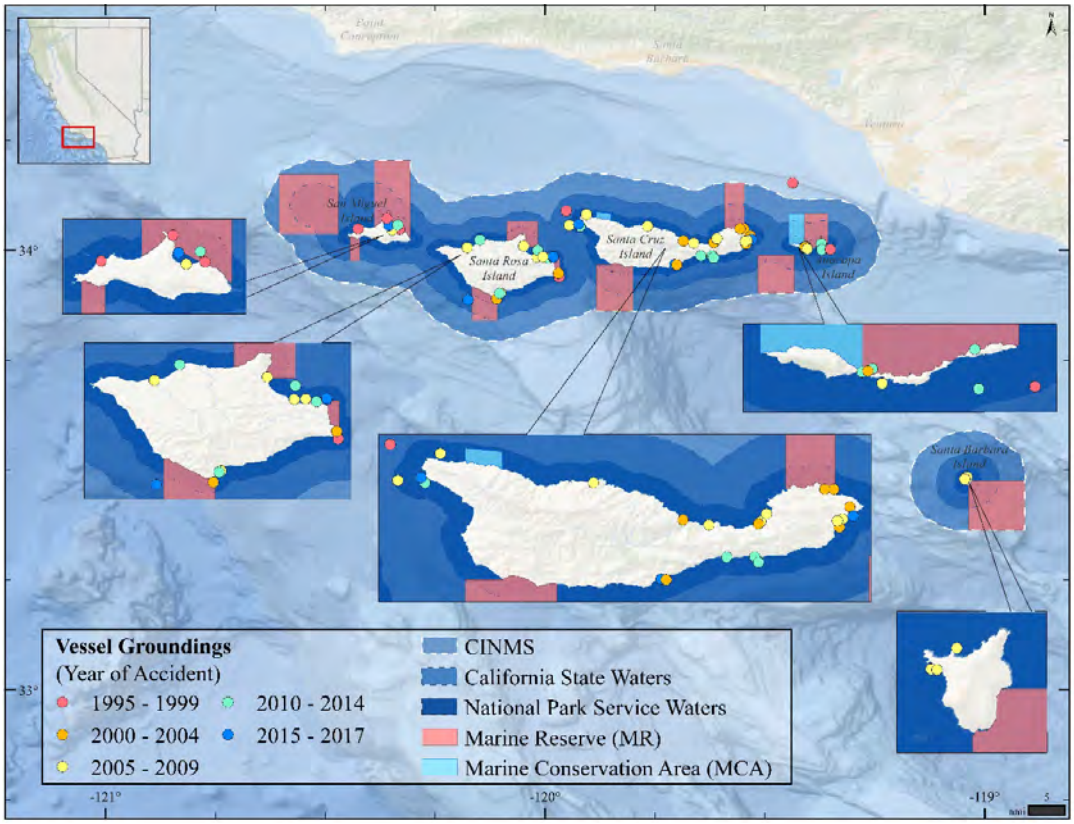


Figure S.P.3.3. Location of vessel groundings reported from 1999 to 2016. Not all groundings are shown, as coordinates are not available for some groundings. Data source: Vessel Assist; Map: M. Cajandig/NOAA

Visitation to the sanctuary by private boaters is also of concern, but there is no active comprehensive monitoring to measure levels of boat visitation. One report estimated 375,256 people visited the islands for recreational purposes in 2006 (Stynes 2007). While annual visitation to Frenchy's Cove at Anacapa Island using the local concessionaire company Island Packers shows a recent decline (Whitaker and Richards 2015), overall visitation to the sanctuary and park is believed to have increased (Kushner, pers. comm., Leeworthy, pers. comm). However, it is important to note that there is no direct measurement of visitation to the sanctuary and the impacts associated with this believed increased visitation remain relatively unquantified. At any rate, a number of direct impacts (e.g., anchoring in eelgrass beds, prop fouling of kelp, trampling intertidal organisms) and indirect impacts (e.g., discharge of oil) are believed to be closely linked to increased visitation.

Finally, oil activities in the Santa Barbara region continue to be a threat and the May 19, 2015 Refugio Oil Spill likely had adverse impacts on sanctuary waters. Due to ongoing litigation, much of the data from the Refugio Oil Spill have yet to be released; but please see Question 2 for larger overview of the event. Over 105,000 gallons (~2,500 barrels) of crude oil spilled from the pipeline and approximately 21,000 gallons made it into the Pacific Ocean (NOAA DARRP). Particle models developed at UCSB predicted that some of the oil that made it past the shoreline may have advected to sanctuary waters (Washburn, UCSB, pers. Comm; Fig. S.P.2.1). Tar and oil was found shortly after on island shorelines, but testing of the tar was not completed to determine whether it came from the Refugio Spill or was naturally occurring. Any oil resulting from the spill may have short- and/or long-term negative impacts on the sanctuary and surrounding habitats (see Water Quality Section).

MPA Effects: Marine Reserves and Conservation Areas in Channel Islands National Marine Sanctuary

One purpose of a condition report is to assess the current status of and recent trends in sanctuary resources. Questions 12 and 13 focus on the sanctuary-wide condition of keystone, foundation, and other focal species by integrating monitoring data collected at sites throughout the sanctuary. Though these monitoring sites may differ in various factors (e.g., water temperature, human uses), integration across sites helps to provide an overall assessment of sanctuary-wide condition. Complementary to the sanctuary-wide assessment, examination of differences among monitoring sites, such as regulation of human activities, may provide insight into factors that significantly influence species abundance and ecosystem conditions inside the sanctuary. In addition to providing information on factors influencing abundance of focal species, it also helps evaluate effectiveness of regulations aimed at improving condition of sanctuary resources.

In CINMS, there is a network of 13 marine protected areas[5] (MPAs) that includes 11 no-take marine reserves and two conservation areas that allow some forms of fishing (see Figure MPA.1). State water portions of the MPAs were designated in 2003, and extended into federal waters in 2006 and 2007, under the Magnuson-Stevens Fishery Conservation and Management Act and the National Marine Sanctuaries Act, respectively.

The Channel Islands network of MPAs was designed and implemented to help rebuild depressed populations, restore biodiversity, and improve ecosystem health by protecting habitats and living resources (CDFW 2016b). Understanding the impact of the MPAs on ecosystem conditions has been a focus of long-term monitoring efforts by scientists at universities, government agencies, and non-profit organizations, in partnership with the Office of National Marine Sanctuaries. The first five-year evaluation of marine reserves occurred in 2008 (CDFG et al. 2008) and an additional five years of monitoring have been summarized in various scientific presentations, agency reports, and published journal articles. Results show that in general, biomass and abundance of targeted species are increasing at a higher rate inside reserves compared to reference areas open to fishing. Some of these results are briefly summarized below.

Kelp Forest Habitat

Two long-term monitoring programs — Channel Islands National Park (CINP) and the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) — have been tracking changes in kelp forest and shallow rock habitats in CINMS and CINP, both inside and outside of MPAs. Findings of these monitoring programs align (Hamilton et al. 2008, Caselle et al. 2008, 2015, PISCO 2013, Pondella et al. 2015). Changes in algal, invertebrate, and fish species in the region include:

- Average biomass of species targeted by fishing, such as rockfish, kelp bass, and lobster, has increased both inside and outside of MPAs since their implementation, but the rate of increase is much greater inside MPAs where fishing is not allowed (Figure MPA.2);

[5] For purposes of this report, the term "marine protected areas," which can have varying definitions, is confined to the 11 marine reserves and two marine conservation areas in CINMS.

- Increased biomass inside marine reserves, known as the “reserve effect,” results from larger-sized individuals (e.g., kelp bass, sheephead) and higher density (more individuals in the same size area) inside MPAs (Figure MPA.3, PISCO 2013);
- The reserve effect is more consistently observed for species subject to high fishing pressure, such as California spiny lobster, sea cucumber, and sheephead. Unfished and lightly fished species show no consistent patterns relative to protection; some are more abundant inside and some are more abundant outside MPAs (Figure MPA.4).

This pattern of higher biomass of targeted species inside MPAs is fairly consistent among the four islands surveyed (Figure MPA.5) despite strong biogeographical patterns across the Channel Islands. Although there was significant variation in average biomass of targeted and non-targeted species among islands, the positive reserve effect was observed at most islands. San Miguel Island, which is the coldest and most distant from ports, showed no significant difference in fished species biomass inside and outside the reserve. This highlights the fact that environmental conditions, fishing patterns, and other variables are important to consider when evaluating MPA performance.

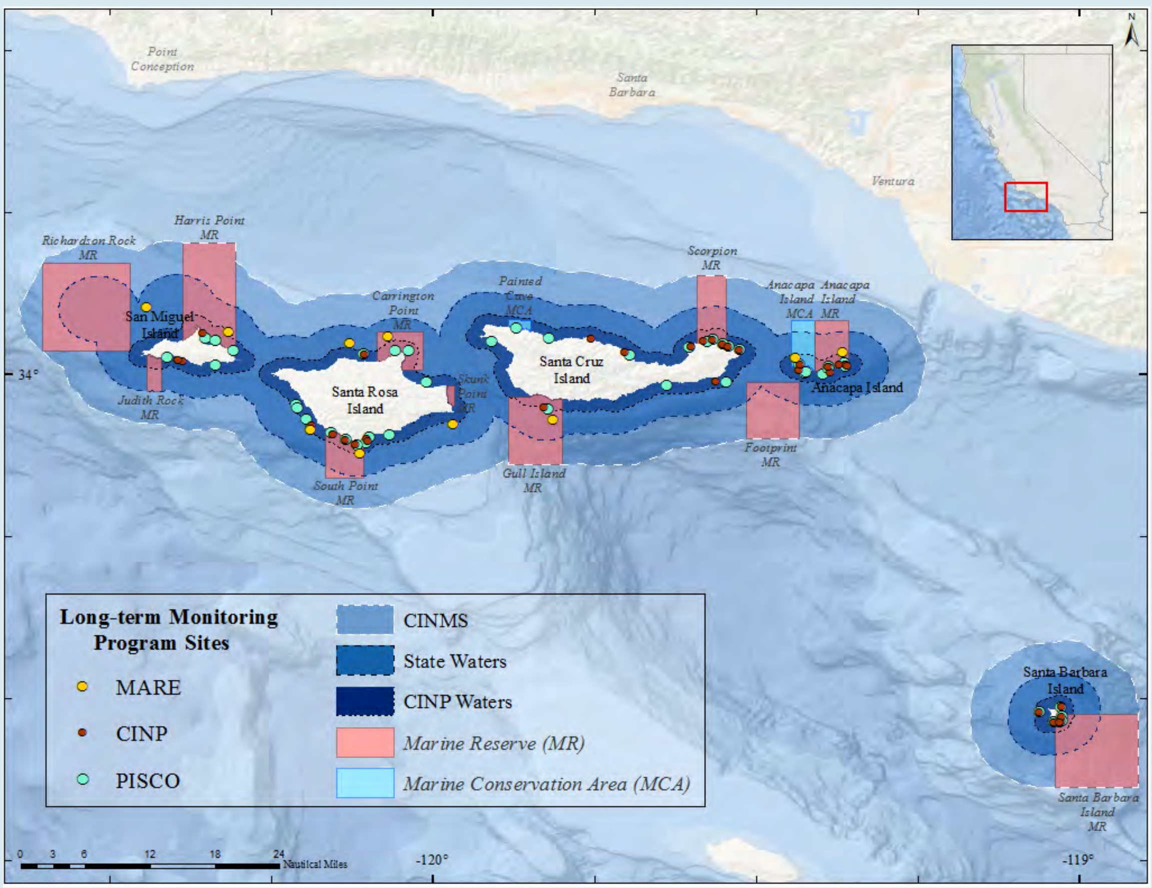


Figure MPA.1. The Channel Islands National Marine Sanctuary boundary extends from the islands’ mean high water line (MHWL) out to six nautical miles (white boundary). State jurisdiction extends from the islands’ mean high tide line to three nautical miles (black boundary). Channel Islands National Park includes most of the islands’ land to one nautical mile offshore. State waters portions of the MPAs were designated in 2003, and extended into federal waters in 2006 and 2007, under the Magnuson-Stevens Fishery Conservation and Management Act and the National Marine Sanctuaries Act, respectively. The location of long-term monitoring sites for three programs evaluating the effectiveness of the MPAs are shown: Channel Islands National Park (CINP, brown circles), Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO, teal circles), and Marine Applied Research and Exploration (MARE, orange circle). Map: M. Cajandig/NOAA

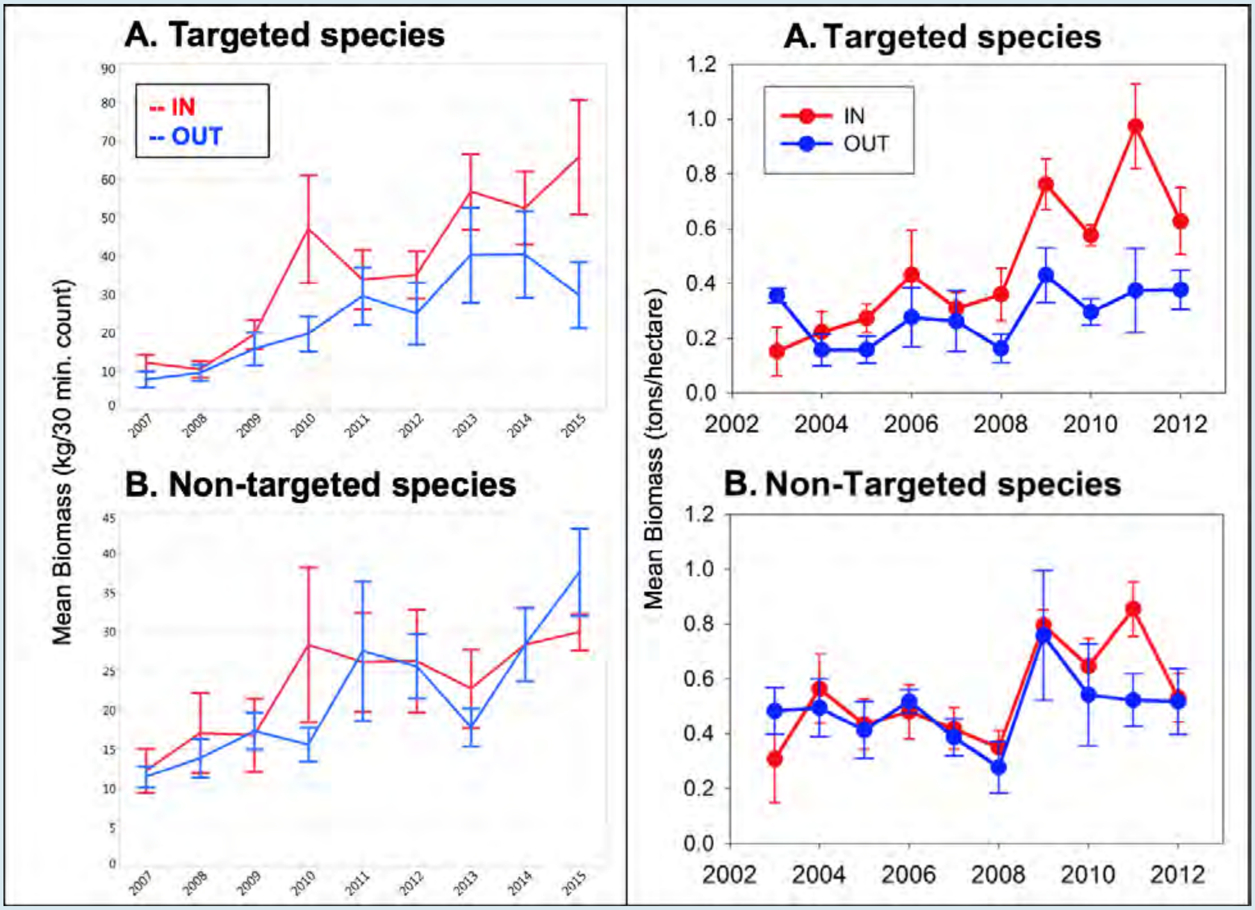


Figure MPA.2. Change over time of average biomass (± 1 standard error) inside (red) and outside (blue) of marine reserves in Channel Islands National Marine Sanctuary for (A) species targeted by fishing and (B) species not targeted by fishing. Data were collected by Channel Islands National Park Kelp Forest Monitoring Program from 2007 to 2015 (left panels) and Partnership for Interdisciplinary Studies of Coastal Oceans from 2003 to 2012 (right panels). Figures: Channel Islands National Park, unpub. data (left panels); Caselle et al. 2015 (right panels)

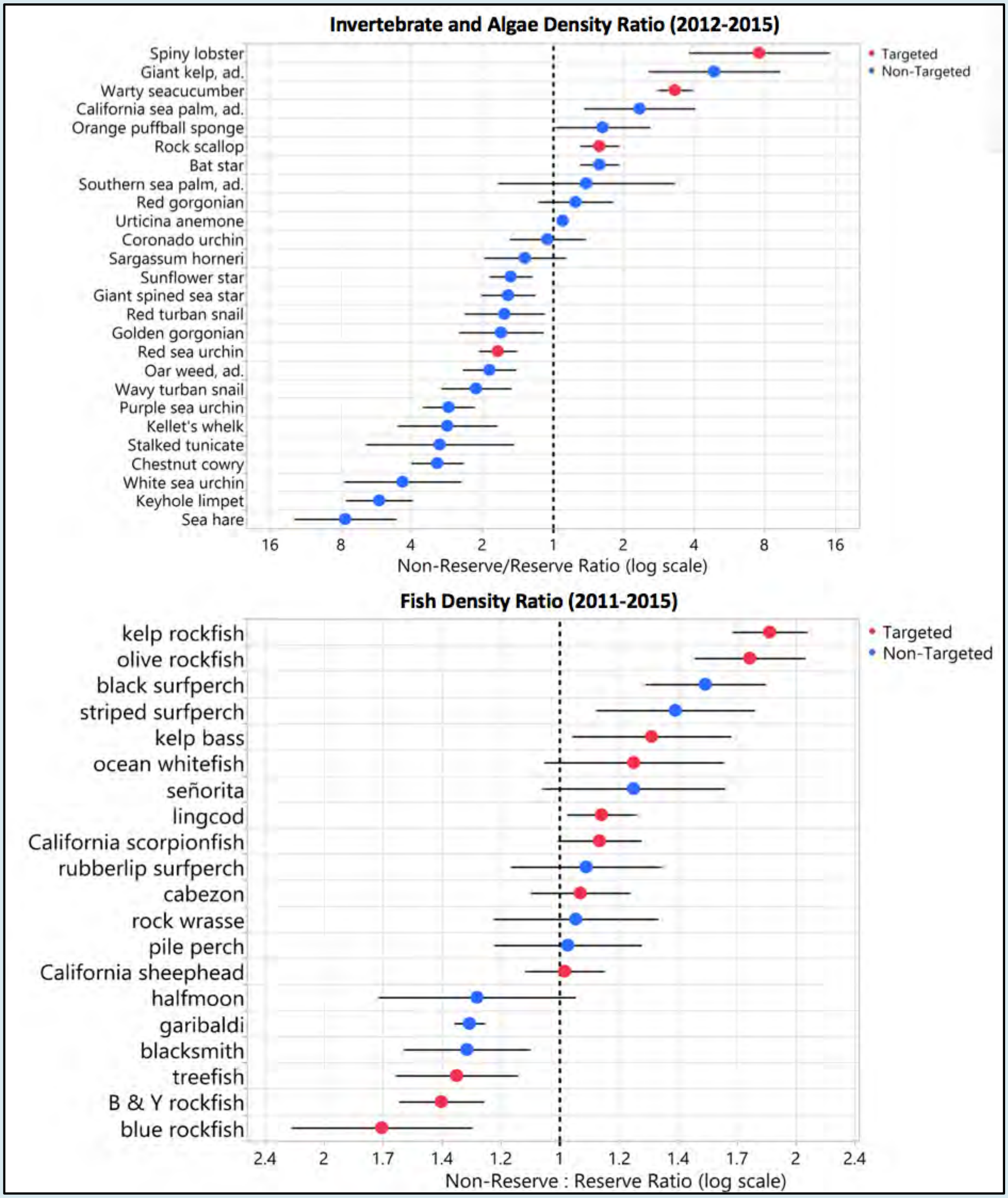


Figure MPA.3. A comparison of mean density (± 1 standard error) inside and outside marine reserves for targeted (red) and non-targeted (blue) species of invertebrates and algae (top) and fish (bottom). Species with a mean density to the right of the vertical dotted line have a higher density inside reserves, while those to the left have a higher density in areas open to fishing. Most, but not all, targeted species have a higher density inside the reserves. Note: Due to low fishing pressure of Kellet's whelk, keyhole limpets, and wavy turban snails, they were not included as fished invertebrates. Figure: Channel Islands National Park, unpub. data

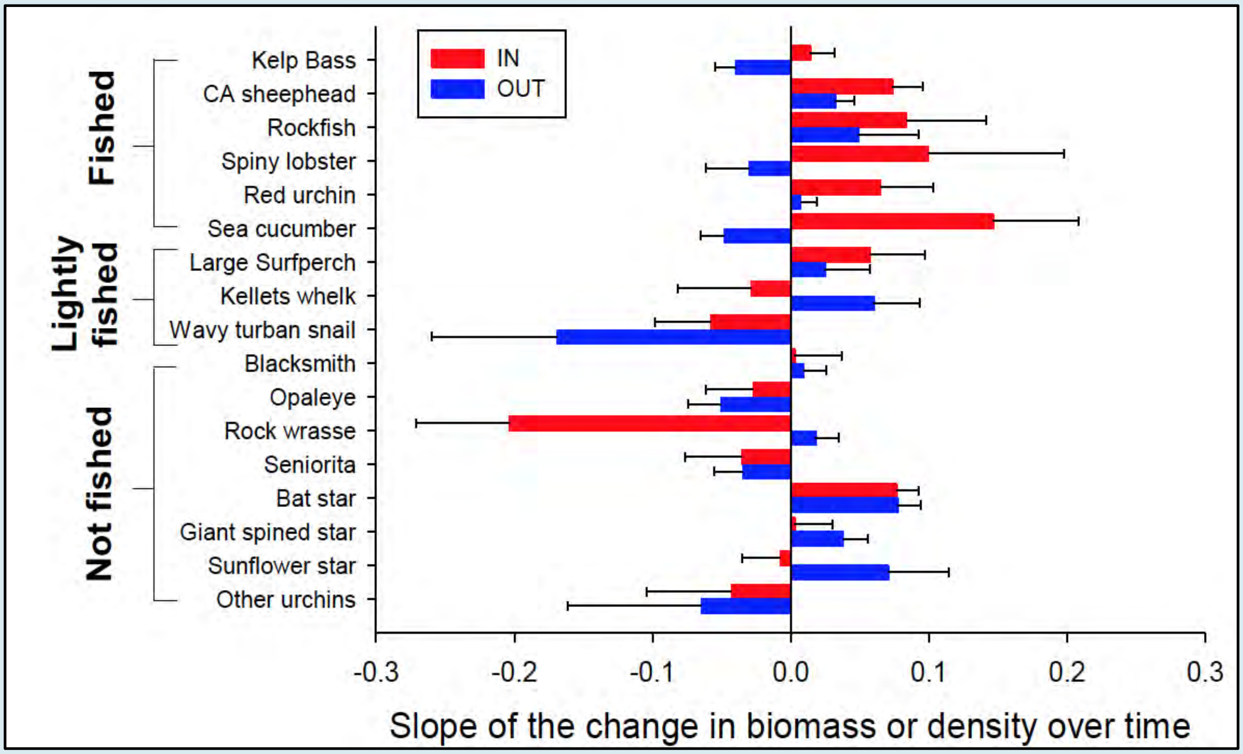


Figure MPA.4. Change over time of average fish biomass or invertebrate density inside (red) and outside (blue) marine reserves in Channel Islands National Marine Sanctuary for fished, lightly fished, and not fished species. Bars to the right of the vertical line denote increasing biomass or density over time while those to the left denote decreasing density or biomass. Error bars are ± 1 standard error. Figure: Pondella et al. 2015

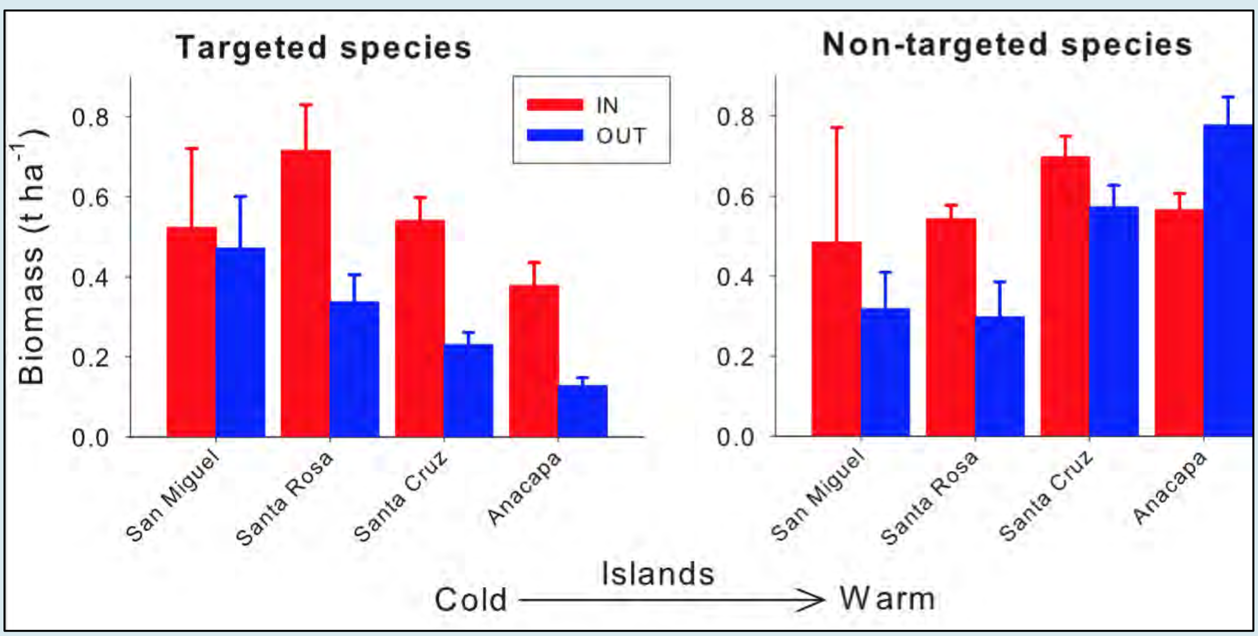


Figure MPA.5. Spatial patterns of average biomass from 2005 to 2012 for targeted (left) and non-targeted (right) species inside (red) and outside (blue) MPAs in Channel Islands National Marine Sanctuary. Error bars represent ± 1 standard error. Islands are listed with westernmost on the left and easternmost on the right; the westernmost island (San Miguel) is surrounded by the coldest water while the easternmost (Anacapa) is surrounded by the warmest water. Figure: Caselle et al. 2015

Mid-depth Seafloor

Two long-term monitoring programs — Marine Applied Research and Exploration (MARE) and the California Department of Fish and Wildlife (CDFW) — have been using remotely operated vehicles (ROVs) for repeated visual surveys of mid-depth (20 to 80 meters) rock and subtidal soft bottom inside and outside of MPAs in CINMS. These habitats are home to many commercially and ecologically important species, such as lingcod, sheephead, and rockfish. Similar to the patterns observed for kelp forest and shallow rocky reef habitats, biomass has increased over time for five focal fish species: gopher rockfish (*Sebastes carnatus)*, copper rockfish (*S. caurinus)*, vermilion rockfish (*S. miniatus)*, lingcod (*Ophiodon elongatus)*, and California sheephead (*Semicossyphus pulcher*). The magnitude of these increases were higher inside of MPAs compared to outside. Specifically:

- The overall mean densities of the five focal species have increased notably since the baseline period (2005 to 2009); overall mean density went from 54 fish per hectare from 2005 to 2009 to 221 fish per hectare from 2014 to 2015 (Figure MPA.6).
- The magnitude of the increase in overall fish density was slightly higher inside MPAs (310 percent) compared to outside (290 percent); however, additional analysis is needed to determine if that effect is significant (Rosen and Lauerman 2016).

Additional processing and analysis of ROV videos is needed to determine trends in abundance of additional fish and invertebrate species and to compare patterns across targeted and non-targeted species.

Initial analyses of changes in abundance of kelp forest and deeper seafloor inhabitants indicate that the MPA network within CINMS is helping to achieve the objectives of rebuilding depressed populations. More abundant sea life within marine reserves will likely provide benefits to areas outside the MPAs with similar habitats, known as "spill-over effects," and contribute to improvements in biodiversity and overall ecosystem condition. Healthier marine ecosystems may be more resilient to disturbances from human activities and environmental changes. Continued monitoring of the MPAs in CINMS will be critical to understanding their long-term effectiveness and impacts on adjacent areas. These results can also benefit the evaluation of other types of MPAs, including an extensive network throughout California's state waters.

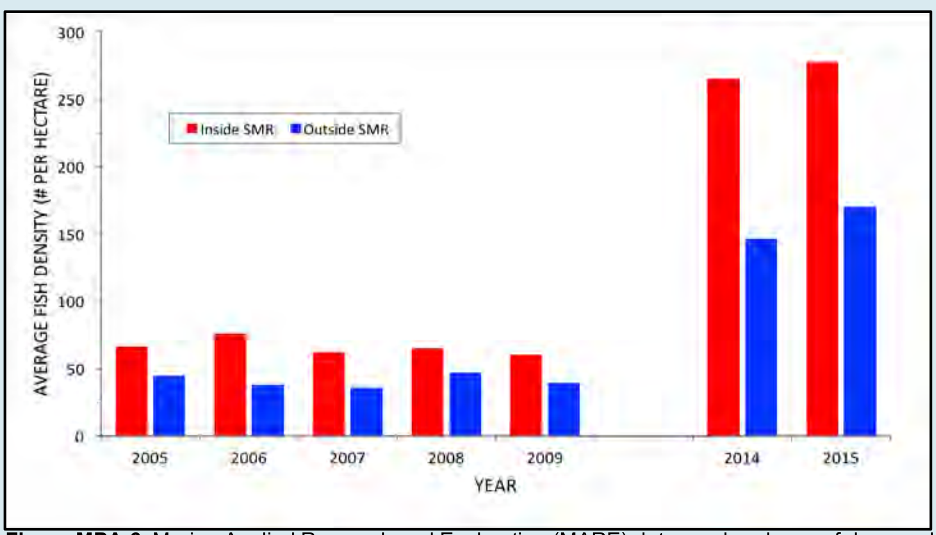


Figure MPA.6. Marine Applied Research and Exploration (MARE) data on abundance of demersal fishes along seafloor transects at 20 to 80 meters depth inside (red) and outside (blue) of state marine reserves (SMR). Data source: Rosen and Lauermann 2016; Figure: NOAA

4. What are the levels of human activities that may adversely influence living resource quality and how are they changing?

The 2009 status rating of human activities that may adversely influence living resource quality in the sanctuary was fair and the trend was declining because increased visitation and potential disturbance, along with expected climate change impacts, offset gains made in resource protection. The 2016 status rating remains fair (medium confidence) with a worsening trend (high confidence) because a number of human activities have had and continue to have measurable, localized impacts on living resources in the sanctuary and many of these activities are continuing at similar levels or increasing in intensity. Confidence in the status rating is medium because data are lacking to track the levels of many of the human activities that have the potential to impact living resources.

The following provides updated information on the status of the human activities that had the most influence on the rating discussion and ultimate decision. Additional information on the levels of human activities and long-term trends is available in Appendix C: Drivers and Pressures Tables and Graphs.

Fishing, both commercial and recreational, is an important human activity that influences the abundance and condition of living resources in and around the sanctuary (Figure S.P.4.1). Fishing activities target a variety of species in the sanctuary including invertebrates (e.g., crab, lobster, sea cucumber, sea urchins), kelp forest fishes (e.g., rockfish, sheephead), soft-bottom fishes (e.g., flatfishes), and pelagic forage species (e.g., market squid, anchovy, sardine). The available data on recent fishing activity in the sanctuary suggest that overall fishing activity has been steady, with some fishing activities increasing and others decreasing likely in response to changing economic forces (e.g., fuel prices, landing values), environmental conditions (e.g., El Niño, La Niña), and fishing regulations (e.g., gear regulations) (Leeworthy et al. 2014a, Chen et al. 2015a, b).

Fishing activity is not uniformly distributed, for example fishing activity on shallow rocky reefs is greatest on the south side of Anacapa and Santa Cruz Islands (Pondella et al. 2015, 2016; Appendix C: Figure App.C.4.1) due in part to closer proximity to mainland ports. The implementation of marine reserves and conservation areas in the sanctuary, which restrict or completely eliminate fishing activity in certain locations around the islands, has influenced the spatial distribution of fishing effort as well.

Figure S.P.4.1. NOAA data have indicated that approximately 450 commercial vessels fish in the sanctuary. This photo shows a commercial squid fishing vessel. Photo: R. Schwemmer/NOAA

Based on data from 2000–2012, the commercial passenger fishing vessel (CPFV) fleet out of Santa Barbara and Ventura (the ports closest to the sanctuary) reached an activity low in 2010, possibly due to the economic recession, but then rebounded back to previously observed levels by 2012 (Chen et al. 2015b, Appendix C: Figure App.C.4.2). Comparatively, activity levels of the commercial fleet appear to have been fairly level from 2005-2012 (Chen et al.

2015a). Annual landings through 2012 (from areas that include CINMS) indicate that recent trends in commercial fishing activity varied by fishery; landings increased for spiny lobster and rock crabs, held steady for sea urchin, prawn, and shrimp and decreased for anchovy, sardine, and market squid (Leeworthy et al. 2014a; Appendix C: Figure App.C.4.4). The reduction of commercial landings of some key forage species — market squid, anchovy, and sardine — was likely in response to very low abundance of these fish stocks throughout southern and central California (see Figure S.LR.12.5, McClatchie et al. 2016a, b).

In addition to removal of targeted species, additional impacts of fishing can include bycatch of non-target species, food web impacts to predators from removal of prey species, and entanglement in fishing gear. Not only can lost fishing traps, pots, and nets continue to catch animals (a phenomenon called ghost fishing), but active lines and nets can be entanglement hazards for non-target fish, seabirds, and mammals. The number of reports of large whale entanglement (primarily humpback whales and gray whales) in fishing gear and other man-made lines (e.g., buoy lines) has recently increased in California (see Appendix C: Figure App.C.4.10). A coast-wide risk analysis found that large whales in the Southern California Bight are at higher risk from entanglement in pots and traps than in other regions (Saez et al. 2013).

Large ships transiting in and near CINMS have the potential to impact sanctuary resources through direct interaction (e.g., collision) and noise production. CINMS and partners have attempted to minimize the risk of ships striking whales through a number of resource protection efforts, including moving shipping lanes and piloting incentivized speed reduction programs;[6] however, information on strikes is limited. Monitoring of underwater noise in the southern California Bight showed a net reduction of 12 decibels between 2007 and 2010 due to a reduction in shipping traffic (McKenna et al. 2012). Since 2011, shipping traffic, and therefore underwater noise, has been increasing, but has not returned to the higher levels observed in 2007 (J. Hildebrand, UCSD, unpubl. data; Appendix C: Figure App.C.4.13). Other than in the northwestern portion of the sanctuary that intersects with shipping lanes (Figure SH.7), noise from shipping does appear to be reduced in the sanctuary compared to other areas in the channel as a result of an Area to be Avoided (ATBA) (Redfern et al. 2017). The ATBA, which overlaps all of the sanctuary except the shipping lanes, was designated by the International Maritime Organization in 1991 and requests that all cargo carrying ships avoid the area.

The variety of underwater sounds in the sanctuary, or its "soundscape" (i.e., the cumulative acoustic sources, both natural and artificial, within a given area), includes noise generated by physical processes (e.g., wind, waves), animal communication (e.g., fish, marine mammals, invertebrates), and human activities. A variety of human activities, in addition to shipping, influence the soundscape. For instance, some fisheries use commercially produced, non-lethal explosives to deter nuisance marine mammals, like sea lions and dolphins; an example of this are "seal bombs", small weighted firecrackers that detonate approximately three meters below the water's surface, intended to scare away pinnipeds and help protect fishing gear and catch. Passive acoustic monitoring data collected between 2008 and 2014 at 16 sites within southern California provide an initial assessment of the location and frequency of these small-charge underwater detonations. The average number of explosions peaked in 2009 and then steadily

[6] Channel Islands National Marine Sanctuary, Office of National Marine Sanctuaries. Ship Strikes. Retrieved from: http://channelislands.noaa.gov/management/resource/ship_strikes.html (last visited Apr. 11, 2018).

declined through 2014. Maximum monthly explosion counts ranged from 12,000 to 37,000 per month at some sites, including sites around the sanctuary (Meyer-Loebbecke et al. 2016). The majority of explosions occurred at night, on weekdays, and during fall and early winter months (Meyer-Loebbecke et al. 2015, 2016). Spatial and temporal patterns of explosions were found to be similar to operating hours and seasonality of commercial fisheries landings of squid and forage fish purse-seiners in the region (Baumann-Pickering et al. 2013; Meyer-Loebbecke et al. 2015; 2016). Both the National Marine Fisheries Service and the Office of National Marine Sanctuaries are interested in better understanding the use, and potential impacts, of non-lethal acoustic deterrents across sanctuaries and this is one focus of continued soundscape research.

Marine debris has been documented in the Southern California Bight on mainland beaches (Ribic et al. 2012), beaches at Santa Rosa Island (S. Whitaker, CINP, pers. comm.), in the upper water column (Gilfillan et al. 2009), and on the seafloor (Moore and Allen 2000, Keller et al. 2010, Moore et al. 2016) (Figure S.P.4.2, Appendix C: Figures App.C.4.14-16). Although negative impacts to living resources from ingestion and entanglement of debris have been demonstrated in other national marine sanctuaries on the West Coast (ONMS 2015, Donnelly-Greenan et al. 2014), CINMS staff are not aware of any recent studies in CINMS specifically and thus, cannot determine if impacts are increasing; however, the fact that many types of debris, in particular plastic debris, do not degrade raises concern that this problem will increase in severity in the future. The ability for plastics to attract and transport contaminants into the marine food web has been documented (Arthur et al. 2009) and this is a topic that would benefit from further study to determine potential impacts to the sanctuary's living resources.

Figure S.P.4.2. The types of plastic pellets and other debris commonly found in sand on coastal beaches. Plastic pellets are a threat to marine organisms because their small size (1-5 millimeters) allows them to be easily ingested. This is further compounded by the fact that plastic pellets absorb persistent organic contaminants, which can then enter the food web. Photo: SCCWRP

On May 19, 2015, an estimated 142,000 gallons (3,400 barrels) of crude oil was released when a corroded onshore pipeline ruptured near Refugio State Beach on the mainland coast. Transport models based on sea surface currents data suggested oil spread across the Santa Barbara Channel and reached the northwest coastlines of Santa Rosa and Santa Cruz Islands by May 23 (see Figure S.P.2.1). Channel Islands National Park observed oil at multiple sites along the coast of Santa Cruz Island, but the origin of the tar collected at that time was not able to be confirmed as originating from the Refugio spill. A natural resources damage assessment is underway by state and federal trustee agencies to determine impacts to a wide variety of species including shoreline animals (e.g, mussels, barnacles, sand crabs), nearshore fishes (e.g., grunion, surfperch), seabirds and shorebirds, and marine mammals (e.g, sea lions, dolphins). Due to legal processes underway, data on impacts of the spilled oil on living resources were largely unavailable during the expert workshop; however, given the trajectory of the spilled oil and the preliminary estimates of impacts to birds, mammals, and other species,[7] it is likely that some sanctuary habitats and living resources were impacted by the Refugio Oil Spill. The effects of the Refugio Oil Spill will be revisited in future condition reports.

5. What are the levels of human activities that may adversely affect maritime archaeological resources and how are they changing?

In the 2009 condition report, this question was rated fair and improving. The 2016 rating remains fair, however, because the level of human activities have remained stable since 2009, the rating is now revised to not changing. Human activities, such as looting, diving, vessel activity, and bottom trawling may affect maritime archaeological resources in the sanctuary. Site looting (i.e., where objects are intentionally pilfered from submerged sites) was a major threat to submerged archaeological resources including these historic shipwrecks: the California Gold Rush side-wheel passenger steamer *Winfield Scott* lost in 1853 (Figure S.P.5.1); the 19th-century-built sailing ship *Aggi* lost in 1915; 19th-century bark *Goldenhorn* lost in 1892 (Figure S.P.5.2); the 19th-century-built cargo/passenger steamer *Cuba* lost in 1923; and the 19th-century steamship collier *Crown of England* lost in 1894. With the successful legal prosecution of sport divers involved in site looting in the 1980s, along with expanded education and outreach programs established by the sanctuary, the risk of looting has declined (Schwemmer 2001). Other potential impacts to archaeological sites include sport divers accidentally causing damage through poor diving techniques, such as inadvertently holding onto fragile artifacts or striking them with scuba tanks. In addition, vessel activities, such as anchor drags or modern ship groundings, can also cause serious injury to submerged archaeological resources (Figure S.P.5.3).

A shipwreck brochure was developed in 2013 that provides the sport diving community with information on sanctuary regulations and how to protect maritime heritage resources. Since the 2009 condition report, National Park Service rangers that patrol sanctuary and park waters have been part of a science dive team that surveys shipwrecks. This provides rangers with awareness of the wreck site locations and current site conditions, enhancing on-water protection and enforcement efforts. Also since the 2009 condition report, site monitoring has shown no evidence of archaeological sites being looted by sport divers. A damage assessment was recorded in 2011 at the site of the *Winfield Scott*, where damage to historic iron artifacts was likely caused by a sport diving vessel's anchor tackle, and not by divers (Figure S.P.5.3). The annual shipwreck reconnaissance monitoring program includes the documentation of newly discovered artifacts that become exposed in part due to strong wave action. During a 2016 site survey of the fishing vessel *Equator* shipwreck that was lost off Anacapa Island in 1949, a Pelorus navigation instrument was discovered (Figure S.P.5.4). The Pelorus remained undisturbed from November 2016 to April 2017, when it was recovered by divers during a joint mission with federal and state partners, and is currently being conserved for public display.

Historical and recent bottom trawling is one probable impact to offshore maritime archaeological resources from which these resources cannot recover. With recent trawl closures, the shift of fishing effort to new areas may increase risk to resources that have not previously been impacted. Because the majority of wreck locations are unknown, the impacts from historical and recent trawling are also unknown. Other

[7] Southern California Coastal Ocean Observing System. 2015. Refugio Beach Oil Spill Natural Resource Damage Assessment Update. Retrieved from: http://sccoos.org/media/filer_public/b7/58/b758c4b8-ce67-48e7-ae17-9b294e0aefa6/refugio_beach_oil_spill_nrda_newsletter_november_2015.pdf.

potential impacts are the placement and retrieval of crab and lobster cage traps, although the placement of these traps is typically in nearshore environments.

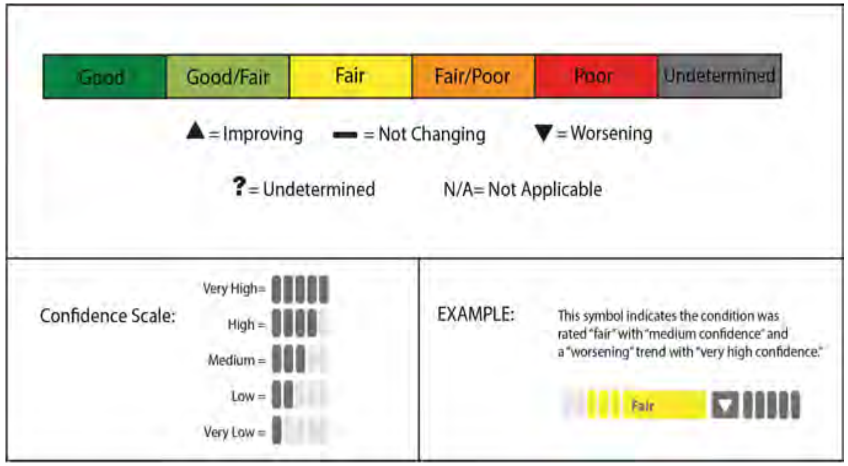
Figure S.P.5.1. Paddle-wheel shaft and flanges can be seen at the shipwreck site of the California Gold Rush Steamer *Winfield Scott*. Image: R. Schwemmer/NOAA

Figure S.P.5.2. Divers survey the 19th-century bark, *Goldenhorn*, lost in 1892. Photo: L. Murphy/National Park Service

Figure S.P.5.3. National Park Service volunteer diver examines damage likely caused by a vessel's anchor tackle at the site of the *Winfield Scott*. Photo: R. Schwemmer/NOAA

Figure S.P.5.4. During a 2016 monitoring survey of the fishing vessel *Equator* shipwreck site off Anacapa Island, a Pelorus navigation instrument was discovered and recorded. Photo: R. Schwemmer/NOAA

Driving Forces and Pressures Status and Trends



#	Issue	Rating	Basis for Judgment	Description of Findings
1	Drivers*	Fair ▼	Growing populations and per capita incomes in the counties adjacent to the sanctuary, in the U.S. generally, and in China, drive demand that promotes shipping and resource use; relative low, stable fuel prices further stimulate visitation.	Selected drivers are influencing pressures in ways that cause measurable resource impacts
2	Human Activities and Water Quality	Good/Fair ?	Some levels of human activities are decreasing, some are increasing, and some are stable. Few monitoring data sets exist. Evidence showing human activities have negatively affected water quality is sparse and inconclusive. Oil spill frequency and volume has generally decreased, apart from the 2015 Refugio Oil Spill. Short- and long-term oil spill impacts still need to be assessed. Vessel grounding impacts are localized to grounding site.	Some potentially harmful activities exist, but they have not been shown to degrade water quality.

3	Human Activities and Habitat	Fair ?	Consistent with 2009 findings, a number of human activities have localized impacts on sanctuary habitats i. Marine debris and vessel groundings continue to occur, while clean-up efforts also continue. Fishing activity has remained high, although changing gear types has resulted in reduced impact to benthic habitats. Visitation to the islands remains consistent.	Selected activities have caused measurable resource impacts, but effects are localized and not widespread or persistent.
4	Human Activities and Living Resources	Fair ▼	Consistent with 2009 findings, a number of human activities have measurable, localized impacts on living resources in the sanctuary and many of these activities are continuing at similar levels or increasing in intensity.	Selected activities have caused measurable living resource impacts, but effects are localized and not widespread or persistent.
5	Human Activities and Maritime Archaeological Resources*	Fair –	Impacts to maritime archaeological resources may result from site looting, injury by divers, vessel activity, and bottom trawling. Increases in education, enforcement, and trawling closures may allow for improvement.	Selected activities have caused measurable impacts to maritime archaeological resources, but effects are localized and not widespread or persistent.

** Note that a confidence score was not assigned to the Drivers question (1) or the Maritime Archaeological Resource question (5) because subject matter experts were not consulted on these ratings. Due to a limited number of experts in these fields, and Office of National Marine Sanctuaries (ONMS) in-house experts available, ONMS internally evaluated the Driver question (1) and the Maritime Archaeological Resource questions (5). Two socioeconomists with ONMS determined the Driver question rating. Two archaeological experts with the ONMS Maritime Heritage Program determined the Maritime Archaeological Resource question ratings; these subject experts have been monitoring existing archaeological sites since the 1980s, as well as recording new discoveries.*

STATE OF SANCTUARY RESOURCES

Water Quality (Questions 6–9)

The following information provides an assessment of the status and trends of key water quality indicators in CINMS from 2009 to 2016. Experts at the May 31, 2016 workshop discussed available water quality data (see Appendix D: Water Quality Graphs), assessed the status and trend for each condition report question, and rated their confidence in each assessment.[8] Supporting data were compiled from academic, private and public monitoring programs, and long-term oceanographic studies. A number of important indicators, however, did not have sufficient data and are therefore excluded from this report. In particular, information gaps in the sanctuary include non-point source pollution from commercial and private vessels, coliform and other contaminant levels throughout the water column and within higher trophic taxa, water quality data near oil platforms, and levels of other human activities.

The 2016 state of CINMS water quality is addressed in Questions 6–9. Eutrophic conditions, specifically concentrations of the limiting nutrients nitrate and phosphate, of sanctuary waters and their influence on primary production between 2009–2015 is the focus of Question 6. Eutrophication is the accelerated production of organic matter, particularly algae, usually caused by an increase in the amount of nutrients in surface waters. Eutrophication can impact the condition of sanctuary resources, for example by promoting nuisance and toxic algal blooms. In general, chlorophyll concentrations in regional waters have increased since 1997, and nutrient concentrations have increased at depth, but have been stable in surface waters apart from a recent decrease during an extreme warm water event. Typically, dissolved oxygen is an indicator of eutrophic conditions; however in the Santa Barbara region, the euphotic zone is generally oxic due to periodic influx of oxygenated water, mixing, and high primary production. In total, this means that sanctuary and surrounding waters are not strongly stratified. Deep water in the Santa Barbara Channel is characterized by anoxic and suboxic conditions; therefore, dissolved oxygen is assessed in relation to climatic drivers that influence levels of dissolved oxygen around the Channel Islands.

Question 7 focuses on parameters affecting public health and highlights the large harmful algal bloom (HAB) in 2015 that affected fisheries California-wide. Human health concerns arise with water, beach, and/or seafood contamination (bacteria or chemical). Indications of health impacts include beach and/or fishery closures and seafood consumption advisories.

Question 8 focuses on shifts in water quality due to climate drivers. The multi-year sea surface temperature (SST) anomaly that occurred from 2013–2016, a marine heat wave (hereinafter referred to as “the warm water event”), and the 2015–2016 El Niño event are discussed. Climate indicators include indices of large-scale climate patterns (e.g., Pacific Decadal Oscillation), water temperature, acidity, upwelling intensity and timing, and dissolved oxygen. Shifts in water temperature can affect species growth rates, phenology, distribution, and susceptibility to disease. Acidification can affect organism survival, growth, and reproduction. Upwelling influences oxygen content and nutrient cycling.

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[8] For additional information about the expert workshop and confidence scoring process, see Appendix B: Consultation with Experts and Document Review.

Question 9 assesses other biotic and abiotic stressors, individually or in combination, that may influence sanctuary water quality, but were not addressed in other questions. Examples include non-point source contaminants, and hard-to-quantify stressors that influence the condition of habitats and living resources. Such inputs may include industry discharges and emissions, fertilizers, pesticides, heavy metals, and sewage.

6. What are the eutrophic conditions of sanctuary waters and how are they changing?

Eutrophic conditions, an increase in the rate of supply of organic matter, naturally occur in the Santa Barbara Channel when a localized event, such as upwelling, results in abnormally high concentrations of nutrients in surface waters. Eutrophication can promote algal blooms, which sometimes result in high concentrations of toxins and subsequent negative impacts to fisheries, coastal ecosystems, and human health. Previously in 2009, eutrophic conditions in the sanctuary were rated good with an unchanging trend, primarily because coastal eutrophic conditions and/or runoff rarely reach the sanctuary's offshore location. This status and trend remain the same for 2016, good (very high confidence) and not changing (very high confidence), respectively. Experts agreed that eutrophication from point (e.g., sewage outfall) and non-point (e.g., runoff from episodic rain event) source mainland inputs to sanctuary waters remain infrequent and inconsistent, and therefore are of little concern for sanctuary water quality.

The following provides updated information for water quality parameters related to eutrophication, including nitrate, phosphate, and chlorophyll concentrations, and terrestrial and anthropogenic nutrient inputs (see Appendix D: Table App.D.6.1). The first four of these parameters were assessed using multiple data sets from various regional locations.

The cool California Current from the north meets the warmer California Countercurrent at the Channel Islands; therefore, temperatures increase as one moves east in the sanctuary (Figure S.WQ.6.1(a)). Since

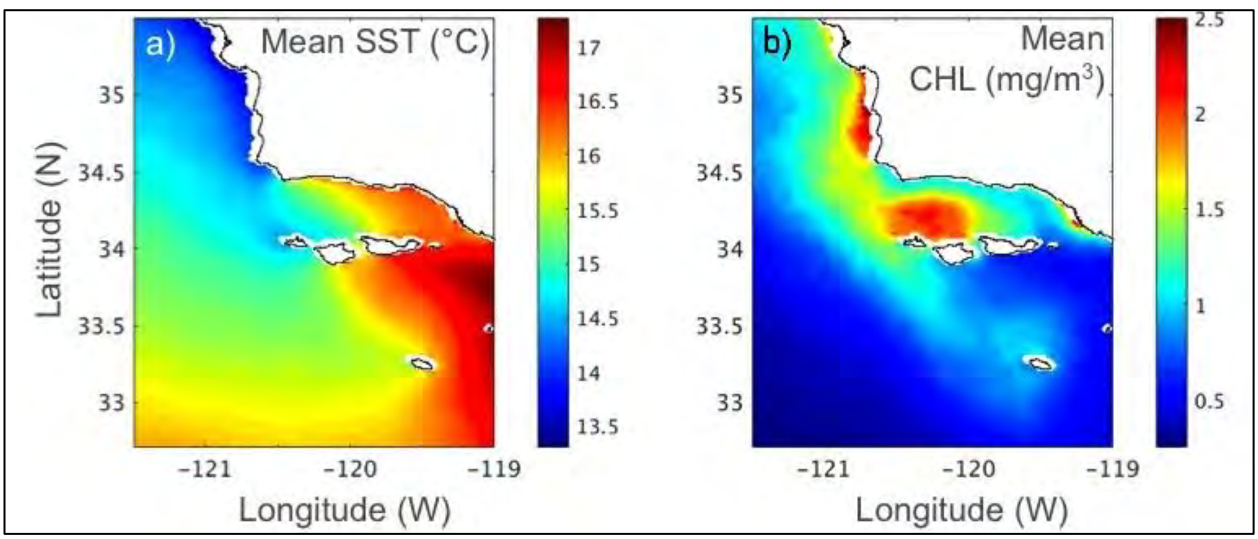


Figure S.WQ.6.1. (a) Composite average sea surface temperature (°C) from Advanced Very High Resolution Radiometer (AVHRR) (1997–2000), Moderate Resolution Imaging Spectroradiometer (MODIS)-Terra (2000–2015), and MODIS-Aqua satellite data (2002–2015). (b) Composite average chlorophyll (CHL) values (mg/m3) for the northern Channel Islands region from SeaWiFS (1997–2010), MODIS-Aqua (2002–2015), Medium Resolution Imaging Spectroradiometer (MERIS) (2002–2012), and Visible Infrared Imaging Radiometer Suite (VIIRS) satellite data (2013–2015). Data Source: NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group. MODIS, MERIS, SeaWiFS, VIIRS: https://oceancolor.gsfc.nasa.gov/. NOAA AVHRR: http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdATssta8day.html. Figure: Henderikx Freitas et al. 2017

1996, chlorophyll concentrations appear to be increasing in the mid-Santa Barbara Channel, with pulses of chlorophyll blooms becoming more frequent starting in 2000 (see Appendix D: Figure App.D.6.2(a)); this is consistent with Kahru et al. (2012) who showed increasing chlorophyll in central California from a merged ocean color product from 1996 to 2011. Some of these blooms have resulted in toxic conditions, particularly the 2015 HAB (see Question 7 in this section). Recent extreme warm water anomalies (see *The Warm Water Event* and Question 8 in this section) induced strongly negative chlorophyll anomalies, anomalously deep chlorophyll maxima (Zaba and Rudnick 2016,) and dramatic impacts on species abundance and distributions throughout the marine food web (Leising et al. 2015, Cavole et al. 2016).

The availability of nitrate and phosphate typically play a key role in limiting primary production in the euphotic zone. In the Santa Barbara Channel, nitrate is most often the limiting factor (Zimmerman and Kremer 1984). Between 1997 and 2015, nitrate values in mid-channel ranged 0–30 micromole per liter (μmol/L), and phosphate concentrations ranged 0–2.5 μmol/L. Concentrations of each at depth have gradually increased over time, but have been stable in surface waters (see Appendix D: Figures App.D.6.5(a) (nitrate) and App.D.6.6(a) (phosphate)). A disruption to this stability began in December 2013 with the warm water event (see *The Warm Water Event*), when temperature increased and mixing decreased. Particularly in 2014 and 2015, the water column was strongly stratified and upwelled nutrients were reduced relative to concentrations in the four years prior (see Appendix D: Figures App.D.6.5(b) and App.D.6.6(b)). This inverse relationship between temperature and nitrate was most pronounced in shallow (7–10 meters) nearshore water along the mainland-side of the channel (Figure S.WQ.6.2).

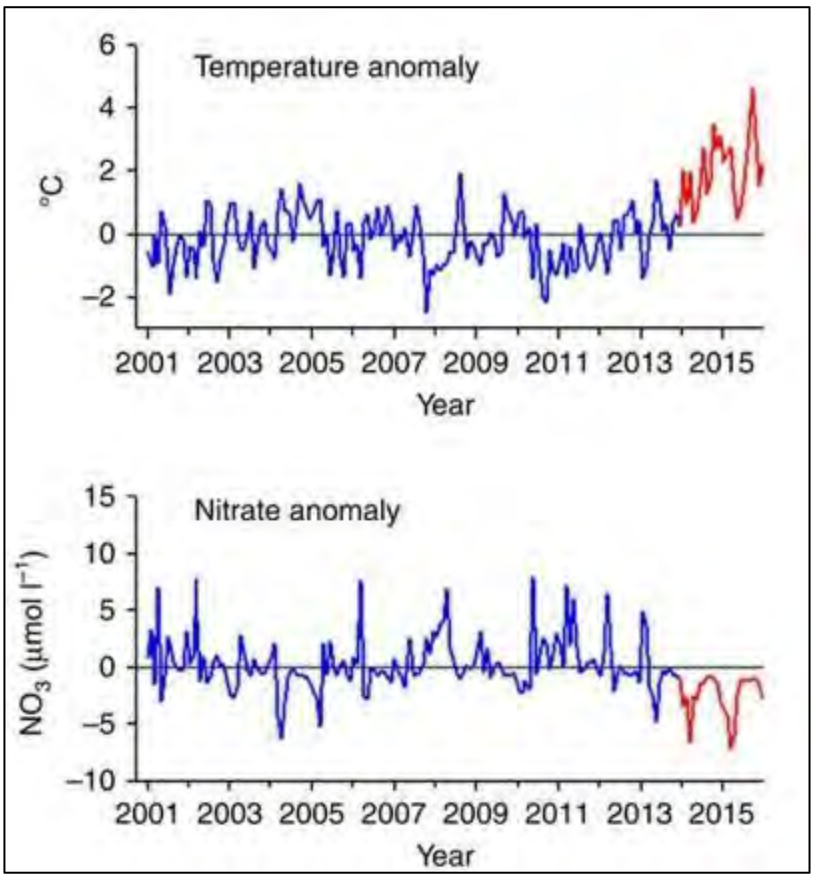


Figure S.WQ.6.2. Monthly anomalies in (top panel) observed bottom temperature (°C) at 7–10 meters depth and (bottom panel) modeled bottom nitrate concentrations (μmol/L) at 7–10 meters depth along the Santa Barbara Channel mainland nearshore (nine sampling sites roughly spanning from Gaviota east to Ventura). The anomalously warm years of 2014–2015 are shown in red. Similar trends were seen at the islands. Data source: Santa Barbara Coastal Long-term Ecological Research; Figure: Reed et al. 2016 Note: This figure was unavailable for expert review during the workshop; however a representative from the monitoring program was present at the workshop and discussed the data.

At the time of the expert workshop in May 2016, extreme warm water anomalies had not fully dissipated. It is unknown if the regional marine heat wave phenomenon will reoccur, and if so, at what frequency. Recent research suggests that North Pacific decadal variability under greenhouse forcing (i.e., climate change) will intensify and continue to produce warm water events like from 2013 to 2016 (Di Lorenzeo and Mantua 2016). Currently, it is premature to predict if and when temperature, chlorophyll and nutrient levels in the Santa Barbara Channel will stabilize or resume their previous trends. Continued monitoring and targeted research is critical to describe water quality conditions over time.

Since 2012, California has been experiencing extreme drought conditions and rain events have been rare. When they occur, freshwater runoff containing land sediments, known as plumes, may contribute to nutrient-loading and episodic eutrophication events in the channel (Otero and Siegel 2004). Such plumes generally do not reach sanctuary waters, but can affect mobile species that rely on regional pelagic habitat.

Other episodic coastal water eutrophication events can result from non-point pollution, groundwater drainage, sewage outfalls, industrial non-point pollution, and/or inputs from ephemeral streams and mainland runoff. For example, Santa Clara River watershed runoff events disperse nutrients 10s of kilometers into the Santa Barbara Channel (see Pressures: Figure DP.P.1) with nitrate to phosphate ratios (N:P) of 5:1, compared to upwelled N:P of 10:1 (Warrick et al. 2005). Overall, mainland nutrient inputs contribute little to the annual nutrient budget for the channel.

The islands themselves have minimal development and provide little anthropogenic nutrient enrichment to sanctuary waters. There are biological sources of nutrients from the islands, including fecal matter from increasing pinniped populations (e.g., sea lions) and seabird nesting sites (see Appendix F: Figures App.F.13.6, App.F.13.7, App.F.13.23–13.27). Although discharge from untreated sewage is prohibited throughout the sanctuary, some vessels visiting or transiting through the sanctuary may discharge unknown amounts of untracked nutrients, including from marine sanitation devices providing varying levels of waste treatment, or the release of untreated human waste from holding tanks or overboard discharge. Compliance with the sanctuary's discharge regulation, especially for sewage waste, is difficult to measure. Additional information would be needed to estimate the level of illegal, localized discharge in sanctuary waters.

7. Do sanctuary waters pose risks to human health and how are they changing?

The 2009 status and trend rating for sanctuary water quality's influence on human health was good/fair and not changing as there were no known occurrences of health problems related to water contact or seafood consumption near the islands; since there was potential for human risks, experts did not give a rating of good. Specifically, there were no human illness cases reported from amnesic shellfish poisoning (ASP), paralytic shellfish poisoning (PSP), nor diarrhetic shellfish poisoning (DSP) in Santa Barbara County, since commercial shellfish are highly regulated by the California Department of Public Health. Certain diatom (e.g., *Pseudo-nitzschia* spp.) blooms can lead to accumulation of domoic acid in shellfish, and when affected seafood is consumed by humans, ASP symptoms can occur. Similarly, PSP or DSP symptoms can occur when humans consume seafood contaminated with toxins produced by dinoflagellate algae and/or cyanobacteria. These potential threats are closely monitored by the California Department of Public Health and the Integrated Ocean Observing System regional associations, Southern California Coastal Observing System (SCCOOS), and Central and Northern California Ocean Observing System (CeNCOOS). Additional efforts at University of California Santa Barbara, University of California Santa Cruz, and the University of South Carolina have provided offshore bloom monitoring for the Santa

Barbara Channel since 2009. The 2016 status is also rated good/fair and not changing (medium confidence for both ratings) for the same reasoning as in 2009 — there are no known related human illness cases, but the potential for negative impacts to human health remains.

The following provides updated information on the status of water quality parameters that reflect a possible impact to human health in the region, with a focus on HABs and related neurotoxins in shellfish (e.g., domoic acid) (see Appendix D: Table App.D.7.1).

Along the central California coast, spring and summer upwelling brings macro and micronutrients to the surface, supporting mixed-assemblage diatom blooms that include *Pseudo-nitzschia multiseries* and *Pseudo-nitzschia pseudodelicatissima*. These two species of *Pseudo-nitzschia* produce domoic acid, a potent neurotoxin that can accumulate up the food chain and cause ASP when affected seafood is consumed by humans. Since 2000, the Santa Barbara Channel has been a hotspot for seasonal *Pseudo-nitzschia* blooms and other HAB activity in the Southern California Bight, as HABs have increased in frequency, spatial distribution, and toxicity (Anderson et al. 2009, Anderson et al. 2011, Sekula-Wood et al. 2011). Blooms usually occur during spring and sometimes fall upwelling (cold water, high nutrients) periods; however, in May 2015 during the warm water event (see *The Warm Water Event*), there was an unprecedented *Pseudo-nitzschia* bloom that stretched from the Gulf of Alaska to the Channel Islands (Figure S.WQ.7.1). Although *Pseudo-nitzschia* blooms do not normally occur during warm water months off central California, the anomalously warm water seemed to enable *P. australis* cells to grow quickly and outcompete other phytoplankton species, fueled by pulses of moderate nutrients during sporadic coastal upwelling events (McCabe et al. 2016). Recent research shows that over the past approximately 20 years, the timing of elevated domoic acid along the U.S. West Coast is strongly related to warm phases of the Pacific Decadal Oscillation (see Question 8 in this section) and the Oceanic Niño Index. Scientists predict that as the frequency of anomalously warm ocean conditions increase, so will HABs (Krause et al. 2013, Cavole et al. 2016, McKibben et al. 2017).

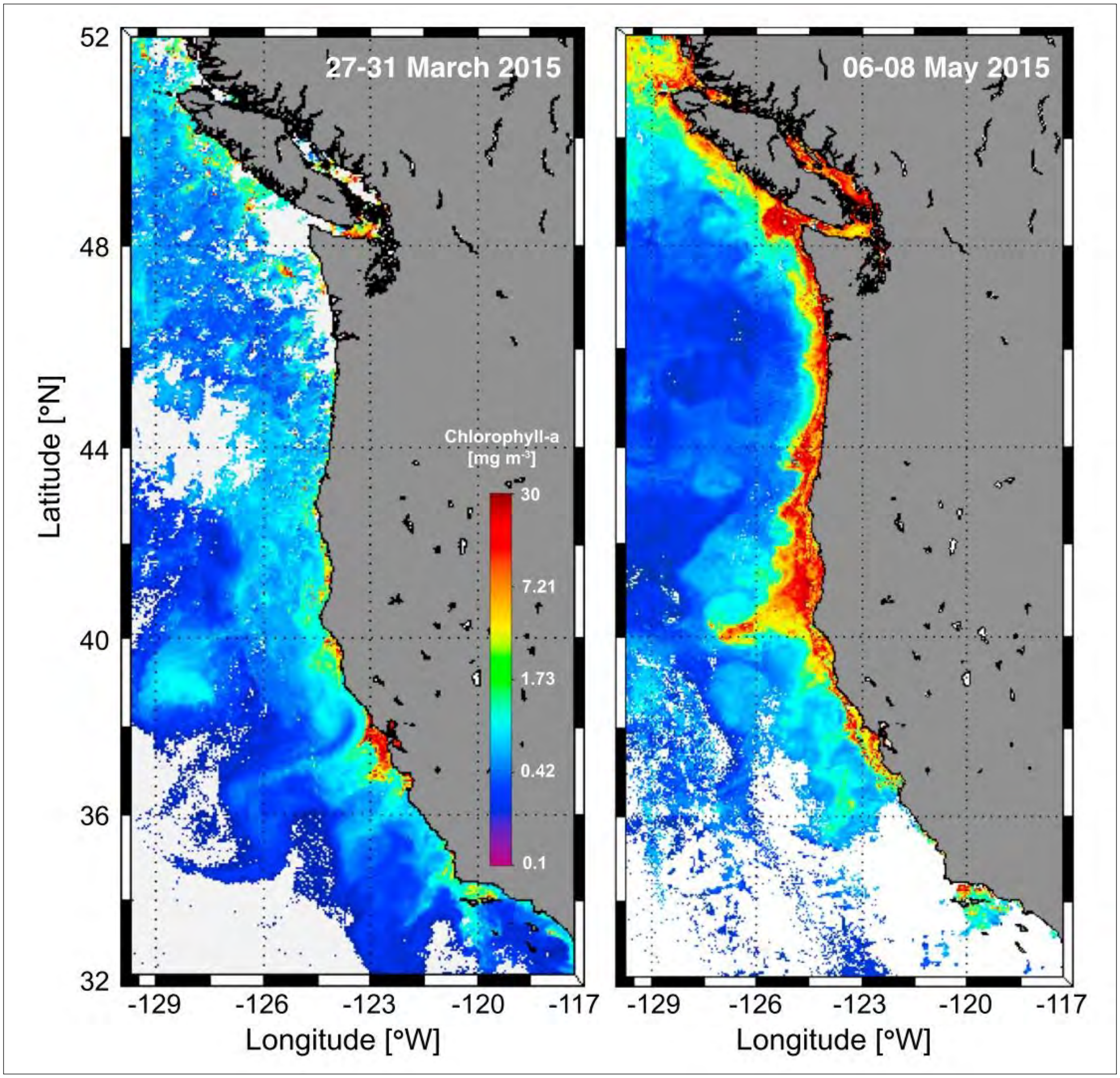


Figure S.WQ.7.1. In May 2015, an unprecedented West Coast-wide harmful algal bloom (HAB) extended from the Gulf of Alaska to southern California. The bloom was composed of *Pseudo-nitzschia*, a toxigenic diatom that has the ability to produce domoic acid, a potent neurotoxin that can cause amnesic shellfish poisoning (ASP) and threaten human health if affected shellfish are consumed. These satellite images show chlorophyll-a estimates averaged over the periods of March 27–31, 2015 (left panel), and May, 6–8, 2015 (right panel). Data source: Satellite data were obtained from the National Aeronautics and Space Administration Ocean Biology Processing Group (OBPG) using a combination of the MODerate resolution Imaging Spectroradiometer (MODIS) on Aqua and Visible Infrared Imaging Radiometer Suite (VIIRS) chlorophyll products. Data were processed using standard OBPG processing with 4 kilometer imagery. Figure: McCabe et al. 2016

The toxic bloom continued into 2016 and resulted in the largest outbreak of domoic acid ever recorded along the West Coast of North America (McCabe et al. 2016). The highest particulate domoic acid levels across the bloom were measured in the Santa Barbara Channel at 19,978 nanogram per liter (ng/L) (about 0.02 parts per million [ppm]) (Figure S.WQ.7.2). Current (2016) California Department of Public Health and U.S. Food and Drug Administration action levels for domoic acid in seafood are ≥ 20 ppm in all seafood, except ≥ 30 ppm in viscera (i.e., guts) of Dungeness crab. When these levels are met or exceeded, closure of harvest areas and/or evisceration (i.e., removal of internal organs, especially those in the abdominal cavity) of contaminated seafood are considered management actions.

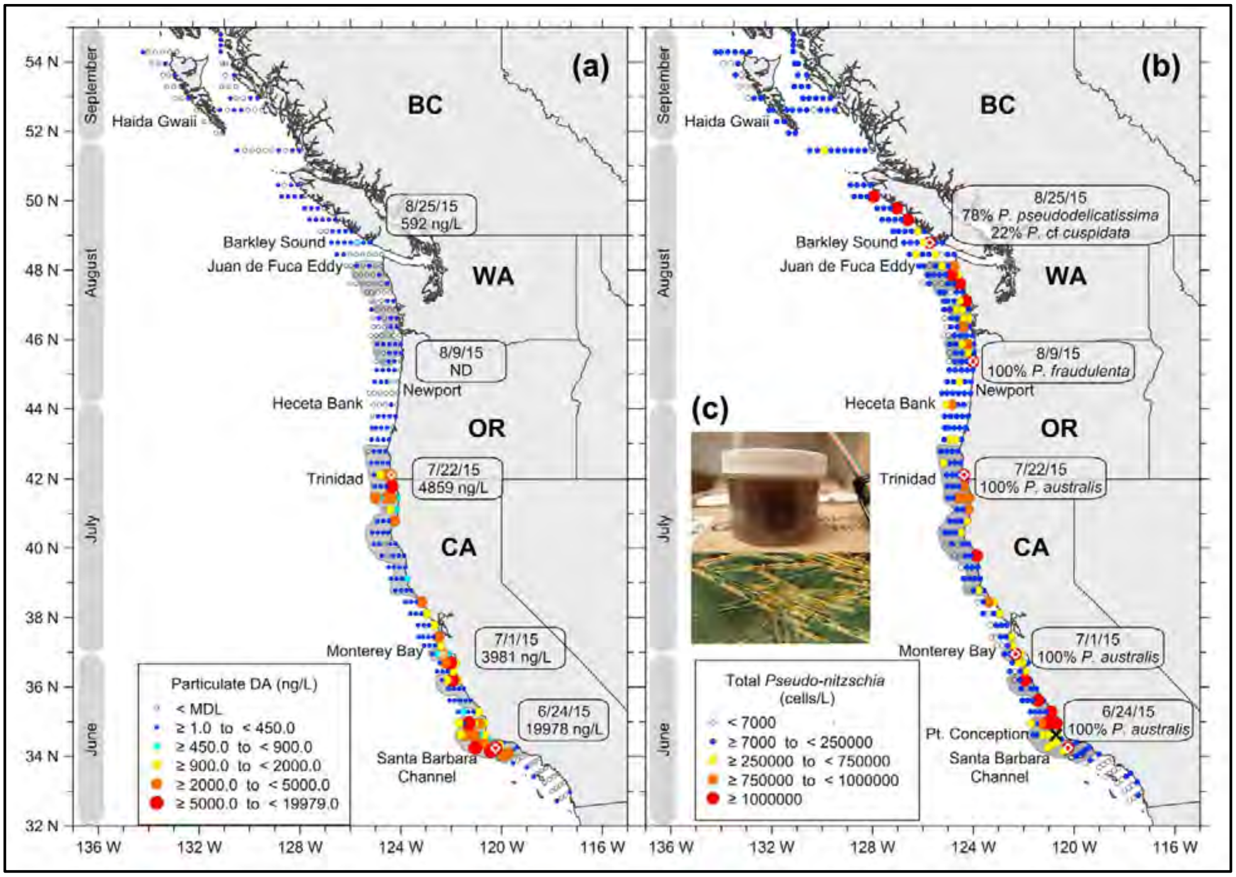


Figure S.WQ.7.2. (a) Particulate domoic acid (pDA) and (b) *Pseudo-nitzschia* abundance in surface (3 meter) seawater samples collected aboard the NOAA ship *Bell M. Shimada* from June through September 2015 (months shown in shaded boxes, left side of both panels). Red "targets" in (b) are locations where representative pDA and *Pseudo-nitzschia* abundances are shown on select dates in adjacent boxes. Gray shading along the coast indicates regions where *Pseudo-nitzschia* was the dominant phytoplankton. (c) A Bongo net tow sample off Point Conception on June 24, 2015 (concentrated sample, top panel; microscopic image of approximately 100X diluted sample at 200X magnification, bottom panel). ND = not detected. Highest domoic acid levels from the bloom were identified within the Santa Barbara Channel (19,978 ng/L), but no known related human illness cases were reported. Figure: McCabe et al. 2016

High toxin levels in surface waters remained long after the *Pseudo-nitzschia* bloom subsided posing a threat to local fisheries and the entire food web. As a result, from November 2015 to March 2016, California Department of Public Health closed rock crab recreational and commercial fisheries from offshore Santa Barbara County and north, including around the Channel Islands (OST 2016a, CDFW 2015, CDFW 2016c). There were no known HAB-related human shellfish poisoning cases at the time of the expert workshop however, all along the West Coast in 2015, there were a number of marine mammals that stranded with domoic acid poisoning, which marked the largest geographic extent of domoic acid detection in marine mammals ever recorded globally (see Appendix D: Figure App.D.7.2). Dating back to 2003, domoic acid poisoning is believed to have caused periodic mass stranding events for marine mammal and seabird populations in the Santa Barbara Channel. In addition to anomalous warm water and domoic acid poisoning in 2015, marine mammal populations were also impacted by reduced available prey resources.

Other water quality factors that could impact human health include elevated coliform levels and pathogens. Both may be influenced by growing pinniped communities, seabird nesting sites, and vessel discharge, but measurements in the sanctuary have not been taken with enough frequency to assess potential threats to public health. Improved future monitoring could help managers track these risks and initiate health advisories when necessary.

8. Have recent changes in climate altered water conditions and how are they changing?

In the 2009 condition report, a variation of this question was assessed which read, "Are specific or multiple stressors, including changing oceanographic and atmospheric conditions, affecting water quality?" At that time, the status was good/fair, but the trend was undetermined due to lack of data. In regards to climate, the 2009 report stated that "the effects of global climate change are not well understood but could adversely affect water quality through changes in ocean chemistry, seawater temperature increases and changes in upwelling and oceanographic condition."

The current status of climate stressors is rated as fair (medium confidence), with a worsening trend (medium confidence) due the impacts of the 2013–2016 unprecedented sea surface temperature (SST) anomaly known as "the warm water event" (see *The Warm Water Event*), as well as concerns about dissolved oxygen (DO) decreasing and ocean acidification (OA) increasing with ocean temperatures. The following provides updated information on climate parameters that influence sanctuary water quality, such as SST anomalies, pH, and DO (see Appendix D: Table App.D.8.1).

Over long time scales (years to decades), SST and productivity off California, particularly in the Southern California Bight, reflects El Niño-Southern Oscillation patterns (ENSO) (approximately three to seven years between periods of warming and cooling), North Pacific Gyre Oscillation (NPGO) (approximately three to seven years), and Pacific Decadal Oscillation (PDO) (upwards of two to three decades) (Figures S.WQ.8.1 and Appendix D: Figure App.D.8.2). ENSO includes El Niño (warming) and La Niña (cooling) phases, interspersed among "neutral" conditions. The Oceanic Niño Index (ONI) is positive during El Niño and negative during La Niña, outside of neutral conditions between -0.5 and 0.5. The NPGO Index reflects currents and upwelling specific to Northeast Pacific conditions (Di Lorenzo et al. 2008). Positive NPGO values indicate stronger currents and higher productivity, and negative NPGO values indicate weaker currents and lower productivity. Finally, PDO indicates warm (positive) and cool (negative) sea surface temperature regimes in the North Pacific Ocean.

Since 1997, surface water (0–5 meter) temperatures in the mid-Southern California Bight ranged from 12 to 20°C (see Appendix D: Figure App.D.8.4(a)). In 2009, PDO was in a cool regime, indicating high productivity and upwelling (Figure 8.1, middle panel). That year, the Southern California Bight experienced moderate El Niño conditions, followed by weak-moderate La Niña conditions from 2010 to 2012, with notably high productivity during winter (i.e., January, February, and March) 2010. In 2014, PDO shifted to a warm regime, indicating low productivity and weaker currents. The 2015–2016 El Niño was considered very strong (Figure S.WQ.8.1, top panel), although its effects were muted in California waters (Jacox et al. 2016).

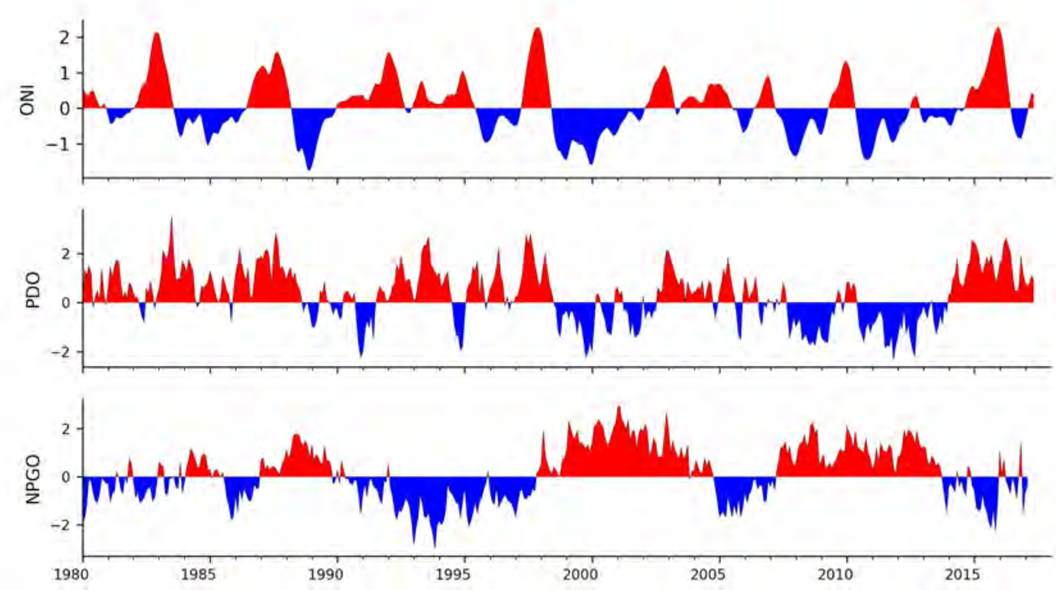


Figure S.WQ.8.1. Three indices of climate and ocean conditions in the North Pacific Basin shifted in 2014 from conditions promoting high primary productivity to less productive conditions. The Oceanic Niño Index (ONI) indicates the presence/absence of El Niño conditions with positive anomaly values (red) denoting El Niño conditions and negative values denoting La Niña conditions, outside of "neutral" conditions between -0.5 and 0.5. The Pacific Decadal Oscillation (PDO) Index is related to North Pacific sea surface temperature with cold regimes (blue) associated with higher productivity and warmer regimes (red) associated with lower productivity. The North Pacific Gyre Oscillation (NPGO) is influenced by sea level and circulation patterns. Positive values of the NPGO (red) are linked to stronger currents and higher productivity while negative values (blue) are linked to weaker currents and lower productivity. The graphs show the long-term mean (0) ± 3.0 standard deviations based on the full time series. Data source: NPGO data from http://www.o3d.org/npgo/; PDO data from http://jisao.washington.edu/pdo/; ONI data from http://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php. Figure: I. Schroeder/ NMFS SWFSC.

In addition to the cyclic regimes discussed above, a 2013–2016 warm water event coupled with the 2015–2016 El Niño altered water quality in an unprecedented way (see *The Warm Water Event*). Anomalous warming peaked at 5°C above normal in 2014 and 2015 in the Santa Barbara Channel (Zaba and Rudnick 2016), and 5.8°C in nearshore (mainland) shallow water in 2015 (7–10 meters deep, see Figure S.WQ.6.2(a)). Congruent with these anomalously warm years, nutrient availability, chlorophyll levels, and dissolved oxygen in channel surface waters were low. While the 2015–2016 El Niño was most pronounced south of Point Conception and had peak SST anomalies similar to the 1997–1998 strong El Niño (as high as 2.3°C above average SST, Figure S.WQ.8.2), it had a weaker subsurface signal than previous strong El Niño events (e.g., 1982–1983, 1997–1998) (Jacox et al. 2016). In sum, prolonged low primary production during 2016 was mostly due to the warm water event, not from El Niño. As climate changes, it is unknown if marine heat waves will become regular occurrences or if this was a one-time phenomenon; however, evidence from recent research and other temperate regions suggest the former (Oliver et al. 2013; Di Lorenzo and Mantua 2016).

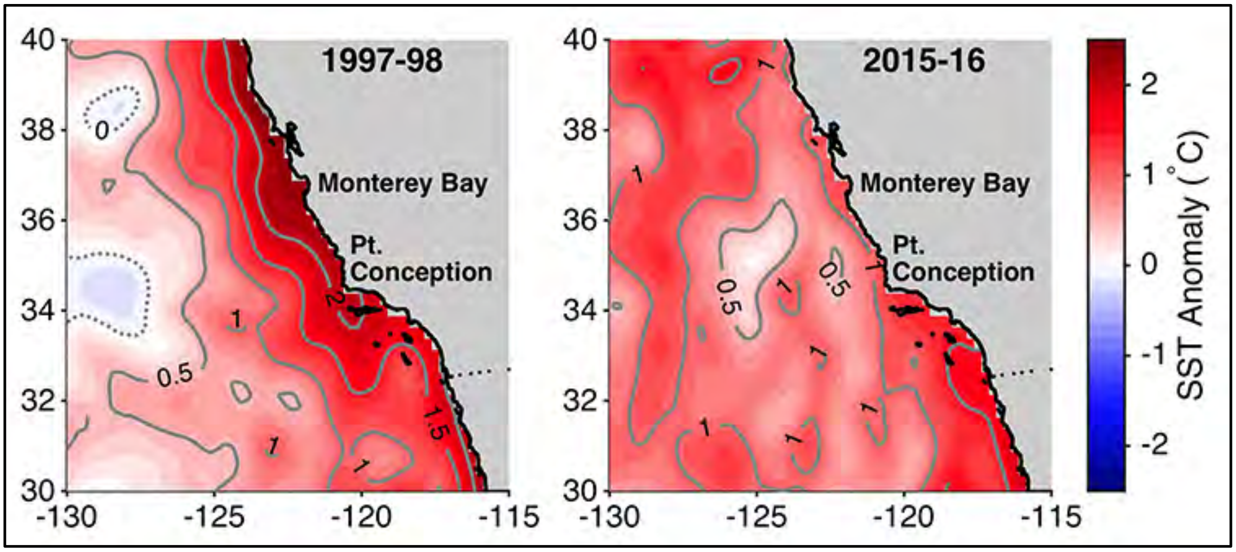


Figure S.WQ.8.2. December to February mean sea surface temperature (SST) anomalies for the winters of 1997–1998 and 2015–2016, the last two major El Niño events. Anomalies were calculated using NOAA's 0.25° Optimum Interpolation Sea Surface Temperature (OISST) product with a 1981–2015 base period. The Channel Islands are shown in black and are roughly located at 34°N and 119°W. Equatorial Pacific temperature anomalies were characterized using the Niño 3.4 Index (http://www.cpc.ncep.noaa.gov/data/indices/), calculated using Extended Reconstructed Sea Surface Temperature v4 with five-year centered base periods to remove any long-term trends, and 20° C isotherm depth anomalies, averaged from 2°S to 2°N, from the Global Ocean Data Assimilation System. Figure: Jacox et al. 2016

Circulation, ventilation, air-sea exchange, production, and respiration influence dissolved oxygen (DO) concentrations in the ocean (Bograd et al. 2008). In the Southern California Bight, DO has been declining since 1984 (Appendix D: Figure App.D.8.8); there are two potential reasons for the decline. One is a reduction in the downward transport of well-oxygenated surface water via the biological pump, a term describing the flux of organic material from the surface to deep water and bottom sediments. SST warming reduces the efficiency of the biological pump and increases the stratification of the water column, which leads to the shallowing of the oxic-hypoxic depth and the rate at which the ocean can absorb atmospheric carbon dioxide (Keeling and Garcia 2002). A second reason is the advection of new, low DO source water from the Pacific equatorial region into the Southern California Bight (Bograd et al. 2015). The new Pacific equatorial source water is warmer, saltier, oxygen-poor, acidic, and more nutrient-rich compared to historic California Current source water, and its advection has begun to change the Southern California Bight's water properties (Meinvielle and Johnson 2013). Estimates of DO decline per year (1980–2012) range from 0.8 up to 1–2 µmol/kg, with the largest relative DO declines occurring in mid-water, below the thermocline (e.g., mean decrease of 21 percent at 300 meters) (Bograd et al. 2008, Koslow et al. 2011, Meinvielle and Johnson 2013, Bograd et al. 2015). Since 2009, DO levels within sanctuary surface waters have remained oxic (>1.43 milliliters per liter [mL/L] [Grantham et al. 2004], Appendix D: Figure App.D.8.9) and have not posed a threat to CINMS water quality. However, scientists warn that in general, further warming, increased stratification, reduced ventilation, and expansion/shoaling of the equatorial Pacific oxygen minimum zone could lead to continued DO declines off California (Schmidtko et al. 2017).

Seawater pH was not formally included in the 2009 condition report because, at the time of assessment, there was a lack of time-series pH data in the California Current. Since 2009, there has been ongoing ocean acidification research in the sanctuary and elsewhere. It has been hypothesized that with the gradient of temperature (1–4°C) and upwelling, pH increases from west to east across the sanctuary

(Harms and Winant 1998); however, upwelling at the islands is weaker than north of Point Conception, and despite the strong temperature gradient, in-situ observations across the sanctuary do not show a strong west to east pH gradient (Kapsenberg and Hofmann 2016). This suggests that the northern Channel Islands may serve as a biogeographic refuge from extreme upwelling and other low pH (< 7.7) events (Kapsenberg and Hofmann 2016). Between 2012 and 2015, sanctuary pH values were generally greater than 7.9, with fewer low pH events than what the nearby mainland experienced (Kapsenberg and Hofmann 2016).

Ocean acidification results in decreased pH and lower carbonate ion concentrations that can adversely affect the growth and development of shell-forming organisms (e.g., bivalves) (Feely et al. 2008, Bednaršek et al. 2014, Busch and McElhany 2016, Hodgson et al. 2016, Marshall et al. 2017). Aragonite is a soluble form of calcium carbonate used by many marine organisms to form hard structures (e.g., coral) via calcification (Ries et al. 2010). Monitoring the saturation state of aragonite, in addition to pH, is critical to better understand how decreases in carbonate ion concentration will inhibit calcifiers from thriving, particularly juveniles and deep-sea corals (Cao et al. 2014a, Kapsenberg et al. 2017). Additionally, ocean acidification has been linked to harmful algal blooms (OST 2016b).

Scientists believe there are two drivers of ocean acidification in the California Current ecosystem. One is the significant increase of atmospheric carbon dioxide (CO_2), and therefore dissolved CO_2 (pCO_2) in seawater (see Appendix D: Figure App.D.8.13(b)). The other is climatic forcing, an increase in alongshore wind stress, which induces coastal upwelling and increases dissolved inorganic carbon in surface waters (Turi et al. 2016). In effect, as CO_2 increases in water, pH decreases. Climate change is expected to increase the duration and strength of upwelling (Wang et al. 2015). Under current projected rates of climate change to the year 2500, when atmospheric CO_2 concentration reaches 1,962 parts per million (ppm), global ocean pH is projected to decrease by approximately 0.33 and aragonite saturation state (Ω) to decrease by ~0.56 for each °C of ocean warming (Cao et al. 2014b). Rates of change and how organisms respond to acidification will vary at regional scales and require monitoring (Hofmann et al. 2014, Kapsenberg et al. 2017).

The northern Channel Islands experience seasonal coastal upwelling and primary production, and therefore seasonal fluctuations in seawater pH. On shorter time scales, episodic phytoplankton blooms, seagrass and kelp biomass, daily cycles of kelp/eelgrass respiration, temperature, and changes in wind direction and upwelling influence pH variability (Kapsenberg and Hofmann 2016). As such, upwelling systems have inherent seasonal drops and variability in pH (late winter and spring for CINMS, Figure S.WQ.8.3(a)), and therefore overall have low-pH conditions relative to other ecosystems (Kapsenberg and Hofmann 2016). Some believe this dynamic makes these systems particularly vulnerable to ocean acidification (Feely et al. 2008). Others argue that organisms that have evolved and thrive under such variability are well equipped to handle changes in ocean chemistry (Hofmann et al. 2014, Reum et al. 2014, Marshall et al. 2017).

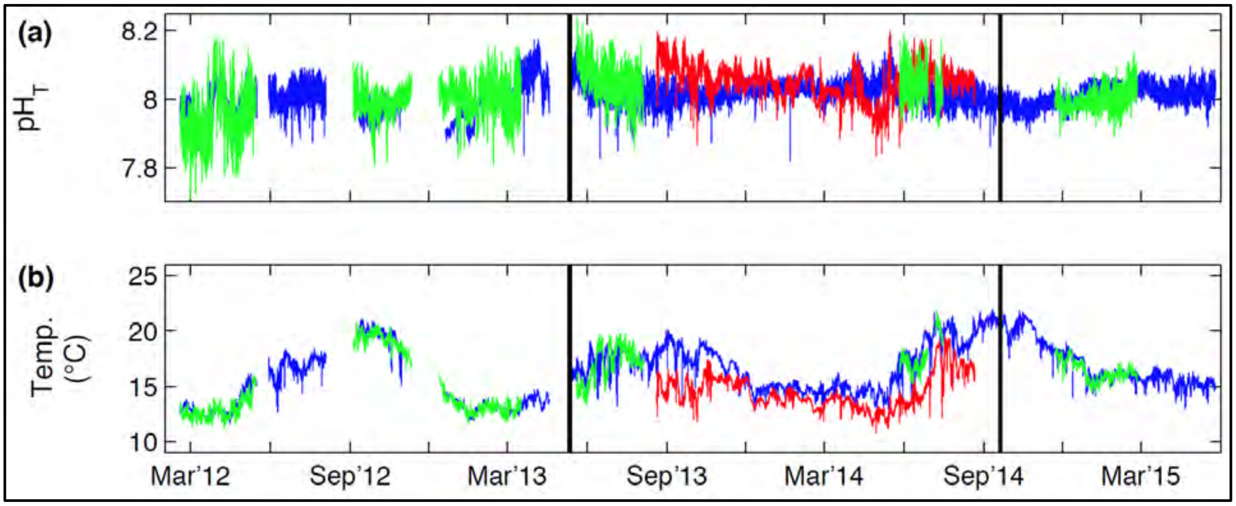


Figure S.WQ.8.3. (a) pH and (b) temperature (°C) measured across the northern Channel Islands and in different habitat types, from east to west: Anacapa Island (blue, kelp forest), San Miguel Island (red, subtidal mooring), and Santa Cruz Island (green, eelgrass bed). Deployment period of Conductivity, Temperature, Density, and Oxygen (CTDO) sensors is marked by solid vertical lines. Figure: Kapsenberg and Hofmann 2016

While the sanctuary has experienced a ~0.02 per decade pH decline since 1979, the decline is less dramatic than declines in other parts of the California Current north of Point Conception, such as nearshore northern California and Oregon (Turi et al. 2016). This reduced ocean acidification effect aligns with the current hypothesis that shallow sanctuary waters, particularly kelp and eelgrass communities, sequester carbon and serve as local buffers for changing chemistry (Nielsen et al. 2018). Kapsenberg and Hofmann (2016) report that ocean acidification rates are slower at the islands than in coastal waters, and they predict it will take Anacapa Island three times as long (i.e., 40 years) to experience an anthropogenic signal of ocean acidification (detection of a trend forced by human activities in surface alkalinity) compared with the open ocean (see Appendix D: Figure App.D.8.14). It is unknown how ocean acidification will affect deep-water sanctuary habitats (≥ 40 meters), important habitat for vulnerable deep-water corals and other invertebrates. Efforts should be made to fill these knowledge gaps and to explore if and how ocean acidification refugia benefit the entire sanctuary (e.g., blue carbon).

9. Are there other stressors, individually or in combination, affecting water quality and how are they changing?

To distinguish the human activities discussed in Question 9 and Question 2, Question 9 is focused on "other stressors" (which may result from human activity) that are hard to quantify and/or that have indirect impacts (e.g., vessel discharges), while Question 2 is focused on human activities with direct, measurable impacts (e.g., vessel groundings). Known stressors influencing water quality include deposition of heavy metals, current and legacy agricultural use of pesticides, marine debris, and increased prevalence of plastics.

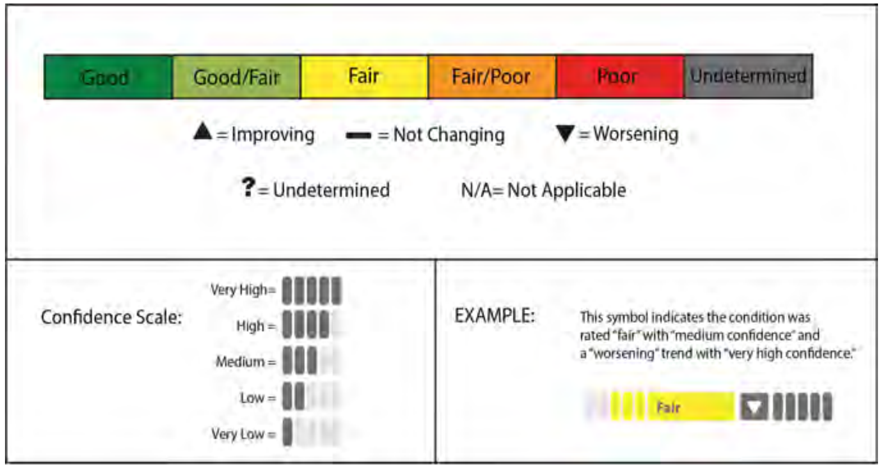
In 2009, "other stressors" were grouped with oceanographic and atmospheric conditions. Conversely, this report separates climatic drivers of water quality conditions (see Question 8) and other stressors (this question). In 2009, the combined question about multiple/all stressors received a rating of good/fair. Experts felt that anthropogenic stressors, such as vessel discharges, persistent contaminants (e.g., DDT), and mainland land runoff, had little effect on sanctuary waters, primarily due to the Santa Barbara Channel buffering the islands from mainland activities. The trend was undetermined because many parameters lacked monitoring data. The current rating for other (indirect) stressors that affect sanctuary water quality, individually or in combination, is undetermined (medium confidence) with an undetermined trend (medium confidence) because again, there is a general lack of information about indirect stressors, and if and how they interact to influence water quality. It is still believed that the sanctuary's offshore location buffers the water quality issues experienced near the mainland; however certain wind and circulation conditions can transport contaminated coastal waters to the sanctuary. The following provides updated information on the status of other stressors that influence sanctuary water quality (see Appendix D: Table App.D.9.1).

Quantitative estimates of contaminant levels in sanctuary waters are limited, as most studies have focused on concentrations in sediments and animal tissue (see Question 11 in Habitat Section). Mesoscale eddies periodically form within the Santa Barbara Channel and may trap or circulate contaminants on the order of a few days to several weeks (Brezinski and Washburn 2011). Upwelling is another major driver of mass water movement in the Santa Barbara Channel and in turn, a potential method for transporting contaminants.

Studies on the ratio of microplastics to phytoplankton and zooplankton across the California Current are few; however the stressor is believed to be widespread. Microplastics are present and assumed to be pervasive in the California Current (see Appendix D: Figure App.D.9.1). Gilfillan et al. (2009) measured microplastics in California Cooperative Oceanic Fisheries Investigations (CalCOFI) water samples in 1984, 1994, and 2007 and found they were present in over 50 percent of samples and equally common in coastal waters as offshore (see Appendix C: Figures App.C.4.15 and App.C.4.16). Additional locally focused plastics and debris studies are needed to update historical data, and to understand current and future implications for sanctuary water quality and living resources.

Air emissions and liquid discharge from anthropogenic sources, such as shipping, industry, cars, etc., can influence the sanctuary's water quality via deposition and biophysical and chemical cycling. The Santa Barbara Channel has ≥ 3,000 commercial ship transits a year, and is a throughway for ships traveling to/from two of the world's largest ports, Port of Long Beach and Port of Los Angeles, and this traffic contributes up to 50 percent of the region's air pollution. Information regarding depositions, ballast water and illegal waste discharge, contaminants, and nonpoint source pollution from industrial and agricultural sources remain lacking since 2009. Research on these stressors and how they influence sanctuary water quality would support a stronger assessment during the next condition report.

Water Quality Status and Trends



#	Issue	Rating	Basis for Judgment	Description of Findings
6	Eutrophic Conditions	Good	Mainland eutrophic conditions generally do not reach islands due to their distance from shore. Extreme episodic events may cause inputs to reach the islands. There are also localized inputs, such as marine mammals and seabirds, and vessel discharges. Nitrate and phosphate concentrations have gradually been increasing at depth, but have been stable in surface waters — apart from 2013–2016 when surface nutrients decreased in response to anomalous warm water and reduced mixing. Typically, chlorophyll decreases when temperatures spike seasonally.	Eutrophication has not been documented, or does not appear to have the potential to negatively affect ecological integrity.
7	Human Health Risks	Good/Fair	Presence of *Pseudo-nitzschia* is cyclic and most frequent with positive upwelling anomalies. Periods of high domoic acid have become more frequent starting in 2001. The 2015 bloom was unprecedented in abundance and spatial extent. HABs are increasing in frequency and intensity.	One or more water quality indicators suggest the potential for human health impacts, but none have been reported.

			No reports of human illness; however, shellfish and crab fisheries, marine mammals, and seabirds have been negatively affected.	
8	Climate Drivers	Fair ▼	Sea surface temperature and episodic warm water anomalies are increasing. There were significant effects of the recent warm water event and El Niño, including low primary productivity. Warming has led to reduced efficiency of the biologic pump (flux of organic material to depth), which in turn has decreased DO in the water column. In general, DO near the surface decreases seasonally during upwelling events. Large-scale climate oscillations can influence other water quality parameters as well; for example, PDO influences HABs. Seawater pH has been steadily decreasing over time. Organisms in CINMS are accustomed to variable pH and therefore, may be less vulnerable to change, but little is known about certain habitats, such as deep sea. Some sanctuary habitats may provide buffer against pH decreases (e.g., eelgrass beds).	Climate-related changes, such as the warm water event, decreasing dissolved oxygen, and ocean acidification have caused measurable, but not severe degradation in some attributes of ecological integrity.
9	Other Stressors	Undetermined ?	Here, "other stressors" are those that are hard to quantify in the water column and/or that have indirect impacts; therefore, there are few datasets to assess. The sanctuary's offshore location buffers from the water quality issues experienced off the coast of the mainland; however certain wind and circulation conditions can transport contaminated coastal waters to the sanctuary. It is believed microplastics are prevalent and increasing in the ocean.	

The Warm Water Event

A multi-year warm water anomaly, broadly known as a marine heat wave (Hobday et al. 2016), was detected in the Gulf of Alaska in fall 2013. It expanded east and south during 2014, reaching the coast in fall 2014. It eventually became the largest and most widespread marine heat wave ever documented in the northeast Pacific Ocean, and was initially coined the “Blob” (Bond et al. 2015, Di Lorenzo and Mantua 2016). As visible in Figure WWE.1, the North Pacific Blob was separate in space and development and thus distinct from the southern California Current anomalous warm water that appeared shortly after. Therefore, this report refers to the anomaly off southern California that affected CINMS as the “warm water event.”

Only half of the California Current warm water events on record have co-occurred with El Niños. This warm water event interacted with the major El Niño that peaked in winter 2015–2016 via an atmospheric bridge between tropical and temperate latitudes (Figure WWE.2). Large shifts in tropical rainfall influenced wind, weather, and ocean temperatures in the North Pacific. In sum, the heat wave began before the onset of El Niño, and in the California Current ecosystem, the warm water event persisted throughout summer 2016 after the El Niño had subsided (Fiedler and Mantua 2017). Climate forcing evidence suggests that the extreme drought conditions experienced in North America since 2012 coupled with the accumulation of greenhouse gases in the atmosphere enabled the regions of anomalous warm water to grow to such extremes in space and time (Diffenbaugh et al. 2015, Di Lorenzo and Mantua 2016).

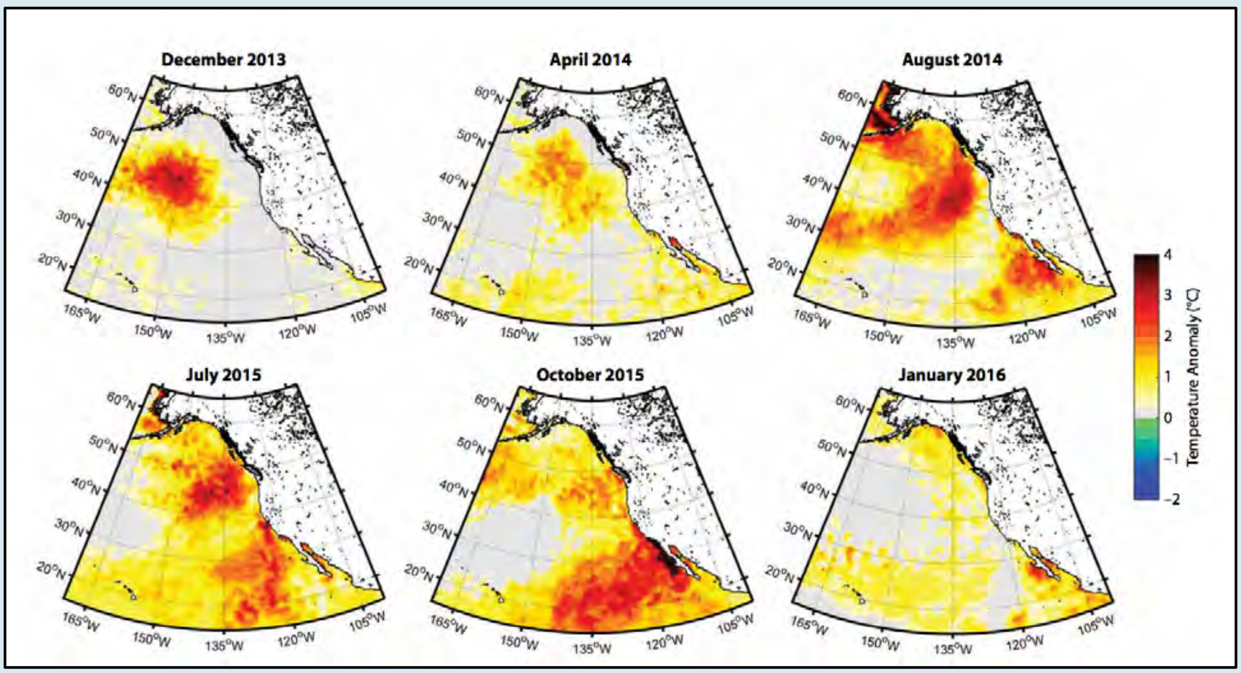


Figure WWE.1. Sea surface temperature (°C) anomalies showing the progression of two regions of anomalous warm water in the northeast Pacific Ocean from December 2013 through January 2016. Temperature data were obtained from the National Oceanic and Atmospheric Administration Visualize High-Resolution Blended Analysis Data. http://www.esrl.noaa.gov/psd.
Figure: Cavole et al. 2016 *Note: This is variant of a similar figure shown during the expert workshop. During the workshop a global figure was shown, whereas this figure focuses on the North Pacific.*

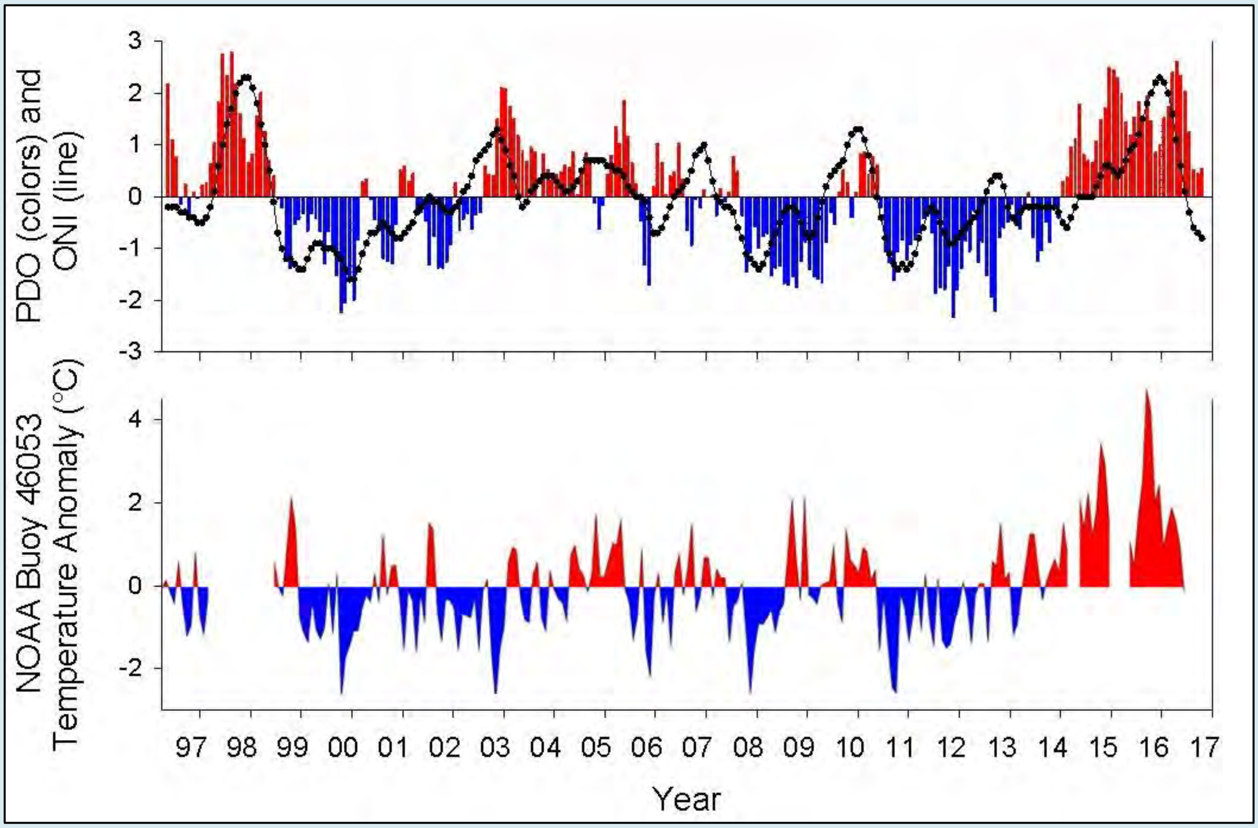


Figure WWE.2. The Pacific Decadal Oscillation (PDO) index shown in the upper panel is blue and positive during North Pacific cold regimes with higher productivity, or red and negative, during warm regimes associated with lower productivity. Oceanic Niño Index (ONI) is also shown in the upper panel as a black dotted line. ONI is a good indicator of El Niño conditions and generally parallels PDO. After a persistent change in direction of either PDO or ONI, ocean conditions in the California Current soon begin to change. Monthly sea surface temperature (SST) are an example of this, and SST anomalies at NOAA Buoy 46053, north of Santa Cruz Island in the middle of the Santa Barbara Channel, are shown in the bottom panel. Figure: Upper panel: NMFS NWFSC; Lower panel: I. Schroeder/ NMFS SWFSC. *Note: This is variant of a similar figure shown during the expert workshop.*

Both the warm water event and El Niño had profound effects on the California Current ecosystem, including CINMS (Figure WWE.3). Warm water temperature anomalies were upwards of 5°C in the Santa Barbara region and caused major shifts in food webs (Bond et al. 2015, Reed et al. 2016). Primary productivity was low across the southern California Current due to reduced coastal winds and upwelling, resulting in suppressed nutrient transport into the mixed layer (Jacox et al. 2015, Whitney 2015). During this time, at least 11 unusual species of copepods were detected, and commercial and recreational fisheries species ranges shifted (Bond et al. 2015, Peterson et al. 2016). The warm water event was linked to the 2015 *Pseudo-nitzschia* harmful algal bloom (HAB) along the West Coast, which was unprecedented in size, duration, and toxicity, and subsequently closed the Dungeness (north of Santa Barbara) and rock crab fisheries (McCabe et al. 2016, McKibben et al. 2017). Seabird and marine mammal die-offs were documented during the warm water event, believed to be due to shifts in prey availability and/or toxicity of the HAB event (Opar 2015, Cavole et al. 2016, NMFS 2016b and 2017b). The elevated strandings of California sea lion pups starting in 2013 prompted NOAA to declare it an unusual mortality event (UME) (NMFS 2017b). Reduction in abundance and quality of prey (sardine and anchovy) available to breeding female sea lions at Channel Islands rookeries, potentially driven by both environmental conditions and fishing removals, were identified as the main causes, potentially in combination with other factors (McClatchie et al. 2016, NMFS 2017b).

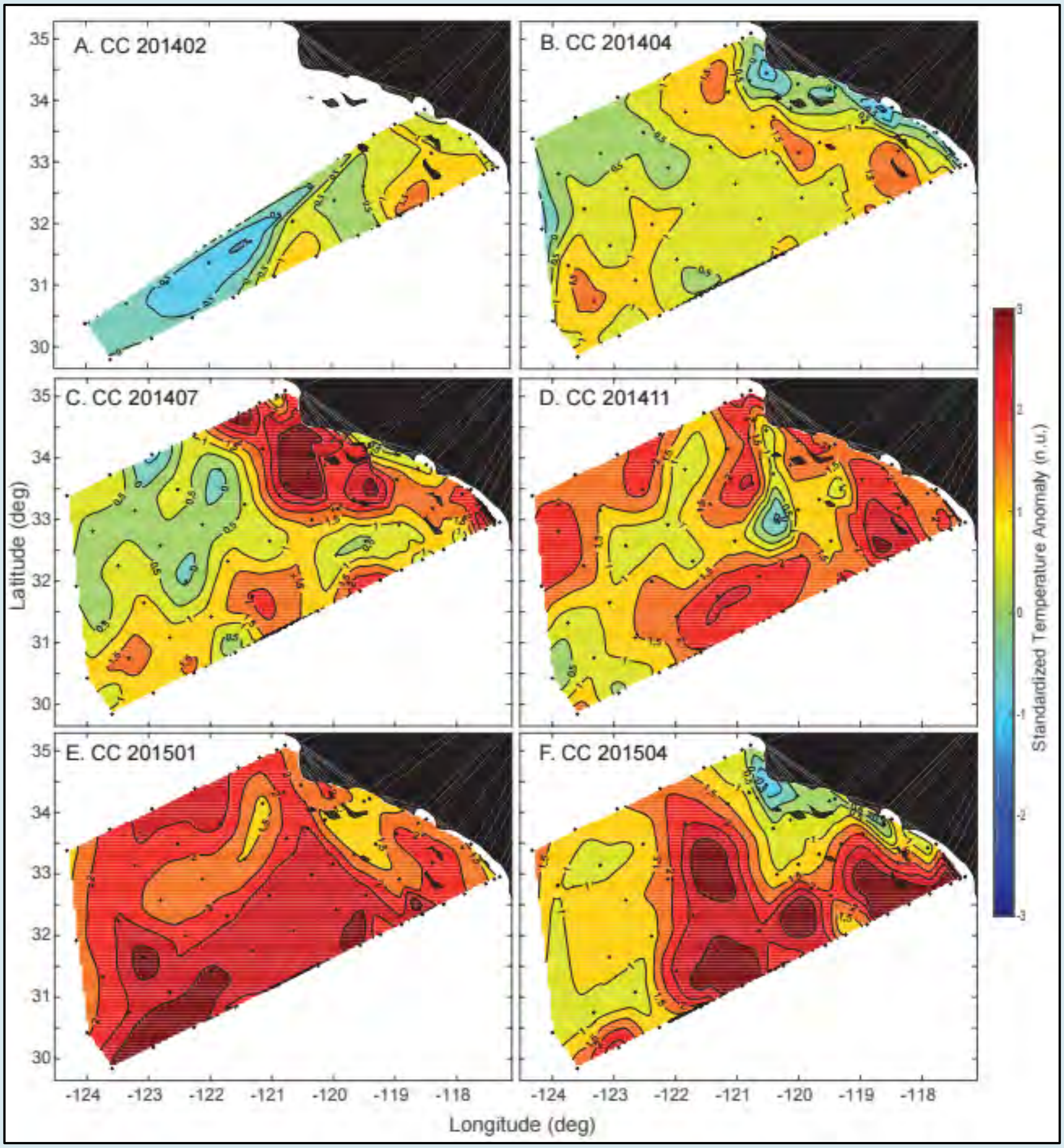


Figure WWE.3. Temperature anomalies at a depth of 10 meters (standardized by the standard deviation of the temperature at CalCOFI station 66) for six CalCOFI cruises that covered the 2014–2015 warm anomaly: winter (A.), spring (B.), summer (C.), and fall (D.) of 2014; and winter (E.) and spring (F.) of 2015. The 2014 winter cruise was not completed due to ship failure. Warm colors (reds) indicate regions with higher than average temperatures, and cool (blues) colors indicate regions with lower than average temperatures.
Figure: Leising et al. 2015 *Note: This is variant of a similar figure shown during the expert workshop.*

Long-term ecosystem impacts of the warm water event in the sanctuary are unknown; however, it is believed that this event will be regarded as the most significant ecological and economic warm water anomaly on record. Recent research suggests that North Pacific decadal variability under greenhouse forcing (i.e., climate change) will intensify and in turn, may continue to produce warm water events like that from 2013–2016 (Di Lorenzo and Mantua 2016).

Plumes and Blooms Time-series (PnB)

The Blooms and Plumes program is a joint collaboration among UCSB faculty and student and staff researchers at the Institute of Computational Earth System Science (ICESS), NOAA researchers at the Coastal Services Center (Charleston, South Carolina), and CINMS resource managers. Since August 1996, monthly research cruises have been conducted to collect measurements for an in-situ database. These measurements include temperature and salinity, ocean color spectra, and water column profiles of red light transmission and chlorophyll fluorescence (indexes of suspended particulate load and phytoplankton abundance). The transect observations begin at the shelf waters north of Santa Rosa Island and end at an area off Goleta Point. These repeat observations, combined with satellite imagery, produce a time-series of the changing ocean color conditions and water quality parameters in the Santa Barbara Channel. For more information about PnB, visit http://www.oceancolor.ucsb.edu/plumes_and_blooms/.

Southern California Coastal Observing System (SCCOOS)

The Southern California Coastal Ocean Observing System (SCCOOS) is one of eleven regions that contribute to the national U.S. Integrated Ocean Observing System (IOOS). The regional observing systems work to collect, integrate, and deliver coastal and ocean observations in order to improve safety, enhance the economy, and protect the environment. The primary goal of SCCOOS is to provide the scientific data and information needed to inform decision-making and better understand the changing conditions of the coastal ocean in southern California.

SCCOOS brings together coastal observations in the Southern California Bight to provide information necessary to address issues in climate change, ecosystem preservation and management, coastal water quality, maritime operations, coastal hazards, and national security. SCCOOS tracks most parameters assessed in the water quality section of this report. For more information about SCCOOS, visit http://www.sccoos.org.

California Cooperative Oceanic Fisheries Investigations (CalCOFI)

California Cooperative Oceanic Fisheries Investigations (CalCOFI), formed in 1949, is a multi-agency partnership that studies marine ecosystems off California and informs management of fisheries resources. Currently, CalCOFI conducts quarterly cruises offshore of southern California collecting a suite of hydrographic and biological data at 66 core and nine coastal stations. Data collected at depths down to 500 meters include: temperature, salinity, oxygen, phosphate, silicate, nitrate and nitrite, chlorophyll, C14 primary productivity, phytoplankton biodiversity, zooplankton biomass, and zooplankton biodiversity. Seabird and marine mammal visual surveys are conducted during transits between stations. Acoustic technicians survey ocean noise with a towed hydrophone array. For more information about CalCOFI, visit http://www.calcofi.org.

Habitat (Questions 10–11)

The following information provides an assessment of the status and trends of key habitat indicators in CINMS from 2009 to 2016. Experts at the June 1, 2016 workshop discussed available habitat data (see Appendix E: Habitat Graphs) to assess the current status and trend for each condition report question and rated their confidence in each assessment. The habitat section covers both biogenic and physical habitat structure, availability, and trends in the rocky shore, kelp forest and rocky reef, sandy beach, shallow sandy seafloor, and deep seafloor habitats. Assessment of the pelagic habitat is discussed in the Water Quality section and is not included here. As the majority of available data covers rocky intertidal, shallow subtidal rocky reef, and kelp forest habitats, assessments in this section are heavily focused on these areas. More research and long-term monitoring is needed to support a more rigorous assessment of the status and trends of sandy beach, shallow sandy seafloor and deep seafloor habitats in the sanctuary; however, the available data for these habitats were considered for this section.

Question 10 focuses on the integrity of major habitats within the sanctuary, including biologically (biogenic) and abiotically (physical) structured habitats. Physical habitats are abiotic structures like boulders, hard pavement substrate, soft sediments, and cobble that often define habitat types, such as rocky seafloor and soft sediment ecosystems. Biogenic habitats are living marine species that create habitat structures utilized by other living marine resources, including habitat-forming species, such as kelp, subcanopy algae, seagrass, mussels, deep-sea corals, and sponges. Biogenic habitats are layered on top of, and are often determined by, the co-occurring physical habitat. Changes to both biotic and abiotic habitat could have large impacts to a number of living marine resources and ecosystem services; thus, ONMS needs to track these alterations in habitat.

Question 11 examines concentrations and variability of contaminants in major sanctuary habitats. Due in part to high population densities along the coast, the Southern California Bight experiences high levels of pollution. The Southern California Bight is home to two large commercial ports, Los Angeles and Long Beach, a marine-based U.S. Environmental Protection Agency (EPA) Superfund site, America's second largest city, Los Angeles, and a number of agricultural activities. Marine water pollution in the region may also result from long-range oceanic and atmospheric transport of toxic chemicals. In general, organic contaminants, heavy metals, and other pollutants are a consistent pressure in Southern California Bight habitats; however, the sanctuary's offshore location within the Southern California Bight and limited visitation is thought to contribute to lowered contaminant levels in comparison to the mainland coastline. Nevertheless, anthropogenic contamination is still present in a number of sanctuary habitats (see Appendix E: Habitat), although the extent of the biological impact is still unclear. Contaminant levels in habitats can be determined by either directly measuring contaminants in sediment samples or by measuring contaminants in the tissues of habitat-forming organisms (e.g., mussels). The magnitude of contaminant concentrations in tissue provides insight on contaminant levels in surrounding habitats, which can be particularly valuable when direct habitat measures are not available. Benthic species abundance, biomass, and distribution are influenced by habitat conditions including salinity, sediment type, and contaminant stressors; thus, an additional means of measuring the potential biological impacts of contamination is by examining the infauna community composition in comparison to the relative abundance of sensitive taxa.

Indicators specific to each habitat were selected and vetted with experts prior to their inclusion in the workshop. (For more information on this process, see Appendix G: Developing Indicators of Condition for Channel Islands National Marine Sanctuary).

10. What is the integrity of major habitat types and how are they changing?

In the 2009 condition report, Question 10 was divided into two separate questions, the first examining abundance and distribution of major habitats and the second looking at the condition of biologically structured habitats. These questions received status ratings of fair with an undetermined trend and fair with a not changing trend, respectively. The ratings were based heavily on expert opinion that historic trawling, lost fishing gear, and marine debris had been shown to degrade soft and hard bottom habitats and were likely affecting sanctuary benthic habitats. At that time, recent trawl bans, marine reserves, and other regulations were expected to result in improved conditions. Other factors that led to the status ratings were the continuing loss of giant kelp and understory habitat-forming algae, declines in eelgrass as a result of white urchin increases, and decline in mussel bed ecosystem health. Short-term increases in kelp, eelgrass restoration projects, marine reserves, and trawl regulations were projected to lead to habitat recovery in the future.

The 2016 integrity of major habitat types is rated fair (high confidence) with a worsening trend (high confidence). While there is no known major change in physical or geological benthic habitat, there has been measurable loss in many components of biogenic habitat, principally in the eastern region of the sanctuary. Many biogenic habitat indicators have exhibited short- or long-term declining trends, such as eelgrass bed extent, understory kelp abundance, and deep-sea coral and kelp health. Only a few indicators have stable or increasing trends, including giant kelp density and red algae cover. Some of these declines showed strong correlations with changing temperatures related to both the marine heat wave and El Niño (see *The Warm Water Event*); however, it is too early to tell what, or if, there will be long-term effects on sanctuary habitats as a result of this and future marine heat wave events.

Below is a brief summary of the updated information used to determine integrity of major habitat types known to play important ecological roles in the sanctuary ecosystem. Additional information on recent abundance levels and long-term trends is available in Appendix E: Habitat Graphs.

Kelp beds provide habitat for many living marine resources, but the extent of giant kelp (*Macrocystis pyrifera*) canopy undergoes seasonal and long-term variation. While seasonal variation is primarily influenced by oceanographic and climatic factors, such as wave height and sea surface temperature (Cavanaugh et al. 2011), interannual variation has a more complex set of influencers. The 2009 condition report noted destabilization of kelp forests due to historic harvest of important predators, including southern sea otters (*Enhydra lutris nereis)*, California sheephead (*Semicossyphus pulcher*), and California spiny lobster (*Panulirus interruptus*). This drastically reduced top-down pressure on kelps by sea urchins, ultimately resulting in urchin barrens where kelp forests once thrived. While sea otters are still extirpated in the sanctuary, both sheephead and lobster have seen increases in abundance since 2009, which may positively influence kelp recovery in the future. Despite a brief uptick in the years preceding the 2009 report, kelp areal extent has shown a long term decline since 2005; however, it remains around levels recorded in the 1980s (Figure S.Hab.10.1, SBC LTER data). At three of the five islands within CINMS, kelp biomass density data is low, with less than one plant per square meter (Figure S.Hab.10.2). Recent kelp density spikes at Anacapa and Santa Barbara islands could be due to a co-occurring decrease in urchin abundance in the sanctuary (see Appendix F: Figures App.F.12.5 and App.F.12.6). Recent work determined that kelp health, as determined by chlorophyll to carbon ratio, appeared to be declining as well between 2012 and 2015 (Bell et al. 2018, Bell et al. 2015), although it does appear healthier in western, cooler water habitats.

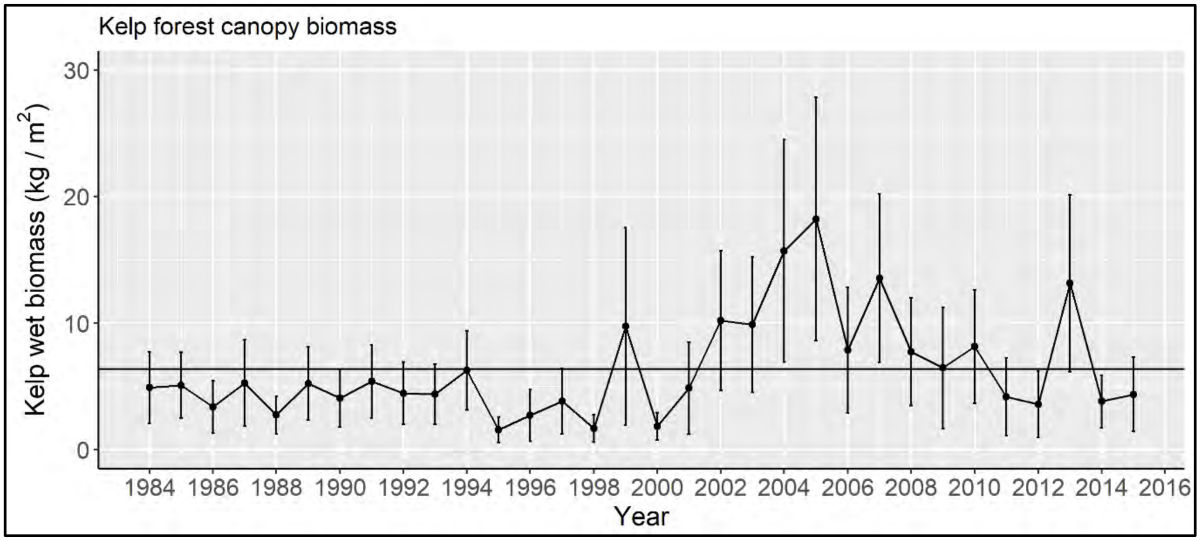


Figure S.Hab.10.1. Kelp biomass, as determined by Santa Barbara Channel Long-term Ecological Research project (SBC LTER) satellite imagery, within CINMS shown around the long-term mean (horizontal black line). Kelp biomass is determined from the Landsat satellite and quantifies kelp visible in the surface layer and may miss kelps which don't have stipes or blades that reach the surface. Figure: R. Miller/ UCSB

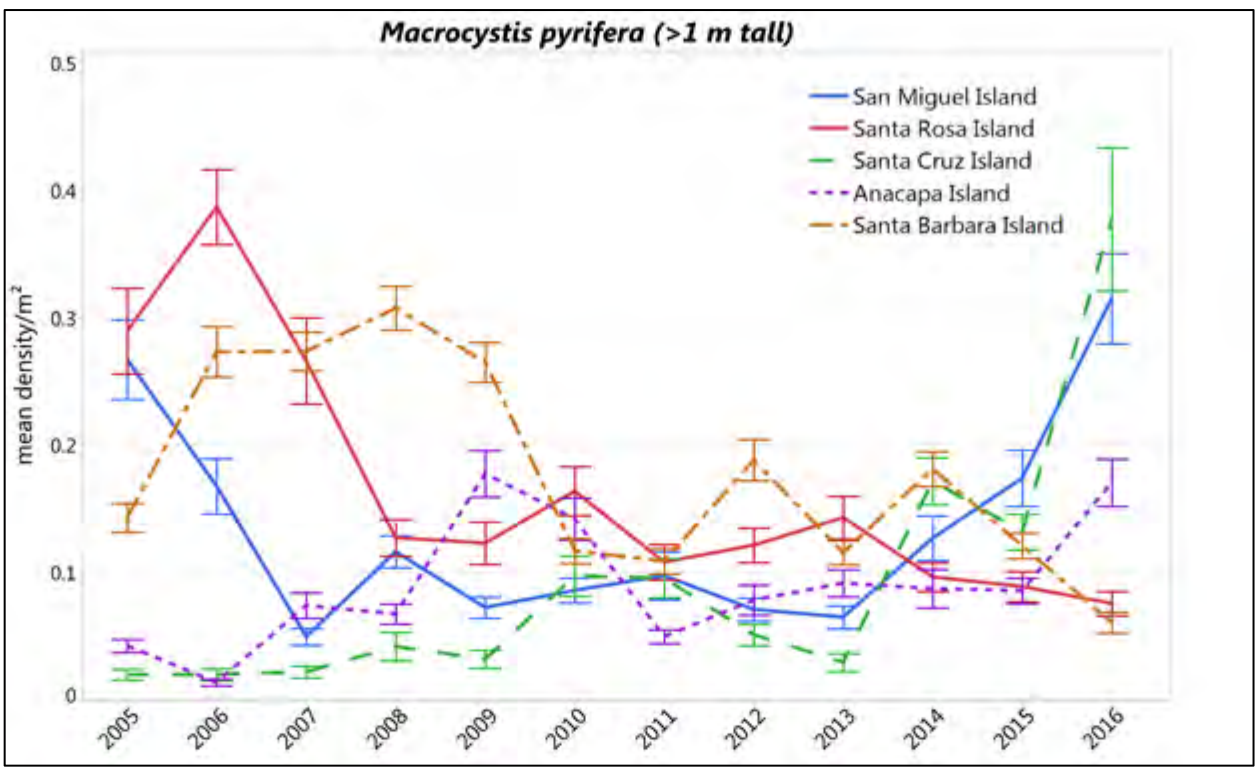


Figure S.Hab.10.2. Giant kelp density from 2005 to 2016 from the National Park Service's Kelp Forest Monitoring sites across all five sanctuary islands (Sprague CINP). Mean density is shown as plant per square meter for each year by island. In order for a kelp to be counted, it must be defined as plants with one or more stipes taller than one meter. Recent density spikes have occurred at the warmest two islands while the more western, cooler islands still have low densities. Figure: Channel Islands National Park

Other biogenic habitat in rocky reefs, such as understory kelp and foliose red algae, appears to vary in abundance by species (SBC LTER, unpub. data). Brown algae abundance throughout the region has been in decline since the mid 2000s. Since 2014, red algae has experienced a recent drop in abundance yet levels still appear to be near the mean of the time series. The drop in red algae abundance is particularly prominent at the islands in comparison with mainland sites. These losses of key kelp and algal habitat could potentially lower habitat quality for a number of economically and environmentally important living marine resources.

Similar to algae in rocky subtidal habitats, Pacific eelgrass (*Zostera pacifica*) serves as a foraging, nursery and biogenic habitat in subtidal and intertidal soft bottom regions of CINMS (Merkel & Associates 2015). Eelgrass is found off Santa Rosa, Santa Cruz, and Anacapa Islands and mapping data shows that most eelgrass beds have been generally stable over time (Engle and Miller 2005). While there is no evidence of a negative effect of El Niño and/or the warm water event on eelgrass in most areas of the sanctuary (Altstatt, UCSB and CINMS, pers. comm.), beds in Frenchy's Cove continue to be disturbed from anchoring and lobster trap placements (Figure S.Hab.10.3). Surveys of a 2003 experimental eelgrass transplant at Anacapa Island showed peak cover in 2009 (Altstatt et al. 2014), declining to limited coverage in 2016 in areas open to fishing (Figure S.Hab.10.4).

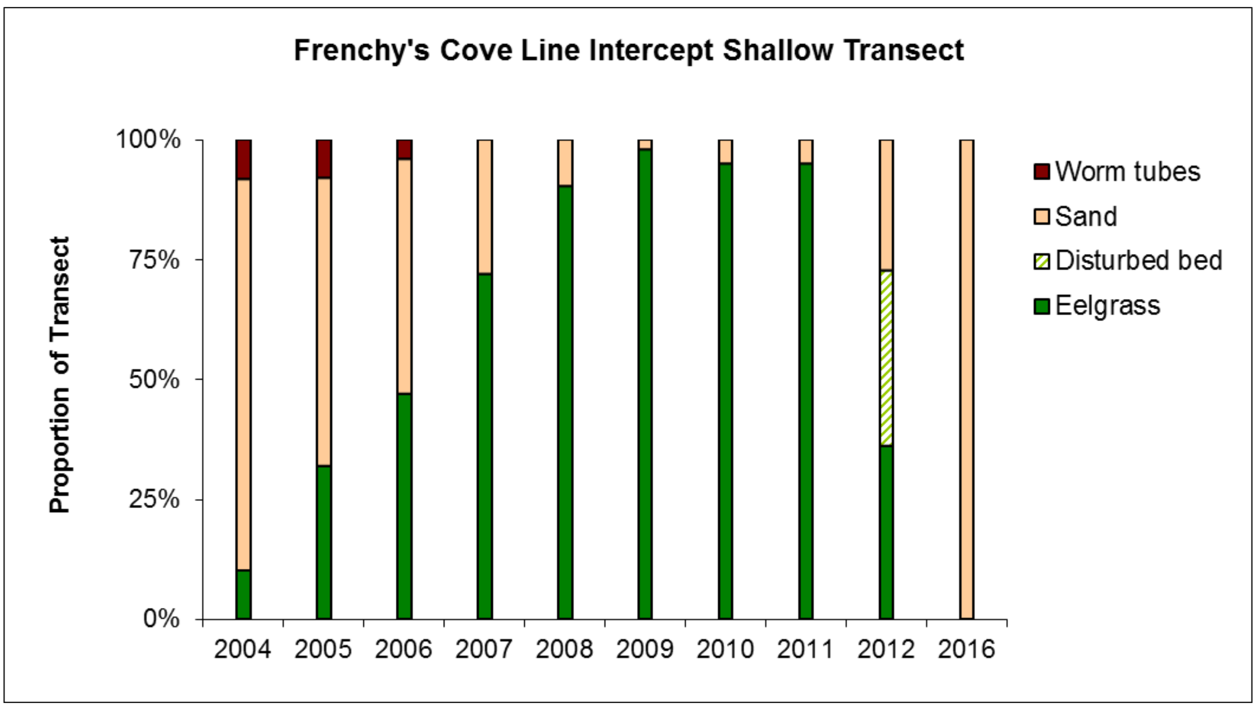


Figure S.Hab.10.3. Eelgrass cover at Frenchy's Cove from 2004 to 2016 after 2003 transplant. Data are collected from diver surveys along a 30 meter fixed transect with points scored every 10 centimeters. The transect lies within the transplant area at Frenchy's Cove are at approximately 24 feet in depth. Declines in eelgrass cover are thought to be potentially due to seafloor disturbance from anchoring and trap fishing. Figure: J. Altstatt/UCSB and NOAA

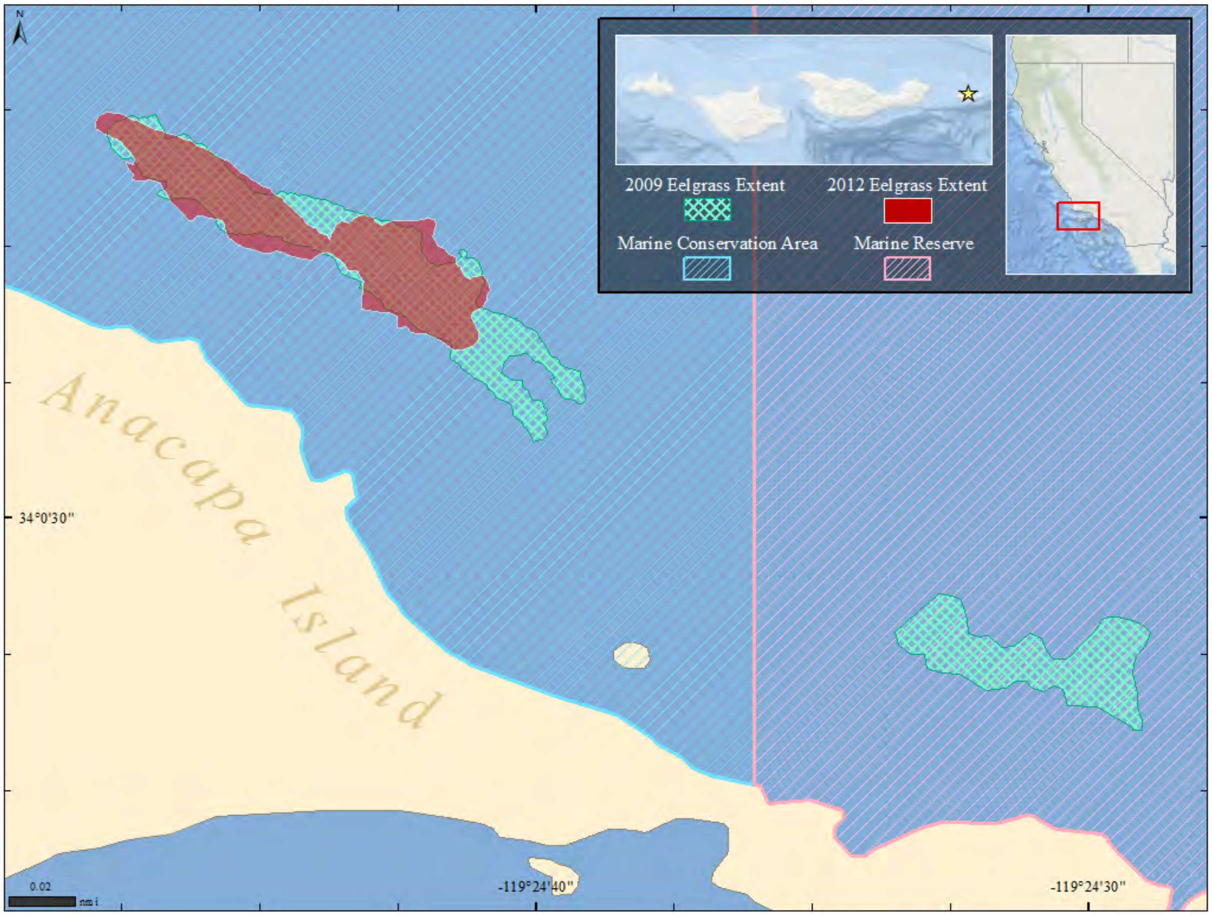


Figure S.Hab.10.4. Eelgrass bed extent from diver surveys is compared between 2009 (turquoise) and 2012 (dark red) at Anacapa Island. Overall, bed extent appears to be declining at Anacapa between 2009 and 2012, with the eastern bed being extirpated. Trap fishing, anchoring, and seafloor disturbance are thought to contribute to recorded declines in bed extent and shoot density, with eelgrass beds inside the marine reserve having higher densities than those in areas with less protection. Data Source: J. Altstatt/ UCSB and CINMS; Map: M. Cajandig/NOAA

Within the rocky intertidal habitat, mussels (*Mytilus californianus)* are an important structure-forming species that provides habitat to many other species in the ecosystem. In the 2009 condition report, mussel beds were thought to be declining over several decades and this trend has continued; however, Channel Islands National Park data show variability across islands (Figure S.Hab.10.5a and 10.5b). Within the last five years, mussel percent cover at Anacapa, Santa Cruz, and Santa Rosa islands has stayed well below the long-term mean, while mussels on San Miguel and Santa Barbara islands have been slightly above the long-term mean. Workshop participants suggested that mussels may have an increased potential for future recovery as a result of sea star wasting disease decimating regional *Pisaster* and *Pycnopodia* populations, thus potentially releasing mussels from predation pressure (for further details, see Question 12).

Deeper seafloor habitats in the sanctuary are typically less understood than shoreline and nearshore systems. The 2009 condition report noted a paucity of mapping data at depths greater than 30 meters within the sanctuary. ONMS is currently working to address this habitat gap with several collaborative mapping and characterization efforts (Freedman et al. 2017).

Repeated remotely operated vehicle (ROV) surveys in 2005, 2009, 2011, and from 2014 to 2016 conducted by Marine Applied Research and Exploration (MARE), National Centers for Coastal Ocean

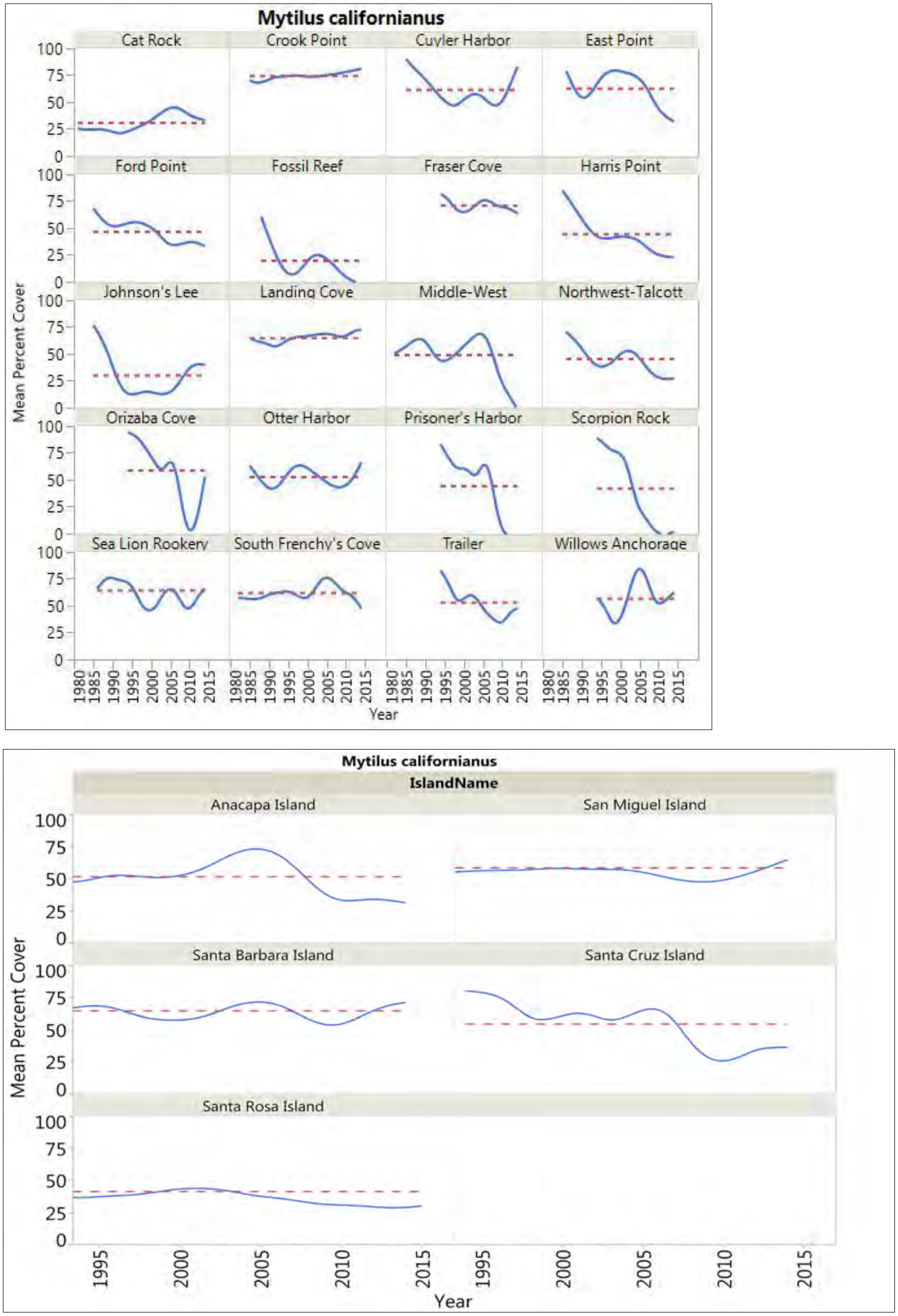


Figure S.Hab.10.5. (a) *Mytilus californianus* percent cover at all Channel Islands National Park monitoring sites and (b) average for each island (CINP). Red dashed lines are the long-term mean and blue lines are the trends for *M. californianus* percent cover. Long-term trends appear to be variable by site; however Santa Cruz, Santa Rosa, and Anacapa islands are all below the long-term mean. Figure: Channel Islands National Park

Science (NCCOS), and CINMS indicate that deep-sea corals are abundant and healthy throughout the sanctuary, but the communities differ across spatial and depth gradients. Below 150 meters, deep-sea corals and sponges appear healthy and abundant with some patchy evidence of injury and occasional disturbance by fishing gear, particularly around Footprint Reserve. In the mesophotic zone (40 to 150 meters), corals are exceptionally abundant (> 100 colonies/100 square meter) and healthy, particularly around Santa Rosa Island; however, the eastern side of the sanctuary has higher documented abundance than the western side (Etnoyer, NOAA NCCOS and Rosen, MARE, pers. comm.). There were some notable declines in the 20 to 30 meter depth zone. Specifically, at Anacapa Island, the density of healthy *Leptogorgia* corals has declined sharply since 2005 with increased occurrence of unhealthy or dead corals in 2015 surveys (Figure S.Hab.10.6 and 10.7). Although rare, there is some evidence of contact with fishing gear at these depths (see Appendix C: Figures App.C.3.3-3.5). Researchers believe that the recent decline in condition of shallower, soft corals could be related to the drastic short-term variations in water temperature and acidic conditions associated with the marine heat wave and El Niño (see Appendix E: Figure App.E.10.29). Deeper-water corals are subjected to less drastic variation over time and thus, may not be as affected by ocean acidification. More data are needed to better understand the long-term changes in deep sea habitat and how decreasing ocean pH will impact this ecosystem.

Figure S.Hab.10.6. Images were taken of healthy *Leptogorgia chilensis* colony (left) at Cortes Bank and unhealthy *Leptogorgia chilensis* colony (right) at Anacapa Island, CINMS. Photos: NOAA, SWFSC, and MARE.

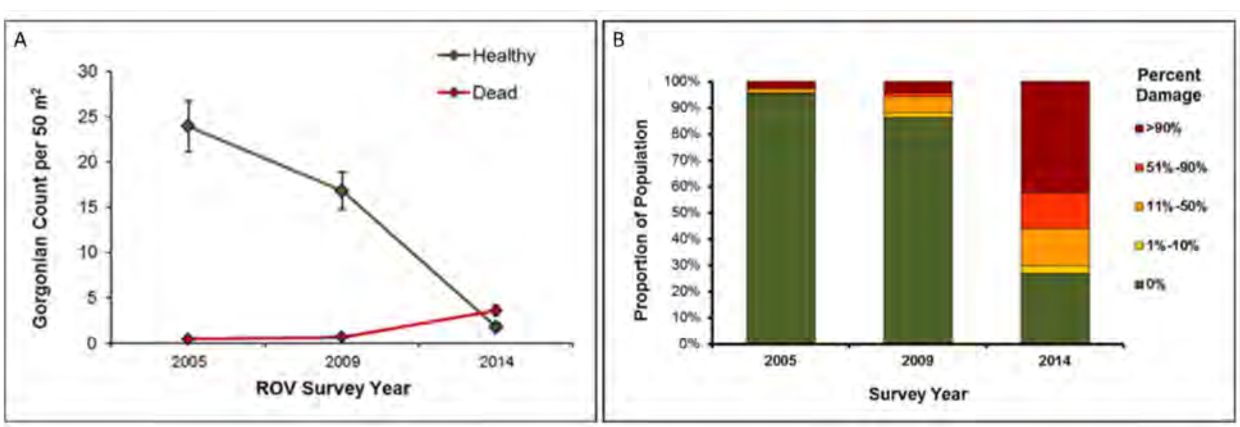


Figure S.Hab.10.7a and b. (a) Decline in healthy gorgonians and increase in dead gorgonians at Anacapa Island between 2005 and 2014. (b) Percent damage between 2005 and 2014 at Anacapa Island. Data source: MARE; Figures: P. Etnoyer/NOAA

11. What are the contaminant concentrations in sanctuary habitats and how are they changing?

In 2009, contaminant concentrations were rated good/fair with an improving trend. The islands' offshore location is thought to provide a degree of protection from mainland discharges, yet impacts from anthropogenic contaminants have been observed in sanctuary habitats. Although legacy toxic pesticides, such as dichlorodiphenyltrichloroethane (DDT), are still detectable in both sediments and animal tissues, the concentrations appeared to be declining. The sanctuary has a regulation that prohibits certain types of materials or other matter from being discharged or deposited in the sanctuary, which can minimize contamination from these sources; however, there is anecdotal evidence of illegal vessel discharges.

In 2016, the status rating for contaminant levels remained good/fair (high confidence), but the trend was downgraded to not changing (high confidence). Continued research has shown that legacy contaminants, such as DDT (Jarvis et al. 2007, Blasius and Goodmanlowe 2008, see Appendix E: Habitat), remain persistent despite prior declining trends. NOAA's Mussel Watch Monitoring Program's data indicated that the heavy metals arsenic and chromium were elevated in mussel tissue from CINMS, perhaps as a result of natural enrichment, compared to mussels from outside the sanctuary; however, some contaminants have shown a possible increase across multiple methods of contaminant measurement. Better understandings of the presence of emerging contaminants of concern that were not considered in the prior report, coupled with the persistence of legacy pollution and alterations in the infauna community have led experts to downgrade the trend to not changing. While evidence across the suite of indicators considered for this assessment is not conclusive, contaminant levels and their potential ecological impacts need further investigation. Indicators were selected through a multi-step process detailed in Appendix G and drew upon a number of research and monitoring programs.

The offshore location of the Channel Islands affords a degree of protection from land-based pollutants, and the sanctuary's relative inaccessibility reduces direct human impacts in comparison to nearshore mainland California habitats. To have a better understanding of the actual contaminant levels and how they are changing, experts were presented with multiple data types from a number of monitoring programs. Sediment contaminant concentrations, infauna community metrics, and mussel tissue contamination levels have all been adopted by monitoring programs as a way to indirectly determine local contamination level. The following provides updated information on the status and trend of contaminant concentrations that had the most influence on the experts determining a rating. Additionally, a suite of chemicals, collectively referred to as contaminants of emerging concern (CECs), are attracting attention in marine regions worldwide. Further information on the recent abundance and long-term trends is available in Appendix E: Habitat Graphs.

The California mussel (*Mytilus californianus*) is prevalent in CINMS nearshore habitats and has been examined for decades as part of the state and national NOAA Mussel Watch Monitoring Program to assess levels of approximately 150 contaminants. The Mussel Watch Program has a time series of mussel contamination on Santa Cruz Island at Fraser Point that shows a number of metal concentrations in mussel tissue have significantly declined (e.g., arsenic, iron, and silver). Despite these declines, the site exceeded the 90th percentile in the Southern California Bight for six metals and five organic contaminants (see Appendix E: Habitat Graphs). There are multiple potential explanations for this finding, including limited spatial resolution, limited recent data, possible return to background levels consistent with the southern California mainland after remediation, or improved instrumentation and analytics that have been developed since data collection began. Because the causes for this are undetermined and the levels of contamination, while potentially increasing, are still not biologically relevant, this was not considered a conclusive demonstration of poor habitat quality.

During its 2003 Southern California Bight-wide survey, Southern California Coastal Water Research Project (SCCWRP) found levels of contaminants in sediments to be minimal and improving at the Channel Islands, except for DDT, which occurred in low to moderate levels. Even though it appears that DDT levels have increased, they are considerably lower in the sanctuary than in other regions of the Southern California Bight. The largest introduction of DDT to the marine environment was at the Montrose Chemical Corporation ocean outfall, where DDT was discharged into the environment between 1950 and 1972. It is possible that DDT from the Montrose site could have moved into CINMS waters through currents, sediment transport, or the movements of contaminated organisms. It should be noted that these data are from the 2003 survey at the Channel Islands and more recent data are unavailable. Increased monitoring and research is warranted to improve understanding of these trends and provide a more current assessment of impacts.

In addition to sediment contamination concentrations, SCCWRP has conducted infaunal surveys since 1994 as part of long-term monitoring during bight-wide surveys. Historically, the shelf around the northern Channel Islands has been considered pristine and a “reference site” according to the ranking of the present infaunal community; however samples collected in 2013 from these same sites detected a decline in community ecological condition (Figure S.Hab.11.1) resulting in a change in designation to low impact. The decline in condition was especially prevalent around Santa Cruz Island. The ranking system is based entirely on infaunal community composition as an indicator of potential effects of contaminant concentration, but is not a measure of contaminant levels themselves. SCCRWP uses a triad of information to determine levels of contamination including infaunal community, sediment chemistry, and sediment toxicity. Sediment chemistry and sediment toxicity were not available in 2013; as such, this should not necessarily cause concern, and further investigation is needed.

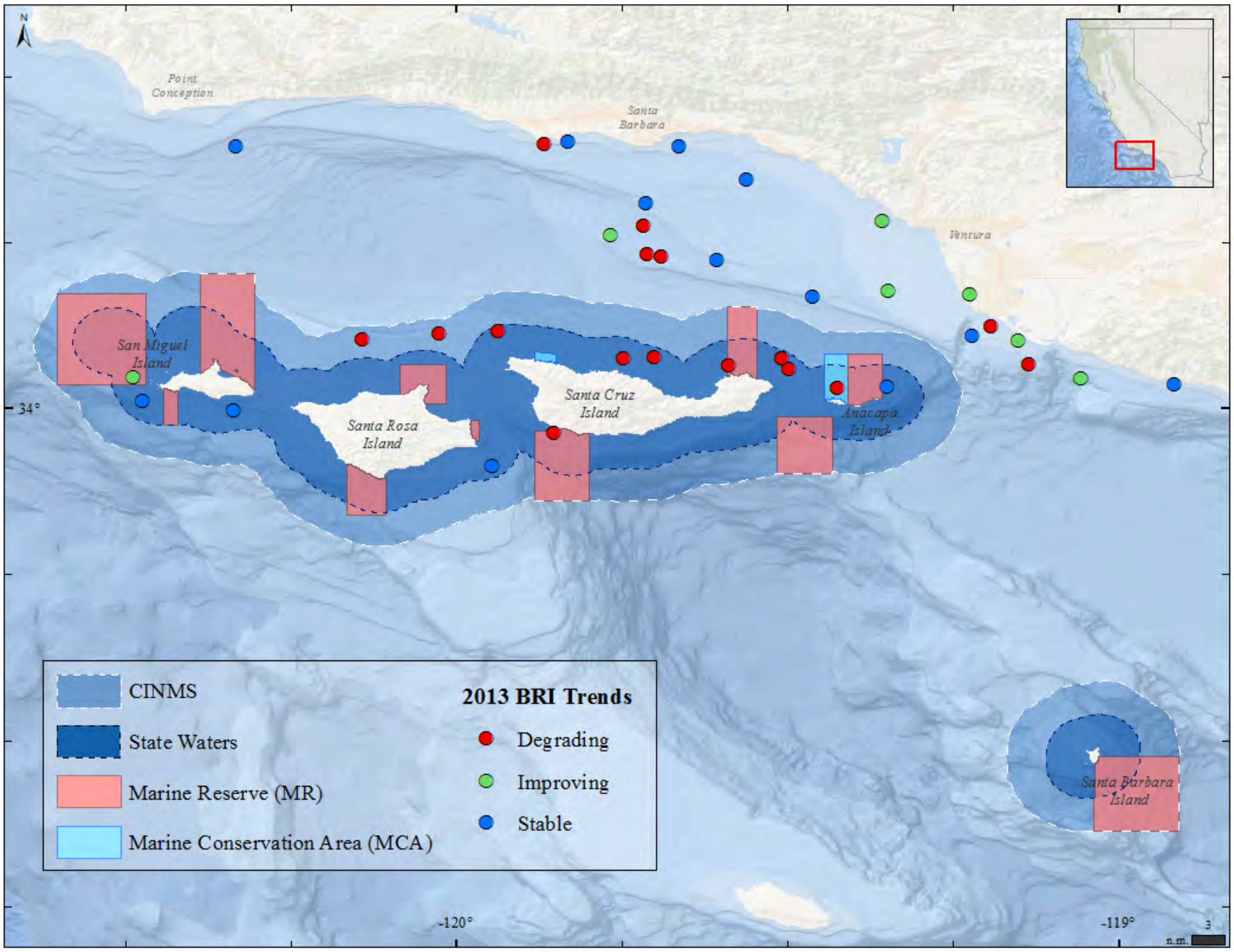
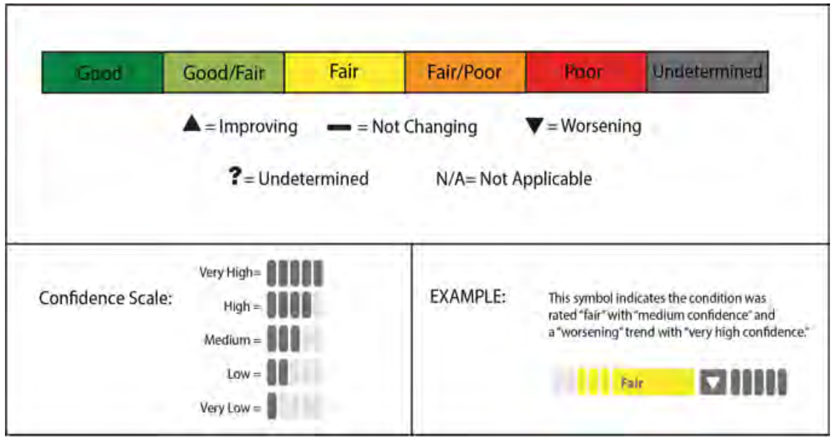


Figure S.Hab.11.1. Infaunal invertebrate communities in sediment samples were characterized based on the proportion of a sediment sample with taxa that was sensitive to as opposed to tolerant of contaminant levels. In the most recent samples collected in 2013, 10 of the 15 sites in Channel Islands National Marine Sanctuary had an infaunal community composition that was shifting to become more tolerant of degraded conditions (red) compared to previous samples. Data Source: Ken Schiff/ SCCWRP; Map: M. Cajandig/NOAA

Habitat Status and Trends



#	Issue	Rating	Basis for Judgment	Description of Findings
10	Integrity of major habitats		Monitoring programs indicate some measurable loss in many components of major habitats including kelp forests, understory kelp, algal groups, mussel beds, and deep-sea corals. Kelp and deep-sea coral declines are primarily in the eastern part of the sanctuary. Other components of major habitat are stable or improving.	Selected habitat loss or alteration has caused measurable, but not severe degradation in some attributes of ecological integrity.
11	Contaminant concentrations		Declines in several contaminants were measured in mussel tissues, but levels remain high for others. Some infauna contaminant samples are no longer considered pristine and received a slight rating downgrade. Sediment contaminants are present at low levels. More data are needed to determine any impacts on habitat, marine life and future trends.	Selected contaminants are suspected and may degrade some attributes of ecological integrity, but have not yet caused measurable degradation.

Channel Islands National Park (CINP) Monitoring Programs

Created in 1980, Channel Islands National Park protects the wealth of natural and cultural resources found on Anacapa, Santa Cruz, Santa Rosa, San Miguel, and Santa Barbara islands, and also in their ocean environments out to one nautical mile offshore. A long-term ecological monitoring program gathers information on the health of these resources. Marine resources that are monitored by CINP include sandy beaches, rocky intertidal, kelp forest, pinnipeds, and seabirds. For more information about CINP monitoring programs, visit http://science.nature.nps.gov/im/units/medn/parks/chis.cfm.

Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO)

PISCO is a long-term monitoring and research program designed to understand the dynamics of the West Coast's ocean ecosystem. In 1999, PISCO began a large-scale, long-term study of the patterns of species diversity in rocky shore and kelp forest habitats and the physical and ecological processes responsible for structuring these communities. PISCO is led by scientists from core campuses: Oregon State University (OSU); Stanford University's Hopkins Marine Station; University of California, Santa Barbara (UCSB); and University of California, Santa Cruz (UCSC). For more information about PISCO, visit http://www.piscoweb.org.

Santa Barbara Coastal Long-term Ecological Research (SBC LTER) Project

The Santa Barbara Coastal Long-term Ecological Research Project (SBC LTER) is housed at the University of California, Santa Barbara and is part of the National Science Foundation's Long-term Ecological Research Network. In 2000, SBC became the 24th site in the LTER network. The primary research objective of SBC LTER is to investigate the relative importance of land and ocean processes in structuring giant kelp forest ecosystems. For more information on SBC LTER, visit http://sbc.lternet.edu//index.html.

Marine Applied Research and Exploration (MARE)

MARE is a nonprofit that uses cost-effective and innovative deepwater robotic technology to survey the seafloor below SCUBA diver depths. MARE provides data analysis expertise to assesses changes in marine life and habitat over time to inform ocean management and support wild sustainable fisheries for future generations. For more information about MARE, visit http://www.maregroup.org.

Southern California Coastal Water Research Project (SCCWRP)

The Southern California Coastal Water Research Project (SCCWRP) is an environmental research institute that works to develop a scientific foundation for informed water-quality management in southern California. Founded in 1969, this public agency takes an interdisciplinary approach to informing water management with active research programs in many areas including contaminants, bioassessment, nutrients, beach water quality, and marine debris. For more information about SCCWRP, visit http://www.sccwrp.org/Homepage.aspx.

Living Resources (Questions 12–15)

The following information provides an assessment of the status and trends of key living resources indicators in CINMS for the period from 2009 to 2016. Experts at the June 1, 2016 workshop discussed available data for living resources indicators (see Appendix F: Living Resources Graphs) and to assess current status and recent trends for each condition report question, including rating their confidence in these assessments.[9] The assessments are based on studies of faunal communities in the six primary habitats in the sanctuary: rocky intertidal, shallow subtidal rocky reef and kelp forest, beaches, shallow sandy seafloor and deep seafloor, and pelagic (Figure SH.13).[10] More research occurs in rocky intertidal, shallow rocky reef and kelp forest, and pelagic habitats; therefore, the assessments are based mostly on the status of living resources in these three habitats. Additional research and long-term monitoring are needed on the status and trends of faunal communities associated with beaches, shallow sandy seafloor, and deep seafloor habitats in CINMS.

Habitat-forming species, such as kelp, subcanopy algae, seagrass, mussels, barnacles, corals, and sponges, are not included in the living resources section because they are covered in the Habitat section of this report (Questions 10 and 11). In addition, the shifts in physical properties of ocean waters, including pH, water temperature, and hypoxia, which are a result of regular climate variability as well as global climate change, are discussed in the Water Quality section of this report (Question 8). Currently, CINMS is not aware of studies documenting direct effects of global climate change on the condition of living resources in CINMS; those studies will be discussed in this section in the future as data become available.

- Keystone species and foundation species are the focus of Question 12; both are important components of an ecosystem as the persistence of a large number of other species depends on them. The two types of species are differentiated by their numerical abundance or biomass:
- A keystone species has a disproportionately large effect on its environment relative to its abundance. It plays a critical role in maintaining the structure of its ecological community and helping to determine the types and numbers of various other species in the community. A classic example is the predatory sea star *Pisaster ochraceus*, which preys primarily on the mussel *Mytilus californianus* (Paine 1966). When sea stars are absent, mussels can outcompete many other space-occupying species in the rocky intertidal, causing major shifts in the local community assemblage.

A foundation species is a numerically abundant or high biomass species that has a strong role in structuring a community by serving as prey or providing habitat. Examples include krill and other zooplankton, kelp, forage fish, such as anchovy and sardine, and coral. Although kelp, corals, and other habitat-forming species could be considered foundation species, they are not included here because they were already covered in the Habitat section (Questions 10 and 11).

"Other focal species" are the focus of Question 13. CINMS selected a set of indicator species for each of the six primary sanctuary habitats through a multi-step process detailed in Appendix G: Developing

[9] For additional information about the expert workshop and confidence scoring process, see Appendix B: Consultation with Experts and Document Review.
[10] For more information on the sanctuary's six primary habitats, see Appendix G: Developing Indicators of Condition for Channel Islands National Marine Sanctuary.

Indicators of Condition for Channel Islands National Marine Sanctuary. One important component in the selection process was to identify species for which some data on status or condition were available.

Question 14 focuses on assessing the impacts of non-indigenous species (NIS). Also called alien, exotic, non-native, or introduced species, these are animals or plants living outside their endemic geographical range. Often arriving in the sanctuary as a result of some type of human activity, either deliberate or accidental, their abundance in sanctuary habitats, along with any known ecological impacts, will be discussed.

Biodiversity is variation of life at all levels of biological organization, and commonly encompasses diversity within a species (genetic diversity) and among species (species diversity), and comparative diversity among ecosystems (ecosystem diversity). Biodiversity can be measured in many ways. The simplest measure is to count the number of species found in a certain habitat or ecosystem, termed species richness. Other indices of biodiversity couple species richness with relative abundance to provide a measure of evenness and heterogeneity. When discussing "biodiversity" in response to Question 15, this report primarily refers to species richness and diversity indices that include relative abundance of different species and taxonomic groups; note that NIS are not included in estimates of native biodiversity.

12. What is the status of keystone and foundation species and how is it changing?

The 2016 status of keystone and foundation species is rated as fair (high confidence) with a worsening recent trend (high confidence). These ratings were based on both the recent drastic decline in sea stars (since 2013) and the continued reduced abundance of California sheephead and spiny lobster due to harvest in areas open to fishing. These keystone species are known to strongly influence the structure and function of intertidal and nearshore communities in the sanctuary. In addition, regional abundance of some key pelagic forage species (e.g., sardine, anchovy, market squid) have declined and contributed to mass strandings and reduced reproductive success for some locally breeding pinnipeds and seabirds. Monitoring data do indicate, however, that some keystone and foundation species in the sanctuary are at relatively high abundance levels (see Appendix F: Table App.F.12.1).

This question was not assessed in the 2009 condition report; however, there were two questions that assessed the status and condition of key species (see Appendix A for a description of changes to the condition report questions). In 2009, the status and condition of key species were rated as fair with a not changing and undetermined trend, respectively. These ratings were based on the status and condition of a variety of key species, including the removal of sea otters, reduced abundance and body size of many fished species (e.g., giant sea bass, lobsters), withering foot syndrome in abalone, and low fecundity in seabirds. Many of these issues persist and are discussed here or in Question 13.

The following provides updated information on the status and trends of keystone and foundation species known to play important ecological roles in the sanctuary ecosystem. Very little monitoring occurs for keystone and foundation species in beach and sandy seafloor habitats, which is why the status and trend for this question focuses on species found in rocky intertidal, kelp forest, and pelagic habitats.

One of the most significant changes in the status of key species in both rocky intertidal and subtidal habitats is the drastic decline of sea star populations along the northeast Pacific coast from Baja California to Alaska due to an extensive outbreak of sea star wasting syndrome (SSWS)[11] that began in summer 2013 (Stockstad 2014, Menge et al. 2016). Similar die-offs have occurred in the past, but never before at this magnitude and over such a wide geographic area. SSWS typically causes lesions followed by decay of tissue, eventual fragmentation of the body, and death. The syndrome has been documented[12] in over thirteen sea star species, including key sanctuary species, the ochre star (*Pisaster ochraceus*), the giant star (*Pisaster giganteus*), and the sunflower star (*Pycnopodia helianthoides*) (Figure S.LR.12.1). *Pisaster* and *Pycnopodia* are considered to be keystone taxa because declines and subsequent release of predatory pressure can lead to changes in community structure or function, such as expansion of mussel beds in the rocky intertidal (Paine 1966, Menge et al. 2016) and more urchins and less kelp in affected kelp forests (Schultz et al. 2016). Hewson et al. (2014) provided evidence for a link between a virus and SSWS. Environmental (e.g., water temperature) as well as biological (e.g., host susceptibility) factors may have contributed to the severity of SSWS observed at some locations, and these perhaps site-specific relationships are actively being researched (Eisenlord et al. 2016, Menge et al. 2016, Miner et al. 2018).

Figure S.LR.12.1. At least thirteen species of sea star have been observed to suffer from sea star wasting syndrome (SSWS) including (a) the ochre star (*Pisaster ochraceus*), (b) the giant star (*Pisaster giganteus*), and (c) the sunflower star (*Pycnopodia helianthoides*). Wasting syndrome typically causes lesions followed by decay of tissue, and death. Curling of the arms (b) is one early sign of SSWS. Photos (a) and (b): S. Lonhart/NOAA; Photo (c): C. King/NOAA

The sea star wasting event resulted in dramatic reductions in the abundance of *Pisaster* and *Pycnopodia* at most long-term monitoring sites in rocky intertidal and kelp forests habitats in CINMS (Figure S.LR.12.2; see Appendix F: Figures App.F.12.2, App.F.12.7-12.9). At deeper (30–80 meters) sites, *Pycnopodia* were completely absent in 2014 along transects that had averaged 8.3 individuals per 500 meter transect in 2008 (A. Lauermann, MARE, unpubl. data; Appendix F: Figure App.F.12.15). This severe decline of ecologically important intertidal and subtidal predators has led to a shift in community structure at some affected locations, but the the long-term impacts of sea star wasting syndrome on distribution and abundance of affected species and associated community-level changes are not yet understood (Menge et al. 2016, Montecino-Latorre et al. 2016). This is and will continue to be a topic of intense study along the West Coast and the ecological implications may be better understood in the coming years.

[11] UC Santa Cruz, Ecology and Evolutionary Biology. Multi-Agency Rocky Intertidal Network: Sea Star Wasting Syndrome. Retrieved from: https://www.eeb.ucsc.edu/pacificrockyintertidal/data-products/sea-star-wasting/ (last updated April 19, 2018).
[12] UC Santa Cruz, Ecology and Evolutionary Biology. Multi-Agency Rocky Intertidal Network: Sea Star Species Affected by Wasting Syndrome. Retrieved from: https://www.eeb.ucsc.edu/pacificrockyintertidal/data-products/sea-star-wasting/species_affected_2016_0825.pdf (last updated Aug. 23, 2016).

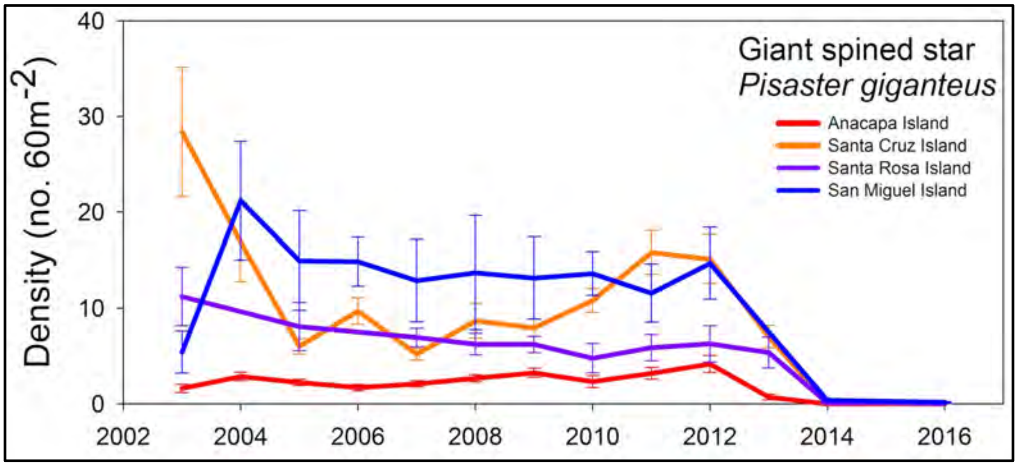


Figure S.LR.12.2. Average density (+/- standard error) of giant spined star *Pisaster giganteus* at 14 sites across four islands in Channel Islands National Marine Sanctuary monitored by the PISCO kelp forest monitoring program from 2003–2016. Sea stars are counted by SCUBA divers swimming along transect lines. Sea stars have suffered severe declines in 2013–2014 at all four islands due to sea star wasting syndrome. Data source: PISCO; Figure: R. Freedman/NOAA

California spiny lobster (*Panulirus interruptus*) and California sheephead (*Semicossyphus pulcher*) prey on sea urchins and gastropods (e.g., snails, abalone) which eat kelp and thus, help maintain the kelp canopy and understory algae, which in turn provide habitat for other species (Hamilton and Caselle 2015, CDFW 2016a). Currently, abundance of spiny lobster and sheephead are far below historic levels due to harvest (CDFW 2016a, Hamilton and Caselle 2015). Recently, however, lobster abundance has been trending upward in the sanctuary (Figure S.LR.12.3), particularly at Anacapa, Santa Cruz, and Santa Barbara islands (Appendix F: Figure App.F.12.11). Abundance of sheephead has been fairly stable since a 2009 assessment with some evidence of very recent increases at some islands (Figure S.LR.12.4, Appendix F: Figures App.F.12.12, App.F.12.14, App.F.12.16). The implementation of a network of marine reserves and conservation areas (where fishing is prohibited or restricted) around the islands appears to be related to these improvements in status and trend for both spiny lobster and sheephead in the sanctuary (see *MPA Effects*).

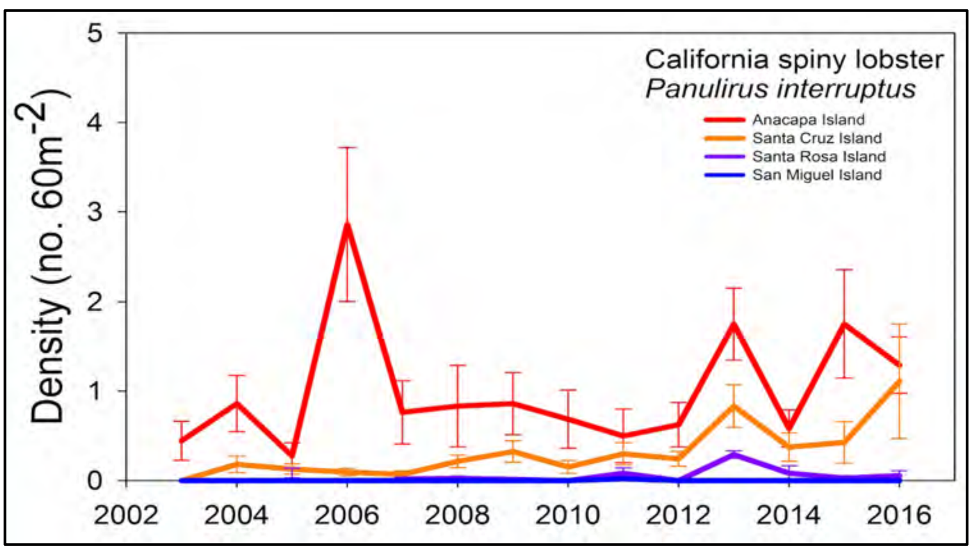


Figure S.LR.12.3. Average density (+/- standard error) of California spiny lobster *Panulirus interruptus* at 14 sites across four islands in Channel Islands National Marine Sanctuary monitored by the PISCO kelp forest monitoring program from 2003–2016. Lobster abundance is low at San Miguel (blue) and Santa Rosa (purple) islands and appears to be slowly increasing recently at Anacapa (red) and Santa Cruz (orange) islands. Lobster are counted by SCUBA divers swimming along transect lines. Lobster density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, lobster density is responding differently inside and outside of some marine protected areas (MPAs) in CINMS. A discussion of MPA effects in CINMS is available in *MPA Effects*. Data source: PISCO; Figure: R. Freedman/NOAA

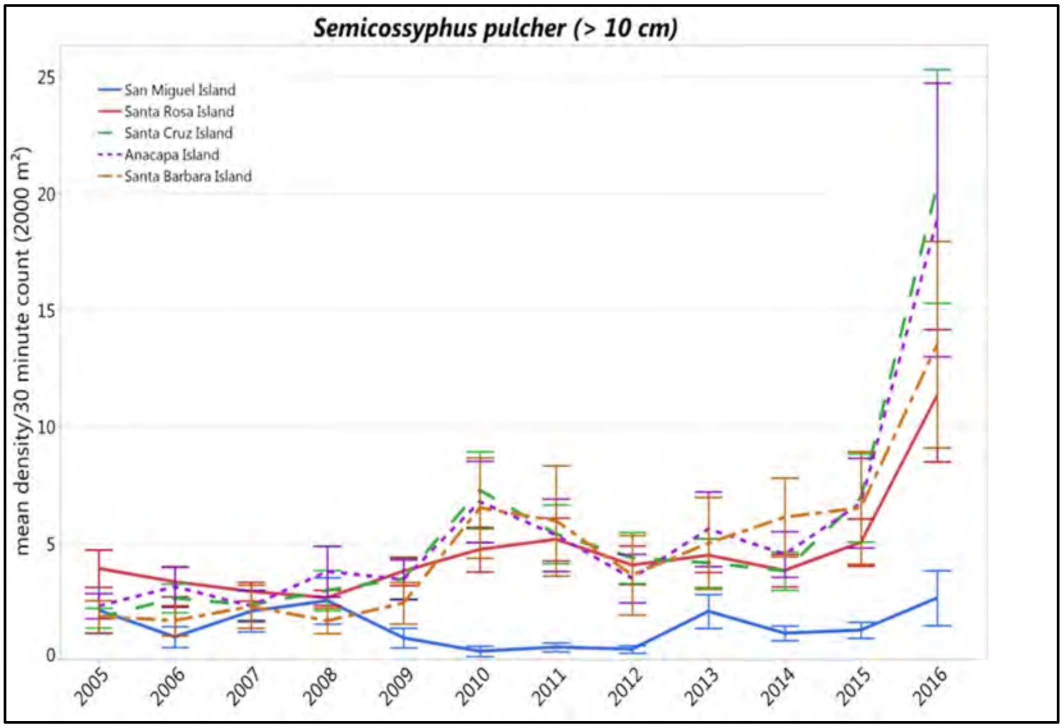


Figure S.LR.12.4. Average density of California sheephead (*Semicossyphus pulcher*) at Channel Islands National Park kelp forest monitoring sites at the five islands in Channel Islands National Marine Sanctuary. Recent increases in average density of sheephead were observed at every island, except for San Miguel (blue). Sheephead density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, sheephead density is responding differently inside and outside of some marine protected areas (MPAs) in CINMS. A discussion of MPA effects in CINMS is available in *MPA Effects*. Figure: Channel Islands National Park

Northern anchovy (*Engraulis mordax*), Pacific sardine (*Sardinops sagax*), and market squid (*Doryteuthis opalescens*) are foundation species that are key prey for many predatory fishes, seabirds, and marine mammals in the pelagic food web in and around CINMS. Abundance in southern California of all three key forage groups has been below the long-term average since 2013 (Leising et al. 2015, NMFS 2016a), including in the waters in and around CINMS (Figure S.LR.12.5). Although it is expected that these species will cycle through high and low abundance periods, it is unusual for all three species to be at low levels at the same time as recorded from 2013 to 2015 (McClatchie et al. 2017). The decreased upwelling, warm temperatures, and lower productivity observed in 2014 and 2015 (see *The Warm Water Event*) is likely correlated to these shifts in abundance and distribution of foundational forage species. For example, there is a strong, negative correlation between market squid and El Niño conditions possibly due to lower survival of market squid larvae during warm conditions (Koslow and Allen 2011, Perretti and Sadarat 2016).

The decline in abundance of forage species has reverberated through the food web and contributed to poor growth rates of nursing pups at California sea lion (*Zalophus californianus*) rookeries on San Miguel Island (McClatchie et al. 2016a, Appendix F: Figure App.F.13.24) and the unusually large number of stranded, malnourished pups that were admitted to rehabilitation centers in southern and central California in 2015 (NMFS 2017b). Likewise, some locally nesting seabirds have experienced poor reproductive success. It is likely that forage populations will recover with a return of favorable oceanographic conditions; however, since the size and scale of these anomalous conditions is a never-before observed phenomenon, it is unknown whether the system will resume historical patterns at some point or enter into a new pattern.

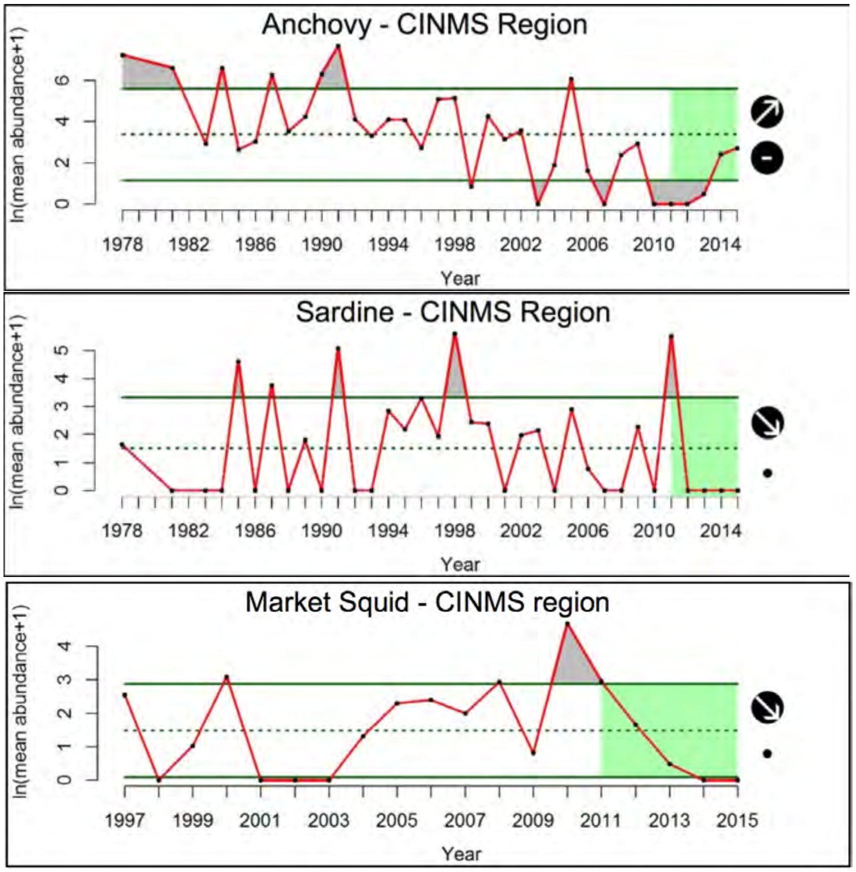


Figure S.LR.12.5. Relative abundance of Northern anchovy *Engraulis mordax* (top), Pacific sardine *Sardinops sagax* (middle), and market squid *Doryteuthis opalescens* (bottom) in bongo nets deployed during spring California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises at sites in the Channel Islands National Marine Sanctuary (CINMS) region from 1978–2015 (except squid collected since 1997). Horizontal lines show the mean (dashed line) ± 1.0 standard deviation (solid lines) over the full time series. Symbol at upper right indicates whether data over the last five years (green shaded areas) had a positive trend (↗), a negative trend (↘), or no trend (↔). Symbol at lower right indicates whether the mean over the past five years was greater than (+), less than (–), or within 1 standard deviation (●) of the mean of the full time series. It is important to note that a mean abundance of zero does not mean that the species is completely absent from the waters off of southern California, but that it was not collected at any sites around CINMS during the spring survey that year (sampling locations shown in Appendix F: Figure App.F.12.17). Data source: CalCOFI; Figure: A. Thompson/NMFS SWFSC

Lastly, it is important to note that southern sea otters (*Enhydra lutris nereis)* were not considered in a response to this question. Although sea otters can be keystone species in kelp forest communities, sea otters were not resident in CINMS for decades prior to designation of the sanctuary (the absence of this species from the sanctuary is included in our assessment of the status of biodiversity in Question 15). Southern sea otter populations have re-established at San Nicolas Island and are expanding their range along the mainland south of Point Conception; during a 2016 census, 72 otters were counted between Point Conception and Gaviota State Beach (Tinker and Hatfield 2016). Sea otters are seen occasionally in the sanctuary (e.g., Couffer 2017) and it is possible that sea otters will re-establish residence in CINMS in the near future. If and when that occurs, CINMS will consider their influence when responding to this question. Experts noted that without sea otters, the system is destabilized and recent perturbations (e.g., warm water, sea star decline) likely led to more extreme responses than if sea otters were present.

13. What is the status of other focal species and how is it changing?

The list of "other focal species" in the sanctuary is extensive and includes species with strong conservation, economic, and ecological value throughout the sanctuary's six major habitats (see Appendix F: Table App.F.13.1). The status of other focal species in the sanctuary is rated as fair (very high confidence) because some are absent or substantially reduced in abundance, while others are stabilizing. Commercially and ecologically relevant species like giant sea bass, cowcod, black abalone, and sea cucumber are depressed compared to historic levels and white abalone may be beyond recovery locally. Generally, marine mammals and seabird populations at the islands appear to be stable or recovering with the exception of the California sea lion and California brown pelican breeding populations on the Channel Islands. Both experienced lowered productivity in recent years, likely due to reduced availability of key prey resources. Population trends since 2009 varied across focal species and thus, the overall trend is rated undetermined (very high confidence).

A direct comparison of the 2016 ratings with the prior report is not possible because this question was not assessed in the 2009 report; however, there were two questions that assessed the status and condition of key species (see Appendix A for a description of changes to the condition report questions). In 2009, the status and condition of key species were assessed as fair with a not changing and undetermined trend, respectively. The 2009 ratings were based on the status and condition of a variety of key species, including the removal of sea otters, reduced abundance and body size of many fished species (e.g., giant sea bass, lobsters), withering foot syndrome in abalone, and low fecundity in seabirds; although some birds had shown recovery from reproductive impairment caused by exposure to high levels of DDT (Dichlorodiphenyltrichloroethane).

The following provides updated information on the status and trends of other focal species that most influenced discussion and rating decisions during the expert workshop. Additional information on recent abundance levels and long-term trends is available in Appendix F: Living Resources Graphs.

Seven species of abalone inhabit CINMS; black (*Haliotis cracherodii*), red (*H. rufescens*), green (*H. fulgens*), pink (*H. corrugata*), white (*H. sorenseni*), flat (*H. walallenssis*), and threaded (*H. assimilis*) abalone. Black abalone are primarily found in rocky intertidal habitat, while the others are primarily found on subtidal reefs. Though most of these species once supported commercial fisheries, extremely low abundance of all species from overharvest and disease led to the implementation of a southern California abalone fishing moratorium in 1997 (Button et al. 2013). Currently, two abalone species, black and white, are listed as federally endangered; black abalone[13] was listed in 2009 and white abalone[14] was listed in 2001.

The available monitoring data indicate that while still far below historic levels, four abalone species (black, red, pink, and green) are slowly increasing at some sites around CINMS (Figure S.LR.13.1, see Appendix F: Figures App.F.13.2, App.F.13.9-11). Unfortunately, white abalone populations at the islands are showing no signs of recovery and experts suggest that it is unlikely that white abalone will ever recover (J. Engle, UCSB, pers. comm., Button et al. 2013).

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[13] National Marine Fisheries Service. Black abalone listing under the ESA. Retrieved from: https://www.fisheries.noaa.gov/action/black-abalone-listing-under-esa (last updated Feb. 16, 2018).
[14] National Marine Fisheries Service. ESA listing of white abalone. Retrieved from: https://www.fisheries.noaa.gov/action/esa-listing-white-abalone (last updated Feb. 15, 2018).

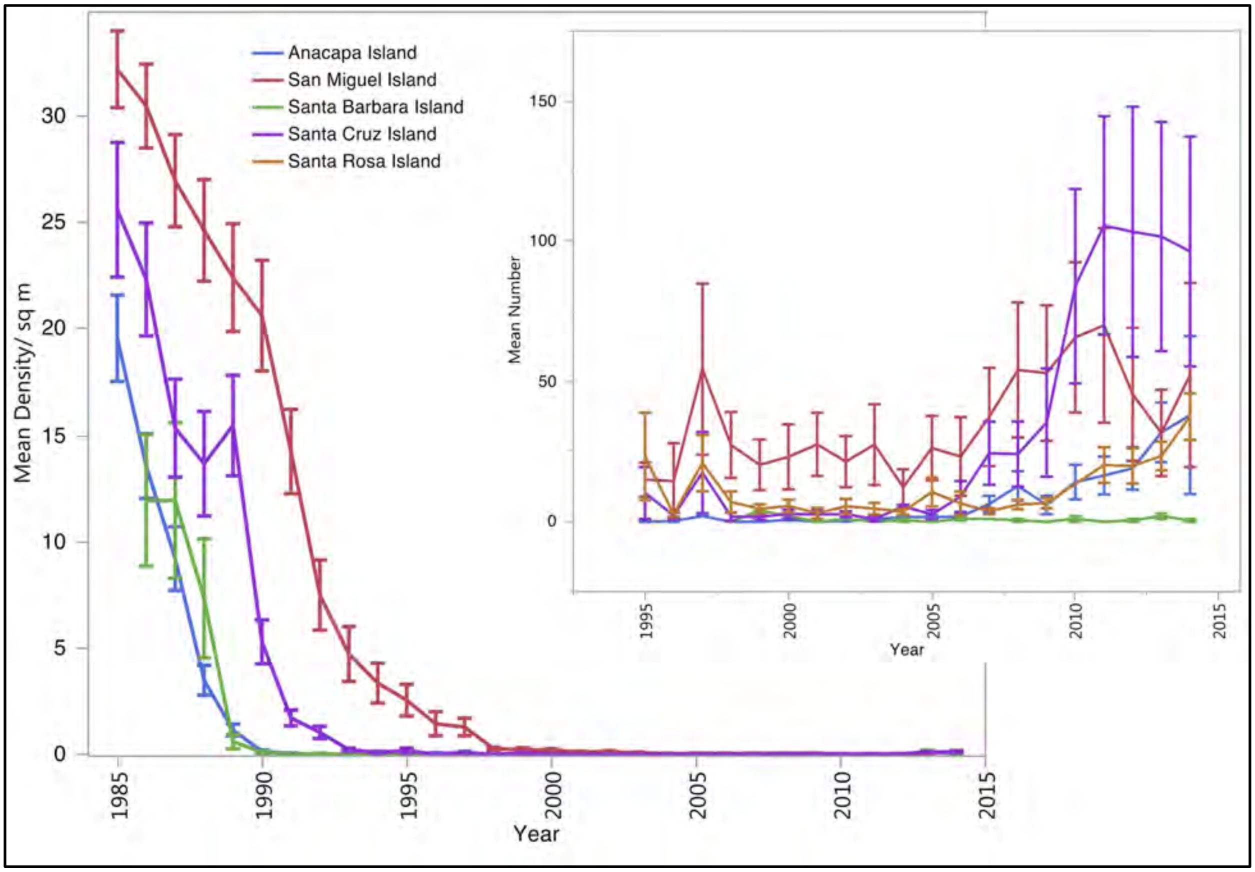

Figure S.LR.13.1. Black abalone *Haliotis cracherodii* mean density from fixed plots from 1985–2014 (left) and mean counts from site-wide searches from 1995–2014 (inset) at four islands in Channel Islands National Marine Sanctuary. Site wide search counts began in 1995 due to the severe declines in abundance that occurred from 1985–1995. Generally, increasing abundances began around approximately 2007–2009. Error bars were constructed using one standard error from the mean. Figure: Channel Islands National Park

Two commercially harvested species of sea cucumbers occur in CINMS: the California sea cucumber (*Parastichopus californicus*) and the warty sea cucumber (*P. parvimensis)*. Both are recreationally and commercially harvested in southern California; the status of the sea cucumber fishery was assessed in 2006 (Rogers-Bennett and Ono 2008) and the California Department of Fish and Wildlife is in the process of reassessing it. Surveys by Channel Islands National Park from 1982 to 1999 found that average density peaked in 1990 at two sea cucumbers per square meter then gradually declined to an average density of 0.4 by 1999 (Rogers-Bennett and Ono 2008). More recently observed densities of warty sea cucumbers range from < 0.1 to > 1.0 per square meter (Figure S.LR.13.2). Since 2005, warty sea cucumber density has been stable at San Miguel and Santa Rosa islands, but has been decreasing at Santa Barbara, Santa Cruz, and Anacapa islands. Notably, density of warty sea cucumbers within marine reserves has been increasing since their implementation in 2004, 2006 and 2007 (see *MPA Effects*, Pondella et al. 2015; CINP, unpubl. data).

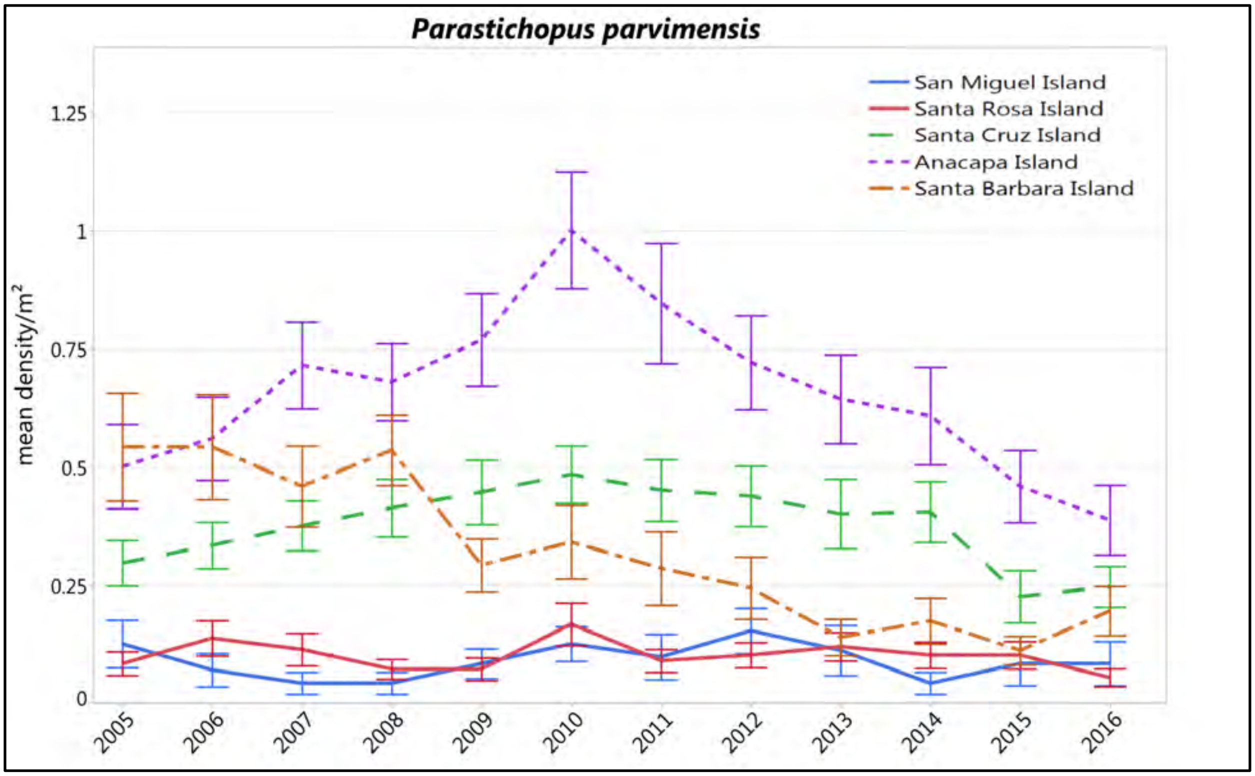

Figure S.LR.13.2. Average density of warty sea cucumber *Parastichopus parvimensis* at Channel Islands National Park kelp forest monitoring sites at the five islands in Channel Islands National Marine Sanctuary. Densities are lower, but stable at San Miguel (blue) and Santa Rosa (red) islands, while densities have declined recently at the other islands. For this graph, sea cucumber density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, sea cucumber density is responding differently inside and outside of some marine protected areas (MPAs) in CINMS. A discussion of MPA effects in CINMS is available in *MPA Effects*. Figure: Channel Islands National Park

Giant sea bass is an apex predatory fish of interest due to severely reduced numbers in sanctuary kelp forests and listing by the International Union for the Conservation of Nature (IUCN) as a critically endangered species on the IUCN Red List.[15] Chabot et al. (2015) recently used genetic techniques to estimate an effective population size of approximately 500 breeding individuals in the Southern California Bight. Research on sea bass at Catalina Island found that numbers of giant sea bass appear to be increasing within the region primarily due to a 1994 ban of the nearshore gill net fishery in California waters (House et al. 2016, Allen 2017).

Monitoring by Partnership for the Interdisciplinary Studies of Coastal Oceans (PISCO) and Channel Islands National Park at multiple sites in the sanctuary indicates that the overall biomass of the kelp forest fish community has generally increased over the last decade (Caselle et al. 2015, CINP, unpubl. data). To explore whether oceanographic drivers or human pressures were resulting in large or unexpected changes in abundance of kelp forest fish species at each in the sanctuary, CINMS examined trends in abundance of five species typical of the kelp forest fish assemblage: kelp and blue rockfish, kelp bass, señorita, and blacksmith (Figure S.LR.13.3, and Appendix F: Figures App.F.13.16-17). Abundances have either fluctuated within the range observed from 2003 to 2016 without a clear trend (e.g., kelp rockfish, kelp

[15] International Union for Conservation of Nature. The IUCN Red List of Threatened Species: *Stereolepis gigas* (black sea bass, giant sea sass). Retrieved from: http://www.iucnredlist.org/details/20795/0 (last visited Apr. 14, 2018).

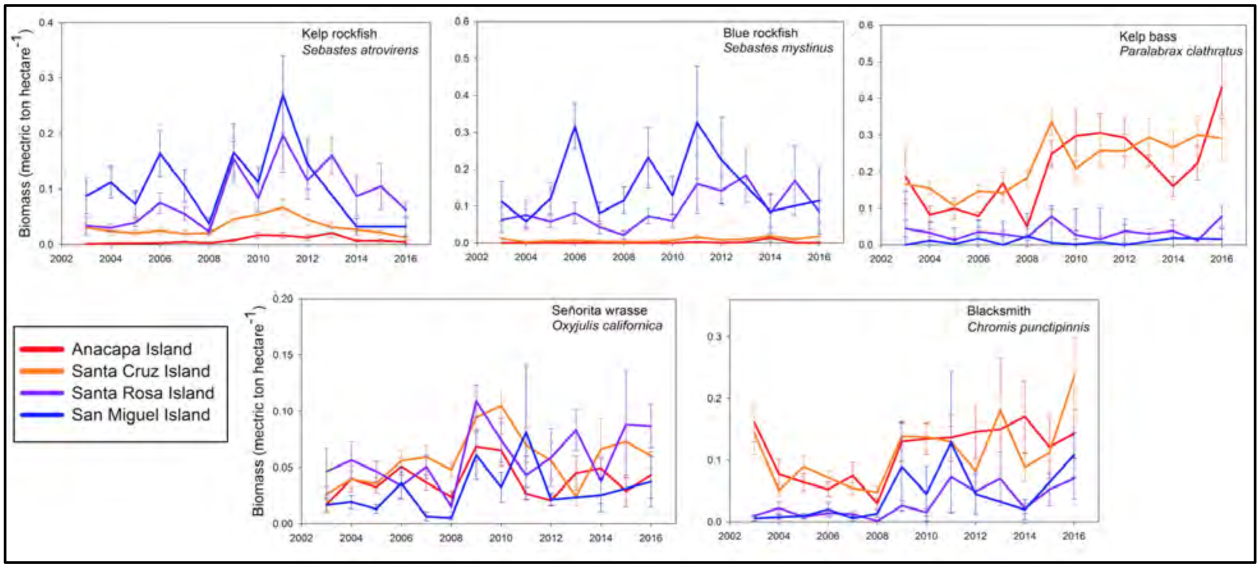

Figure S.LR.13.3. Average biomass of five kelp forest fish species at 14 PISCO monitoring sites across four islands in Channel Islands National Marine Sanctuary from 2003 to 2016. Fish are counted by SCUBA divers swimming along transect lines. Fish density was averaged across all monitoring sites at each island, including sites located inside and outside of Channel Islands marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, fish density may be responding differently inside and outside marine reserves. Data source: PISCO; Figures: R. Freedman/NOAA

bass at the western islands) or increased gradually (e.g., kelp bass at the eastern islands). It is important to note that there is spatial variability in trends for many species, both across the east-west orientation of the islands in the sanctuary (e.g., Figure S.LR.13.3) and inside versus outside marine reserves (for more information see *MPA Effects*).

Repeated visual surveys of demersal fish at depths 20 to 80 meters detected higher overall densities in 2014 and 2015 compared to 2005—2009 (Figure S.LR.13.4, Appendix F: Figure App.F.13.18). Increasing abundance of some demersal fish species has also been detected by hook and line surveys and bottom trawl surveys in the sanctuary and surrounding region (Bradburn et al. 2011, Harms et al. 2008). Most of the species that are well surveyed by these methods, including many harvested rockfish, have stable or increasing catch rates (Appendix F: Tables App.F.13.2–F.13.3). Net surveys of larval rockfish each winter between 1998 and 2013 have found similar patterns; of the 15 species of

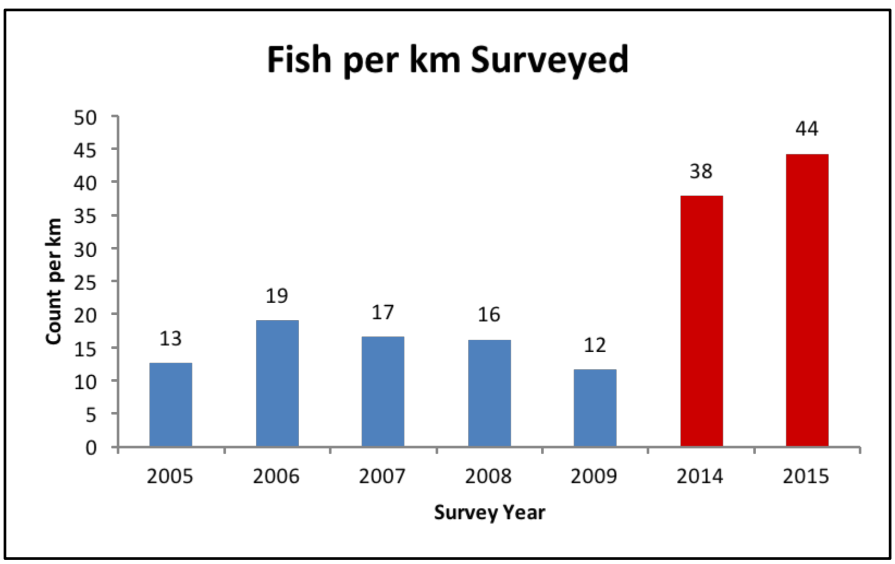

Figure S.LR.13.4. Five species of demersal fish (lingcod, sheephead, gopher rockfish, copper rockfish, and vermillion rockfish) were counted along seafloor transects in Channel Islands National Marine Sanctuary during a baseline period from 2005 to 2009 (blue bars) and again in 2014 and 2015 (red bars). In 2014 and 2015, average counts per kilometer of surveyed transect was 38 and 44 fish, respectively, compared to an averaged 15 fish per kilometer in the baseline period. Figure: MARE rockfish that can be identified in the net samples, ten have increased significantly in abundance during this period (Chen 2017).

Twelve species of seabirds breed on the islands, and the surrounding waters serve as important feeding grounds. The park monitors the productivity of some seabird colonies on the islands, but since 2009, there has been a lapse in regular monitoring for some colonies. Based on limited monitoring, most seabird colonies have experienced interannual variability in productivity since 2009, but appear to be stable with no clear trend (D. Mazurkiewicz, CINP, pers. comm.). One exception are the California brown pelican (*Pelecanus occidentalis californicus*) colonies that have had poor reproductive success since 2009, with a complete nesting failure in 2012 (D. Mazurkiewicz, CINP, pers. comm.). This low reproduction is likely due to low regional abundance of key forage — anchovy and sardine — around the breeding colonies; however, 2016 appears to be the best year for reproduction in the last eight years (D. Mazurkiewicz, CINP, pers. comm.).

Figure S.LR.13.5. A breeding colony of California common murres (*Uria aalge californica*) on San Miguel Island's Prince Island photographed on July 12, 2011. Scientists from the U.S. Geological Survey Western Ecological Research Center used this and other photographs to document the first common murre breeding colony in the northern Channel Islands in 100 years. The red box highlights portion of colony with birds exhibiting breeding behavior. Photo: J. Felis/USGS: http://soundwaves.usgs.gov/2011/11/MurreCol20110712DESLG.jpg

Restoration activities on the islands to aid in the recovery of seabirds of conservation concern, including ashy storm-petrels, Scripps's murrelets (formerly Xantus's murrelet, *Synthliboramphus scrippsi*), and Cassin's auklets, appear to be working. For example, the Scripps's murrelet colony on Anacapa Island has increased in response to the extirpation of rats in 2001 to 2002. The number of occupied nests, the number of clutches, and hatching success all increased substantially between 2001 and 2014 (Whitworth et al. 2015). Other positive news for nesting seabirds was the 2011 discovery of breeding common murres (*Uria aalge californica*) at San Miguel Island; this was the first successful nesting activity on the islands in over a century (Figure S.LR.13.5).[16]

14. What is the status of non-indigenous species and how is it changing?

In the 2009 condition report, the status of non-indigenous species (NIS) was rated good with a declining trend because no problematic species were known to have become established in the sanctuary; however, there was concern that invasive algae from mainland harbors and Santa Catalina Island could reach the

[16] Yvonne Menard, *Murre Seabird Chicks Hatch for the First Time in 100 Years on the Channel Islands*, National Park Service (Aug. 9, 2011), https://www.nps.gov/chis/learn/news/murre.htm.

northern Channel Islands. One of those species of concern, *Sargassum horneri*, has since become established at three of the islands in the sanctuary where it has increased in abundance to cover expansive areas with the potential for negative consequence to native kelp communities; therefore, the 2016 status was downgraded to fair (medium confidence) with a worsening trend (very high confidence). Medium confidence was assigned to the status rating because not all workshop participants agreed with a rating of fair. Specifically, although many experts agreed that *S. horneri* was likely to have caused degradation in some attributes of ecological integrity, no evidence was available because studies to assess impacts are on-going. Other NIS are observed in the rocky intertidal habitat in CINMS, but do not appear to be increasing in abundance or having significant ecological impacts at this time (Blanchette et al. 2015; Appendix F: Figure App.F.14.1). In contrasts, recently detected NIS in CINMS, the bryozoan *Watersipora* spp. and kelp *Undaria pinnatifida,* are emerging concerns because they have become invasive elsewhere in the world.

The following provides new information on the status of NIS that most influenced discussion and rating decisions during the expert workshop. Additional information on recent abundance levels and long-term trends is available in Appendix F: Living Resources Graphs.

Sargassum horneri is a fast-growing brown alga (kelp) native to eastern Asia that has the potential to cause severe degradation to native kelp forest communities in the sanctuary (Figure S.LR.14.1). This species was first detected in southern California in Long Beach Harbor in 2003 (Miller et al. 2007). It was first observed in the sanctuary at Anacapa Island in 2009 and has since spread to new sites (Marks et al. 2015). As of October 2016, it is established at multiple sites at Anacapa, Santa Barbara, and Santa Cruz islands (Figure S.LR.14.2). In addition, drift has been observed at San Miguel and Santa Rosa islands (L. Marks, UCSB, pers. comm.), but monitoring has not detected established populations at these islands. In 2016, density increased substantially at Anacapa, Santa Barbara, and eastern Santa Cruz Islands (Figure S.LR.14.3), which may have been a response to the warm water event (D. Kushner, CINP, pers. comm.). In addition, researchers monitoring rocky shores on the islands have begun detecting *S. horneri* in the rocky intertidal zone at Anacapa and Santa Barbara islands (S. Whitaker, CINP, pers. comm.).

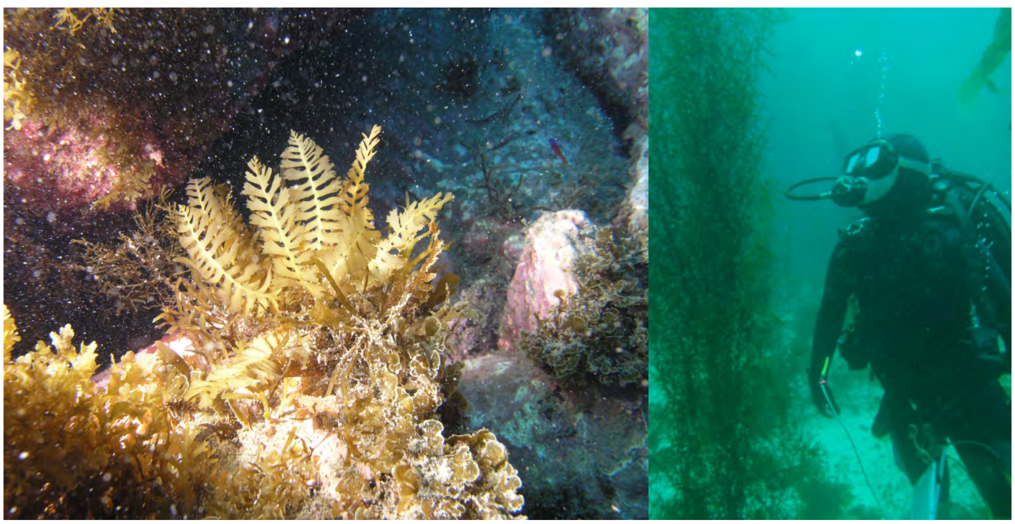

Figure S.LR.14.1. *Sargassum horneri,* an invasive brown algae, has become established at multiple sites in Channel Islands National Marine Sanctuary. Local researchers are studying the abundance, distribution, and ecological impact of this species in the sanctuary. Photos: J. Altstatt/UCSB and NOAA: http://www.eeb.ucsc.edu/pacificrockyintertidal/data-products/invasive-species/index.html

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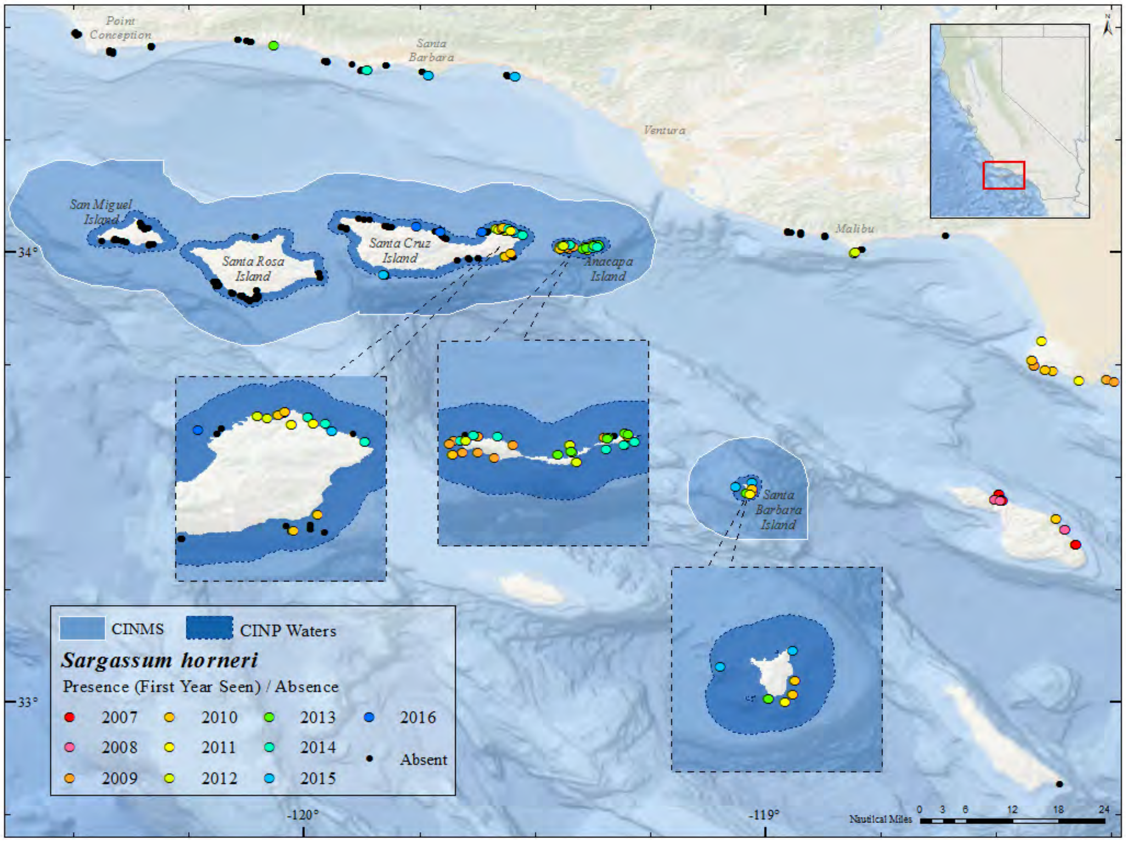

Figure S.LR.14.2. Locations where the invasive kelp *Sargassum horneri* has been observed in the Southern California Bight. The color of circles denote the year *Sargassum* was first seen while black circles indicate sites where it has not been observed. Data source: CINP, PISCO, and SBC LTER data courtesy of L. Marks/ UCSB; Map: M. Cajandig/NOAA

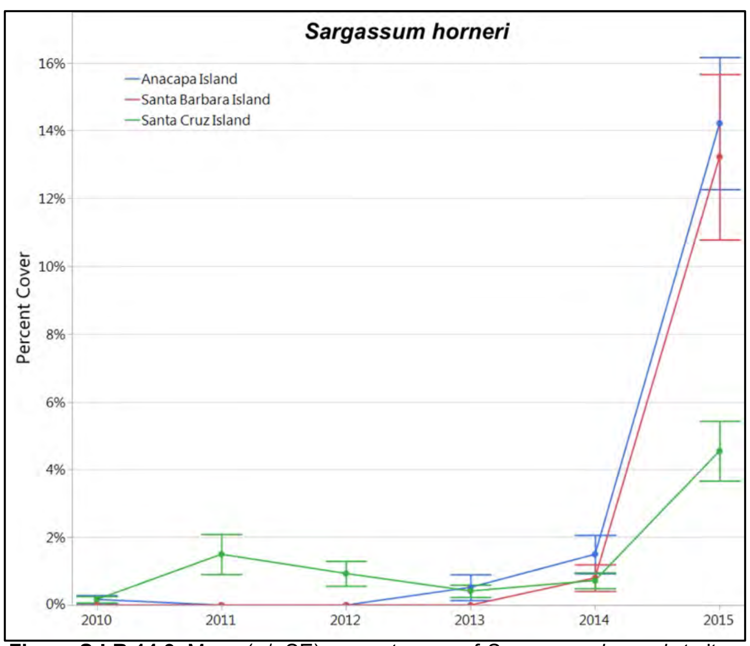

Figure S.LR.14.3. Mean (+/- SE) percent cover of *Sargassum horneri* at sites monitored by Channel Islands National Park at Anacapa (blue), Santa Barbara (red), Santa Cruz (green) islands. Cover has recently increased at all three islands. Figure: Channel Islands National Park

Potential impacts of seasonally tall and dense subtidal thickets of *S. horneri,* including domination of available space and light blockage, are a concern for CINMS based on observations of sparse native species assemblages within *Sargassum* thickets at Santa Catalina and San Clemente islands (J. Engle, UCSB, pers. comm.). Research is underway to directly assess impacts of this NIS on the ecological integrity of kelp forest communities in CINMS (L. Marks, UCSB, pers. comm.). Thus far, intertidal *S. horneri* has been relatively small and sparse, with no known impacts on tidepool communities

Another NIS of concern is *Watersipora* spp.,[17] a Japanese bryozoan that has the potential to colonize natural and manmade hard substrates (Figure S.LR.14.4). In 2011, *Watersipora* was observed for the first time in the sanctuary during kelp forest surveys by Channel Islands National Park (Sprague et al. 2013). In 2017, *Watersipora* was observed at only two of the sites monitored by the park, Cathedral Cove on Anacapa Island and Fry's Harbor on Santa Cruz Island (J. Sprague, CINP, pers. comm.). A recent study surveyed oil platforms and natural reefs in the Santa Barbara Channel for the presence of *Watersipora* (Page et al. 2016). Of the 15 natural reefs surveyed in CINMS, *Watersipora* was observed in low density patches at two sites at Santa Cruz Island; it was also observed on artificial surfaces (e.g., pier pilings) at two sites (see Appendix F: Figure App.F.14.5). Based on available information, it is unlikely that this species currently has any significant ecological impacts on sanctuary resources. Current studies are examining the likelihood of spread from oil platforms where this species is much more abundant (Page et al. 2016, Viola et al. 2016).

Figure S.LR.14.4. The opalescent nudibranch *Hermissenda crassicornis* crawls over the red invasive bryozoan *Watersipora spp.* This invasive Japanese bryozoan has been observed on many oil platforms in the Santa Barbara Channel and on a couple of natural reefs and pier pilings in Channel Islands National Marine Sanctuary. Photo: S. Lonhart/NOAA

The Japanese brown alga *Undaria pinnatifida* is another NIS of concern due to its potential to quickly colonize and reach high densities in intertidal and subtidal habitats.[18] *U. pinnatifida* is listed as one of the world's 100 worst invasive alien species by the International Union for the Conservation of Nature (IUCN) (Lowe et al. 2000). First found growing in Los Angeles Harbor in 2000, it has since spread to other harbors in southern California and northward to harbors in Monterey and San Francisco. During surveys in June and July 2016, many *Undaria* plants, ranging from juveniles to reproductive adults, were found at depths ranging from 30 to 50 feet at Keyhole, a long-term monitoring site on the north side of West Anacapa Island (Figure S.LR.14.5, D. Kushner, CINP, pers. comm.). *Undaria* was growing on all types of substrate, including rocky reef, bedrock, cobble, and sand. Additional monitoring effort and ecological studies of the impacts of this very new invasion are needed.

It is possible that additional NIS occur in beach or soft-bottom habitats, but that information is not readily available either due to lack of study or limited public availability of the data. Pelagic species not typically found in CINMS were observed in the sanctuary region during the recent, protracted warm-water events from 2014 to 2016 (see details on these shifts in biodiversity presented in Question 15); however, influx of warm-water species is a typical occurrence during warm water events and there is no information to indicate that any NIS pelagic species have taken up prolonged residence in the sanctuary region.

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[17] Center for Research on Aquatic Bioinvasions and the San Francisco Estuary Institute. The exotics guide: non-native marine species of the North American coast, *Watersipora subtorquata*, Retrieved from: http://www.exoticsguide.org/watersipora_subtorquata (last visited Apr. 14, 2018).

[18] Multi-agency Rocky Intertidal Network. Invasive species monitoring. Retrieved from: http://www.eeb.ucsc.edu/pacificrockyintertidal/data-products/invasive-species/index.html (last updated July 27, 2017).

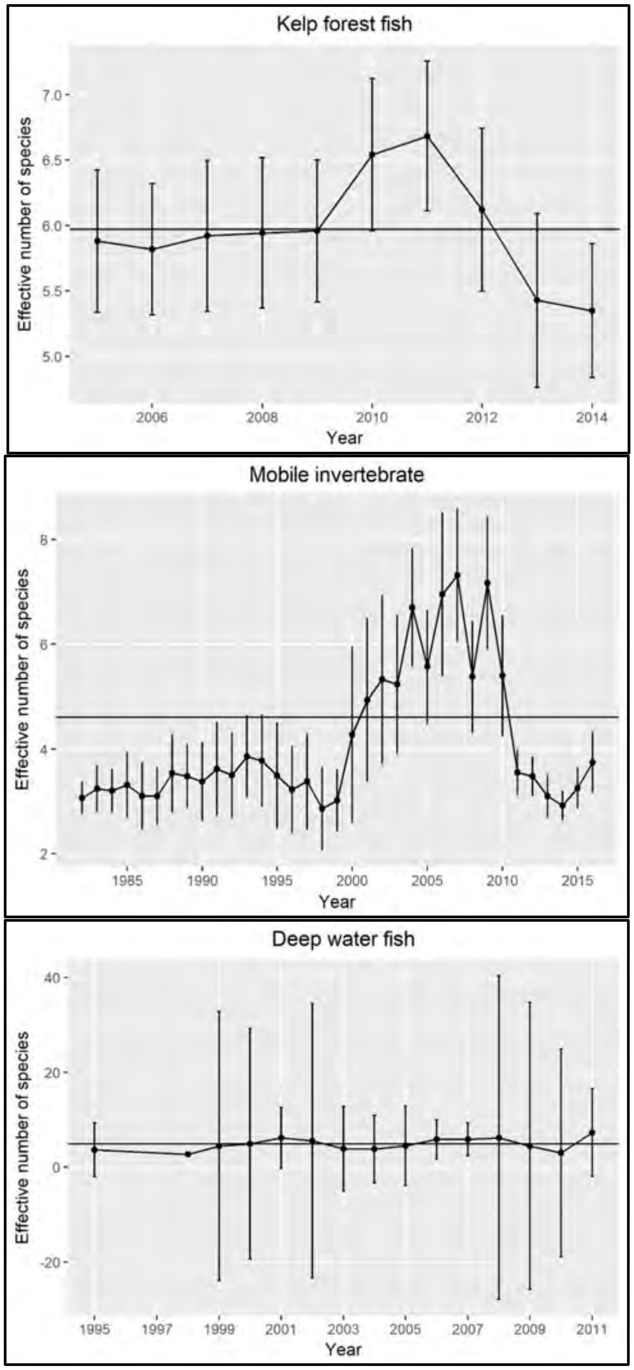
Figure S.LR.14.5. *Undaria pinnatifida*, an invasive brown alga, was first observed in Channel Islands National Marine Sanctuary in June 2016. The Channel Islands National Park Kelp Forest Monitoring Program made these observations during SCUBA surveys at Keyhole, a site on the north side of West Anacapa Island. *Undaria* can be identified in the photos as the brown algae with a distinct mid-rib on a flat, wide blade. Photos: Channel Islands National Park

15. What is the status of biodiversity and how is it changing?

Native biodiversity in the sanctuary was substantially altered prior to sanctuary designation by human-caused local extinction or severe reduction of island-associated populations of nesting seabirds, predatory birds, and marine mammals. While many of these populations are recovering to varying degrees due to state and federal regulatory protections, harvest of fish (e.g., sheephead, giant sea bass, rockfish) and invertebrates (e.g., lobster and all species of abalone) has altered biodiversity and simplified community structure (e.g., dominance of urchins and brittlestars). During development of the 2009 condition report, the recent (2004, 2006 and 2007) implementation of state and federal marine reserves and conservation areas within the sanctuary was assumed to further facilitate recovery of reduced populations based on monitoring results from the first five years of protection (CDFG et al. 2008). However, it was acknowledged that more time in protected status would be needed in order track and assess the impact of those changes on biodiversity. This contributed to the status of native biodiversity in the sanctuary being rated fair with an undetermined trend.

On-going monitoring in rocky intertidal, subtidal seafloor, and pelagic habitats provides additional information on the complex nature of trends in species abundance and community composition. Some of these trends may have a persistent, strong influence on community structure and function. For example, sea star wasting syndrome (see Question 12) led to a dramatic decline in sea stars beginning in 2013. The influential role sea stars have on structuring rocky intertidal and subtidal habitats may result in overall changes to biodiversity. Conversely, anomalously warm conditions in 2015 (see *The Warm Water Event*) led to high species richness and diversity in the pelagic community due to an influx of warm-water associated species. Biodiversity in marine reserves appears to be changing to that of a system less impacted by extraction; however, areas outside reserves do not show similar changes (see *MPA Effects*). More time is needed to determine if these changes in biodiversity will persist; therefore, the status for 2016 remains fair (medium confidence) with an undetermined trend (high confidence).

The following provides newly available information on the status and trends in biodiversity in the sanctuary, with a focus on material that has not already been presented in the responses to Questions 12 and 13. Additional information on biodiversity status and trends is available in Appendix F: Living Resources Graphs.



The Santa Barbara Channel Marine Biodiversity Observation Network (SBC MBON) compiled data from multiple sources to develop biodiversity metrics for kelp forest fishes, mobile demersal invertebrates, and deep-water fishes in the sanctuary (Figure S.LR.15.1). The diversity observed for kelp forest fish showed variability between 2010 and 2014 as compared to prior years, but not drastically outside the range of diversity observed over the entire time series. During the current assessment period (post-2009), a community with a lower diversity of mobile invertebrate species was observed compared to the period between 2001 and 2010 when diversity was notably higher, but similar to the diversity observed during the period from 1982 to 2000. The diversity of deep-water fish species observed has high variability within years but on average has appeared to be fairly stable over time.

Species richness and diversity of the faunal assemblages in CINMS are influenced by multiple factors, including short- and long-term changes in ocean conditions. The sanctuary is located near the significant biogeographic boundary of Point Conception which results in a faunal community that is composed of a mix of species associated with either warmer southern or cooler northern conditions. As ocean temperature warms with changes in global climate, one would expect to see the range of some warm-affiliated species expand while the range of some cool-affiliated species contracts both northward and westward across the sanctuary region.

Figure S.LR.15.1. Mean annual effective number of species for three taxonomic groups: kelp forest fishes (top), mobile demersal invertebrates (middle), and deeper water fishes (bottom). Shannon-Weiner diversity was converted to effective numbers of species, which allows for a more direct and intuitive comparison of community diversity over time. Kelp forest fish were surveyed across 86 shallow reef sites (3 to 16 meters depth) around the four northern Channel Islands from 2005 to 2014. Mobile invertebrates were surveyed across 63 shallow reef sites (3 to 16 meters depth) around the four northern Channel Islands from 1982 to 2016. Deep-water fish were surveyed at three reefs off the Channel Islands (Piggy Bank, Footprint, and Anacapa passage) at depths ranging from 40 to 407 meters in 1995 and annually between 1998 and 2011. Error bars indicate the 95 percent confidence interval in a given year. The horizontal line is the mean across sites over time. Data source: Amalgamated dataset of SBC LTER, CINP Kelp Forest Monitoring Program, and PISCO; Figure: SBC MBON

To understand this potential, CINMS has developed an indicator to track species assemblage changes in response to changing climate variables. The relative abundance of warm:cool species, or thermal ratio, of the kelp forest fish assemblage at each island in CINMS was determined through an analysis of PISCO and CINP long-term monitoring data. The fish assemblages at islands to the east, Anacapa and Santa Cruz, have a higher thermal ratio than the western islands, Santa Rosa and San Miguel (Figure S.LR.15.2). This pattern is consistent with the thermal gradient in water temperature in the southern California Bight (see Figure S.WQ.6.1a). Santa Cruz Island is highly variable possibly because it is located in a transition zone in the thermal gradient around the islands, which may make the fish community at this island more susceptible to the influence of climate change.

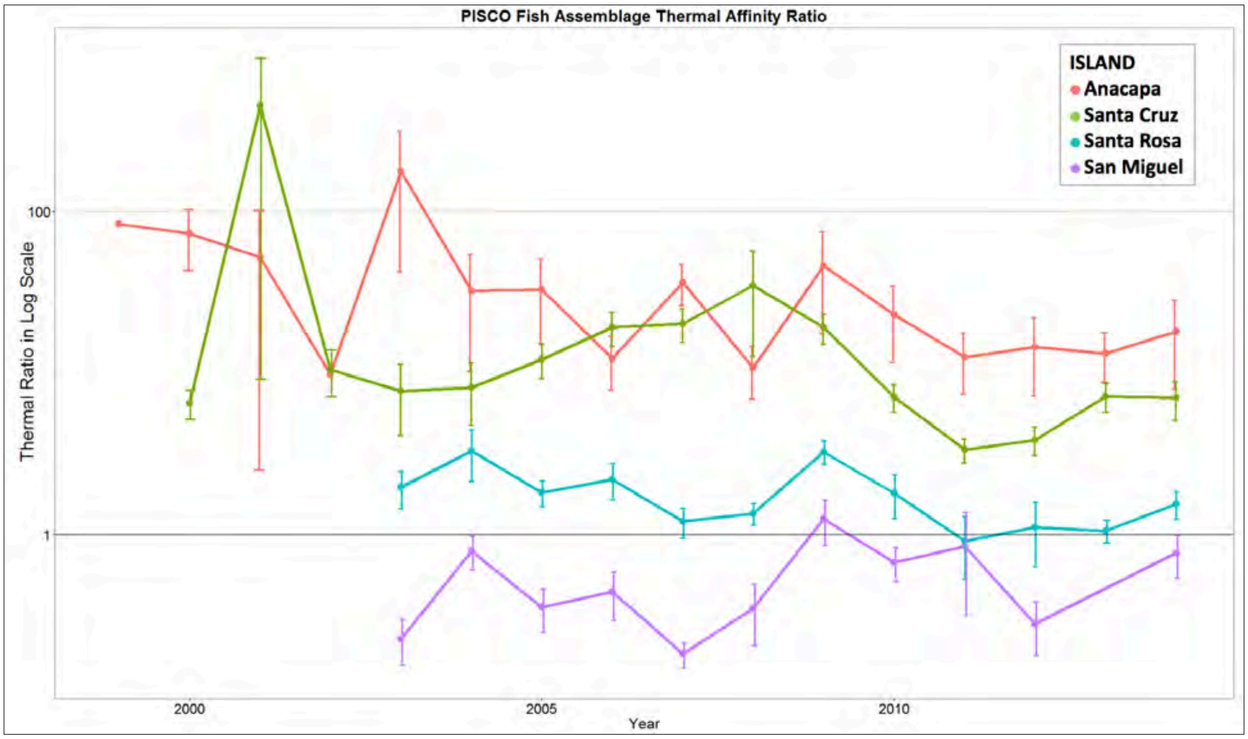


Figure S.LR.15.2. The thermal ratio of the kelp forest fish assemblage shows the relative proportion of the fish community that has a southern (cooler) vs. northern (warmer) affiliation. Islands to the east - Anacapa (orange) and Santa Cruz (green) have a higher ratio of warm:cool species than Santa Rosa (blue) and San Miguel (purple) which are to the west. Santa Cruz Island is highly variable possibly because it is in a transition zone in the thermal gradient around the islands, which may make the fish community at this island more susceptible to the influence of climate changes. Note the log scale for the Y-axis. Data source: PISCO and CINP kelp forest monitoring programs; Figure: R. Freedman/NOAA

Larval fishes in the pelagic habitat are another faunal group that can be strongly influenced by changes in ocean conditions. The California Cooperative Oceanic Fisheries Investigations (CalCOFI) monitoring program has been sampling the ichthyoplankton community off southern California each spring and summer since 1978. The larval fish assemblage contains a mix of species affiliated with cooler and warmer waters and the relative abundance of these groups fluctuates over time (Wells et al. 2014). Cool-water species have increased in abundance over the last ten years (Figure S.LR.15.3), and surprisingly, did not decrease during the anomalously warm conditions that were observed from 2014 to 2015 (see *The Warm Water Event*). In addition, the abundance of warm-water (offshore) species increased in 2015 (Figure S.LR.15.3). Similar increases of warm-water species have been observed during past El Niño events due to an influx of central Pacific species to waters over the continental shelf (McClatchie et al.

2016b). High abundance of many larval fish faunal groups appears to have contributed to a recent spike in species richness; however, species diversity (Gini-Simpson Index) was also high in 2015 (Figure S.LR.15.3) suggesting that this spike in species richness was not due to rare species, but instead all species groups — warm, cool, and central Pacific — being relatively abundant (A. Thompson, NMFS SWFSC, pers. comm.).

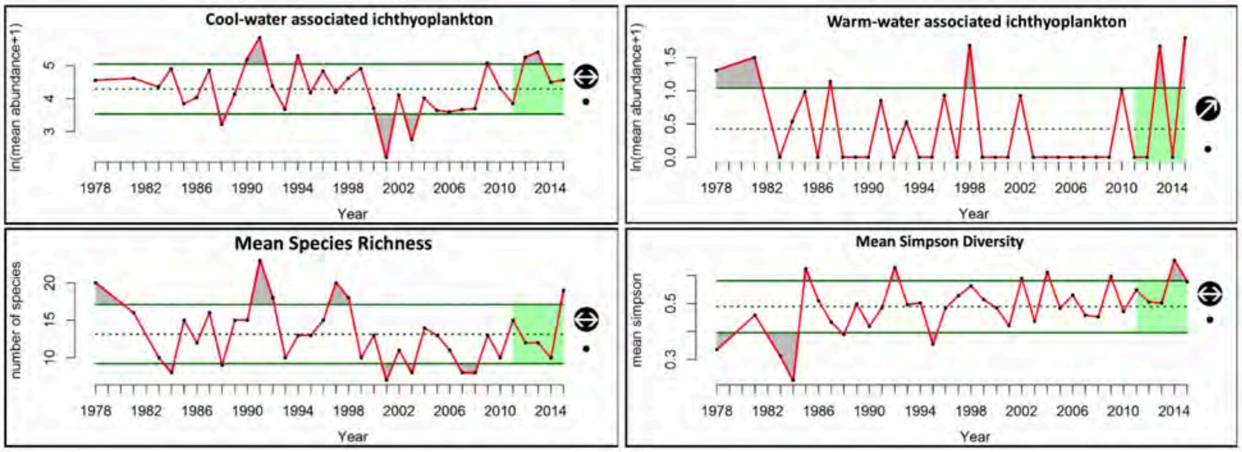


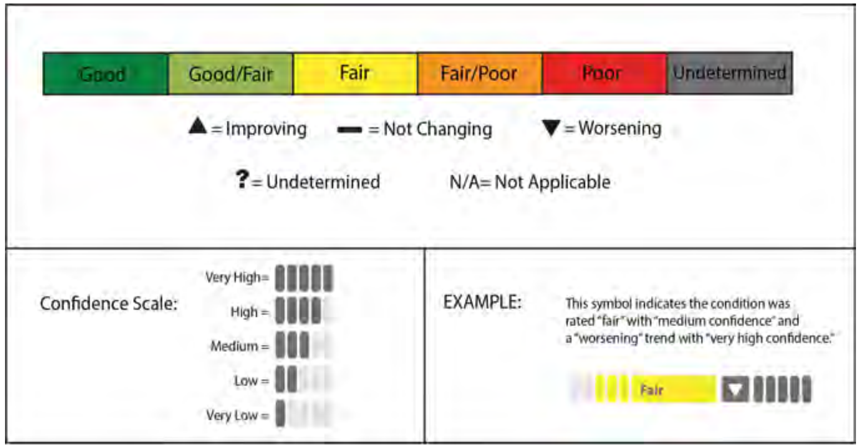
Figure S.LR.15.3. (Top) Mean abundance of (left) cool-water associated and (right) warm-water associated ichthyoplankton (larval fishes) collected in net samples during CalCOFI cruises in spring and summer at sites in the Channel Islands National Marine Sanctuary region from 1978 to 2015. (Bottom) The average species richness (left) and species diversity (right) in each net sample is shown for the entire time series. Gini-Simpson diversity (1-λ form) is a measure of the equitability of species in a sample. When individuals are well-distributed among species, Gini-Simpson diversity is high. Graph format is explained in Figure S.LR.12.4. Data source: CalCOFI; Figure: A. Thompson/NOAA

The warm water event also influenced the relative abundance of warm-water species at higher trophic levels including predatory fish, seabirds, and marine mammals. For example, there were increased sightings of species not usually observed in the region, except during El Niño events, such as hammerhead sharks and green sea turtles. In addition, pygmy killer whales were sighted for the first time ever 150 miles west of the Channel Islands.[19] In addition to unusual species, this period of extended warming resulted in strandings or local declines in some species that do well in a colder, more productive ocean (McClatchie et al. 2016a, b).

Less is known about biodiversity patterns in the sanctuary's nearshore and offshore soft bottom habitats. Based upon collections of infauna by Southern California Coastal Water Research Project (SCCWRP) in 2013, there appears to have been a change in community composition since 1998 (K. Schiff, SCCWRP, unpubl. data, Appendix F: Figure App.F.15.4). These changes may reflect changes in regional stressors (e.g., pollutants or physical disturbance), as well as climatic drivers (i.e., global warming and ocean acidification). Continued monitoring efforts designed to identify potential stressors will be needed to determine if the recently observed changes in the condition and composition of the soft bottom invertebrate community are on-going or a short-term anomaly. Additional long-term monitoring efforts focused on other assemblages that inhabit soft bottom sediments would be useful to further explore status and trends in biodiversity in these extensive sanctuary habitats.

[19] Agha, M. Dec. 13, 2014. Ocean scientists find unusual species off California's coast. The Sacramento Bee. Retrieved from: http://www.sacbee.com/news/state/california/article4473722.html.

Living Resources Status and Trends



#	Issue	Rating	Basis for Judgment	Description of Findings
12	Keystone and Foundation Species		Severely reduced abundance of sea stars and key pelagic forage species, and reduced abundance of lobster and sheephead in areas open to harvest, may impact ecological integrity at some locations. Other keystone and foundation species are stable or increasing.	The status of keystone or foundation species suggests measurable, but not severe degradation in some attributes of ecological integrity.
13	Other Focal Species		Some focal species absent or substantially reduced, which may reduce ecological function, but recovery happening for some species or in some locations. Trends variable across focal species; some stable or increasing while others have declined since 2009.	Selected focal species are at reduced levels, but recovery is possible.
14	Non-indigenous Species		Several non-indigenous have been observed at one or more sites in sanctuary since 2009. *Sargassum horneri* has spread to three islands and is increasing in abundance with potentially negative consequence for native kelp communities.	Non-indigenous species have caused measurable, but not severe degradation in some attributes of ecological integrity.

15	Biodiversity		A few recent changes in abundance of key species may impact biodiversity; however, more time is needed to determine if they will persist. Shallow habitats, deep habitat, and pelagic habitats show different trends in biodiversity.	Selected biodiversity loss or change has caused measurable, but not severe degradation in some attributes of ecological integrity.

Multi-Agency Rocky Intertidal Network (MARINe)

The Multi-Agency Rocky Intertidal Network (MARINe) is a partnership of agencies, universities, and private groups committed to determining the health of the rocky intertidal habitat along the West Coast of North America and providing this information to the public. MARINe monitors over 100 coastal sites and many of the sites have been monitored for periods of 15 to over 25 years. MARINe represents the largest program of its kind. For more information about MARINe, visit http://www.marine.gov/index.htm.

Marine Biodiversity Observation Network (MBON)

The Marine Biodiversity Observation Network (MBON) is a global initiative composed of regional networks of scientists, resource managers, and end-users working to integrate data from new and existing long-term programs to improve our understanding of changes and connections between marine biodiversity and ecosystem functions. The Santa Barbara Channel MBON (SBC MBON) is one of three U.S. MBON demonstration projects (http://www.marinebon.org). SBC MBON is integrating new information with existing data to improve current research and monitoring programs and provide greater insight into marine biodiversity (http://sbc.marinebon.org).

Maritime Archaeological Resources (Questions 16–17)

Archaeological resources are material evidence of past human activities and include vessels, aircraft, structures, habitation sites, and objects created or modified by humans. Question 16 assesses the integrity of known maritime archaeological resources in the sanctuary. The integrity of an archaeological resource refers to its ability to help scientists answer questions about the past through archaeological research. Question 17 addresses the risk of the potential release of hazardous materials by shipwrecks as they age and deteriorate.

16. What is the archaeological integrity of known maritime archaeological resources and how is it changing?

The 2016 status of the integrity of submerged maritime archaeological resources is rated fair with a worsening trend due to past looting of resources located in shallow water and continued natural deterioration that has occurred to all maritime archaeological resources. This status and trend rating is unchanged since the 2009 condition report.

A comprehensive inventory of archaeological resources began at the time of sanctuary designation in 1980 and continues today. Approximately 30 archaeological site locations have been inventoried and are in various stages of survey, including site map development and monitoring (see Figure SH.28). Archival research suggests over 140 historic maritime archaeological resources, including ship and aircraft wrecks, may exist in the sanctuary (Morris and Lima 1996). Most of the reported shallow-water sites are in various stages of degradation due to their close proximity to shore. Sites in shallow-water environments within higher energy zones are more likely to be subjected to degradation by waves, shifting sands, and strong currents. Some sites are regularly visited by divers and in some cases, artifacts have been removed from accessible sites. Shallow-water relic hunting has declined due to enforcement, education, and the fact that most of the accessible sites have already been pilfered. The larger and more prominent shipwrecks that are known to have stranded at the islands have all been surveyed, with the exception of the four-masted wooden lumber schooner *Watson A. West* that grounded on the west end of San Miguel Island in 1923 (Figure S.Mar.16.1). Based on archaeological surveys of the three-masted wooden lumber schooners, *J.M. Colman* lost in 1905, and *Comet* lost in 1911, both at San Miguel Island, the site characterization of the *Watson A. West* would be similar. The remaining inventory of historic vessels not located and surveyed, for the most part, represent smaller wooden vessels that would be subject to the same rate of degradation in a shallow-water environment. The sanctuary's Shipwreck Reconnaissance Program contributes to scientific knowledge and enhancement of management practices related to underwater archaeological resources by encouraging research and monitoring efforts, by utilizing Federally-certified scuba divers for year-round monitoring of submerged sites through cooperative partnerships with Channel Islands National Park, California State Lands Commission, and Coastal Maritime Archaeology Resource organization. Since the 2009 condition report, ongoing degradation of maritime archaeological resources has been documented. One example is a submerged Grumman Af-2W Guardian military aircraft located off Santa Cruz Island. Since the aircraft sunk in 1954, the starboard wing remained partially elevated off the seafloor and attached to the fuselage. During a 2016 site survey, evidence of the starboard wing detached from the fuselage and lying on the seafloor was recorded (Figure S.Mar.16.2).

Submerged cultural material associated with Native American terrestrial sites has been recorded nearshore as a result of coastal land erosion. There is a possibility of Native American submerged materials in deeper water, in areas occupied during times of lower sea levels thousands of years ago, but such resources have not yet been discovered.

There is a greater uncertainty about the integrity of offshore submerged maritime archaeological resources in depths greater than 120 feet (36 meters). To date, only two deep offshore archaeological sites have been inventoried by NOAA in CINMS — World War II-era *TBF-1C Grumman Avenger* (Figure S.Mar.16.3) military aircraft and a shipwreck known as *Bar-bee*, both near Anacapa Island); no other evaluations of deepwater archaeological sites have been conducted by other federal, state, or private resource management agencies. Sites in deep water are naturally in better condition than those in shallow water because they are not impacted by strong currents and the cold, deep-water environment tends to have fewer biological processes accelerating ship degradation; however, because these sites are intact they may be attractive to looters, particularly those with technical diving capabilities who may still be determined to access sites despite recent enforcement efforts in recent years with the successful prosecution of looters by NOAA and NPS in 1987. An additional probable impact in offshore waters is from bottom trawling, but the exact impacts from past trawling are unknown because the majority of wreck locations are unknown. Trawling has recently declined in the sanctuary because with the implementation of marine reserves. Other potential impacts are the placement and retrieval of crab and lobster cage traps that could have an impact to archaeological sites, although the placement of these traps is typically in nearshore environments.

Figure S.Mar.16.1. Four-masted lumber schooner *Watson A. West* lost at San Miguel Island in 1923. Photo: San Francisco Maritime National Historical Park

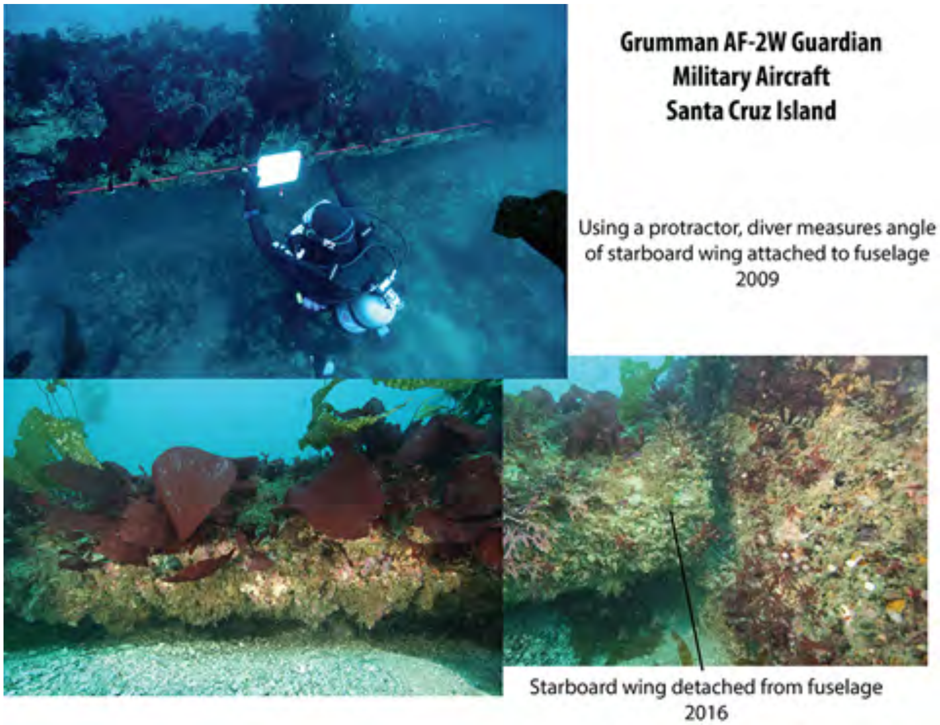


Figure S.Mar.16.2. In 2009, a National Park Service diver using a protractor measured the starboard wing on a Grumman AF-2W sunk off Santa Cruz Island. In a 2016 site survey, the starboard wing is detached from the fuselage and lying on the seafloor. Photos: R. Schwemmer/NOAA

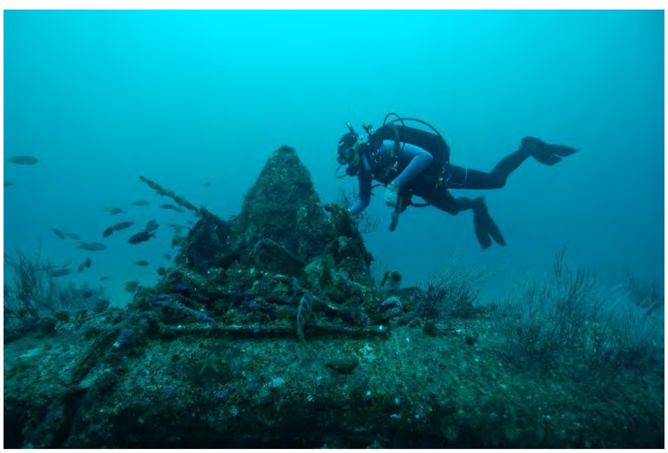


Figure S.Mar.16.3. TBF-1C Grumman *Avenger* military aircraft was lost off Anacapa Island. Photo: R. Schwemmer/NOAA

17. Do known maritime archaeological resources pose an environmental hazard and how is this threat changing?

The sanctuary's inventory of known maritime archaeological resources suggests it is unlikely that shipwrecks within sanctuary boundaries have the potential to pose an environmental hazard to sanctuary resources due to hazardous cargoes and/or bunker fuels; therefore, this question is rated good/fair with a not changing trend (the 2009 rating for this question was good/fair and improving). In 2013, NOAA presented the U.S. Coast Guard with a national report that found 36 sunken vessels scattered across the U.S. seafloor that could pose an oil pollution threat to coastal and marine resources; the report did not identify any shipwreck pollution threats within the sanctuary.

Shipwrecks that once had the capacity to hold bunker fuel and hazardous cargoes have been surveyed and are no longer considered to pose a threat because degradation of hull structure has allowed materials to dissipate. A greater threat to sanctuary resources is from shipwrecks in the contiguous waters just outside the sanctuary. For example, the bulk-carrier *Pacbaroness* that sank approximately ten nautical miles northwest of the sanctuary after a collision in 1987 carried a cargo of 21,000 metric tons of finely powdered copper concentrate, 339,360 gallons of fuel oil, and 10,015 gallons of lubricating oil. Due to the prevailing current and wind, the oil was transported in close proximity of San Miguel Island, considered to be one of the most biologically rich of the islands within the sanctuary. A northerly flowing current became predominant over the wind and carried the oil away from the sanctuary before it reached shore. Since the 2009 condition report, there have been no surveys conducted at the shipwreck site of the *Pacbaroness*; the last ROV survey was conducted by NOAA and the U.S. Navy in 2002. Other submerged vessels that could pose a threat may include those that have been scuttled by the military as target ships and/or to dispose of weapons. A military disposal site, which may include target vessels, target ships, munitions, or other materials, exists off Santa Cruz Island outside of the sanctuary; research to date has not identified the existence of hazardous maritime archaeological resources.

Maritime Archaeological Resources Status and Trends

Good	Good/Fair	Fair	Fair/Poor	Poor	Undet.

▲ = Improving — = Not changing ▼ = Worsening

? = Undetermined trend N/A = Question not applicable

#	Status	Rating	Basis for Judgment	Description of Findings
16	Integrity*	Fair ▼	Past looting of some shallow sites and continued natural deterioration of all sites contribute to declining integrity; integrity of deeper wrecks is unknown, but some accidental fouling by fishing gear may have occurred.	The diminished condition of selected archaeological resources has reduced, to some extent, their historical, archaeological, scientific, or educational value, and may affect the eligibility of some sites for listing in the National Register of Historic Places.
17	Threat to Environment*	Good/Fair —	Sites just outside sanctuary boundaries pose a greater threat from leaching chemicals, such as bunker fuels and cargos.	Selected maritime archaeological resources may pose isolated or limited environmental threats, but substantial or persistent impacts are not expected.

**Note that a confidence score was not assigned to the Maritime Archaeological Resource questions (16, 17) because subject matter experts were not consulted on these ratings. Due to a limited number of experts in this field, and Office of National Marine Sanctuaries (ONMS) in-house experts available, ONMS internally evaluated these questions. Two archaeological experts with the ONMS Maritime Heritage Program determined the Maritime Archaeological Resource question ratings; these subject experts have been monitoring existing archaeological sites since the 1980s, as well as recording new discoveries.*

STATE OF ECOSYSTEM SERVICES

Introduction

Ecosystem services are the benefits that humans receive from natural and cultural resources. Generally, the taxonomy of the Millennium Ecosystem Assessment (MEA 2005) is used in ONMS condition reports (ONMS 2015). MEA (2005) was an initiative of the United Nations to assess ecosystem services including cultural, provisioning, regulating, and supporting services. Categories of ecosystem services include "final" services, which are directly valued by people, and "intermediate" services, which are ecological functions that support final services (Boyd and Banzhaf 2007). In ONMS condition reports, only final ecosystem services are rated, which is consistent with the anthropogenic focus of the reports and highlights priority management successes and challenges in sanctuaries. The complete definitions of ecosystem services considered by ONMS are included in Appendix H.

Final vs Intermediate Ecosystem Service

Nutrient balance leads to clearer water and higher visibility for snorkeling and scuba diving. Nutrient balance is an intermediate service that supports the final ecosystem service of non-consumptive recreation via snorkeling and scuba diving.

Twelve final ecosystem services may be rated in ONMS condition reports

Cultural (non-material benefits)

1. Sense of place — Aesthetic and spiritual attraction, and the level of recognition and appreciation given to efforts to protect a place's iconic elements
2. Non-consumptive recreation — Experiential opportunities that include recreation and community activities
3. Consumptive recreation — Experiential opportunities that result in resource removal
4. Science — The capacity to acquire information and knowledge
5. Education — The capacity to provide intellectual enrichment
6. Heritage — Recognition of historical or heritage legacy

Provisioning (products and supplies)

7. Food supply — The capacity to support market demands for nutrition-related commodities through various fisheries
8. Water — Filtration for drinking water that minimizes pollutants, including trash, nutrients, sediments, pathogens, and chemicals
9. Ornamentals — Resources collected for decorative or aesthetic purposes
10. Biotechnology — Medicine and other chemicals found in sanctuary animals or plants, or manufactured from them
11. Energy — Use of renewable materials or processes to supply energy

Regulating (buffers to change)

12. Coastal protection — Flow regulation that protects habitats, property, coastlines, and other features

For CINMS, only seven of the 12 “final” ecosystem services are rated. Specifically, all of the cultural services are rated: sense of place, consumptive recreation, non-consumptive recreation, science, education, and heritage. There is only one provisioning service rated in CINMS, which is food supply via commercial fisheries. The sanctuary does not provide “final” ecosystem services for other provisioning services: ornamentals used by the aquarium trade, biotechnology, alternative energy, or clean water. Similarly, sanctuary resources do not significantly influence coastal protection (a regulating ecosystem service that involves protection of property values from damaging storms).

Notes: *(1) Some consider consumptive recreational fishing as a provisioning service, but it is included here as a cultural ecosystem service. (2) Although biodiversity was listed as an ecosystem service by both MEA (2005) and ONMS (2015), ONMS decided to remove it, recognizing that biodiversity is an attribute of the ecosystem for which many “final” ecosystem services depend (e.g., recreation and food supply); therefore, it is addressed in the State section of this report. and (3) Although ONMS listed climate stability as an ecosystem service in 2015, it is no longer considered in ONMS condition reports; national marine sanctuaries are not large enough to influence climate stability (Fisher, Turner, and Morling 2008, Fisher et al. 2011).*

Ecosystem Services Indicators

The status and trends of ecosystem services are best evaluated using a combination of economic and non-economic human dimension indicators, as well as relevant ecological/resource indicators evaluated in the State section of this report, to assess the compatibility and sustainability of services relative to the condition of impacted resources.

Economic Indicators

Economic indicators may include direct measures of use (e.g., person/days of recreation or catch levels) that result in spending, income, jobs, gross regional product, and tax revenues, or non-market economic values (the difference between what people pay to use a good/service and what they would be willing to pay).

There are other measures, often referred to as indirect measures, that can impact resources in and around the sanctuary but are not a measurement of the direct use of resources. For example, as populations and per capita incomes increase in the U.S., California, and counties surrounding CINMS, demand for recreation and commercial fisheries’ products would be expected to increase (Bell 1978). In addition, demand in China for seafood products originating off the West Coast of California is so high that population and per capita incomes in China can similarly serve as good indicators of the status and trends for this provisioning service (Bell 1978). The status and trends for science (Sobel 1996, Dixon and Sherman 2009), education (Sobel 1996, Parsons 1997, and Dixon and Sherman 2009), and heritage (Mires 2014) services may also correlate with changes in populations and per capita income in the U.S., California, and local areas surrounding CINMS. In short, people create demand for goods and services, and higher incomes can lead to investments, making these useful indicators for these services.

In addition to population and per capita income, fuel prices can serve as indirect measures of recreational demand at CINMS because the only way to gain access to the sanctuary’s offshore location for recreational purposes is by boat (Gornik et al. 2013). Thus, fuel prices can be a predictor of recreational use by boaters. For example, decreasing or stable fuel prices could support increasing use of CINMS by recreational boaters.

Fuel prices can also affect the cost of production in commercial fisheries, thus impacting food supply. Higher fuel prices might lead fishermen to move closer to port fishing areas outside the sanctuary, thus taking pressures off CINMS fishery resources, thereby decreasing the economic contributions from commercial fishermen previously generated in CINMS. If this potential redistribution of effort from higher fuel prices results in an overall decline in effort (both off and near shore) and fish stocks subsequently increase, it could increase the resources available for food supply in CINMS, too.

In evaluating the above types of economic indicators, it is also important to consider "passive economic use values" (also called "non-use values"), which are an important element in evaluating sense of place. Passive economic value is the value people would be willing to pay for resources to stay in a certain condition, even though they may never actually directly use them. Estimating these values requires the use of surveys that integrate social science information with physical and natural science information in the definition or change in goods or services of value to people. Economic valuation methods (Louviere, Hensher and Swait, 2009, Bishop et al. 2011) can be used to estimate passive economic use value. This kind of research, however, can be expensive, time consuming, and rarely available; as a proxy, some scientifically designed public polls on people's preferences for environmental protection and restoration can serve instead as good indicators for this value.

Non-Economic Indicators

Human dimension non-economic indicators can be used to complement the economic indicators discussed above. These include importance-satisfaction ratings for natural and cultural resources; facilities and services for recreation uses; limits of acceptable change for resource conditions; social values and preferences (measured by polls); social vulnerability indicators; perceptions of resource conditions in the present and expectations for the future; supply of facilities; and access to resources. For CINMS, few studies have measured most of these non-economic indicators, representing a major gap in socioeconomic research and understanding; nevertheless, some non-economic human dimensions indicators are available. For example, to rate the status and trends of science and education, indicators used in this report include the number of scientific permits, the number of publications, the number of classes and students served, and the value of educational programs.

Ecological/Resource Indicators

Ecological/resource indicators are used in determining the status and trend ratings for each ecosystem service. For each ecosystem service, a matrix was developed mapping relevant ecological/resource indicators to each ecosystem service. To rate the status of each ecosystem service, ecological/resource indicators might be used to downgrade a rating based on economic and human dimension non-economic indicators; this is because the ecological/resource indicators suggest that humans are cutting into the stock of natural or cultural resources to get short-term economic gains that are not sustainable. In assessing trends, there is often limited data on economic and human dimension indicators. In these cases, ecological/resource indicators may serve as a substitute to provide sufficient information to allow trends to be rated.

Expert Review Process

Socioeconomists at ONMS Headquarters used indicators for each ecosystem service and developed a preliminary rating and summary report on status and trends using the criteria in Appendix H. Following CINMS staff review, the report was sent to external experts. These experts were asked to provide their ratings using the criteria in Appendix H. ONMS socioeconomists then used the experts' input to develop the final ratings included in this report.

Chumash Ecosystem Services Assessment

Chumash people from the local community bring a unique and important perspective to the ecosystem values they associate with the sanctuary environment. For this assessment, representatives from the Chumash Community seat on the CINMS Advisory Council consulted with Chumash people and authored a separate report about the ecosystem values they associate with these important waters. This report is included within this condition report as a standalone supplement to the seven ecosystem services assessed for CINMS.

Sense of Place

The status of sense of place is "Good/Fair," because performance of this service is considered acceptable even though human activity has caused changes that limit the sanctuary's capacity to fully provide this service. The trend is "Stable," because economic indicators are positive and stable, human dimension indicators are increasing or stable, and resource indicators do not indicate there is a decline in the natural or maritime archaeological resources related to this service.

Sense of place is the aesthetic and spiritual attraction, and level of recognition and appreciation, that humans can derive from a location given efforts to protect its iconic elements. Designation as a national marine sanctuary provides the special recognition and appreciation the American public has for protecting the resources in the sanctuary. In addition, CINMS has additional protections with the 13 specially protected zones within the sanctuary.

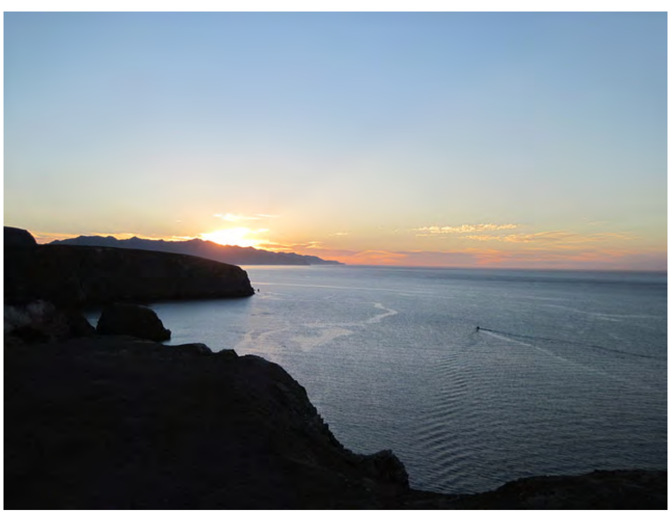


Figure ES.1. Cavern Point is located on Santa Cruz Island. Photo: C. Fackler/NOAA

Non-use or "passive economic use" value is a broad economic expression of the value people have for protecting special places. Generally, estimating these types of values for any place is relatively expensive and thus rarely done; however, existing studies conducted using scientifically sound public surveys have found that environmental attitudes are good predictors of people's non-use of passive economic use value (Aldrich et al. 2007 and Leeworthy et al. 2017); that can serve as good indicators of these values. In addition, studies of non-use and passive economic use values have also found that real per capita income is also a good predictor of people's passive economic use values that can also be used as an indicator of these values (Alberini, Longo, and Veronesi 2006 and Leeworthy et al. 2017).

Economic Indicators

The only CINMS-based study that estimated non-use of passive economic use values focused on the value of avoiding whale deaths from vessel strikes in the CINMS region (Bone et al. 2016). In that study, a national sample was used to estimate the amount of money people would be willing to pay to reduce the number of whale deaths caused by ship strikes if commercial vessels decreased their transit speeds during seasons when whales are known to frequent their transit area. On average, U.S. households were willing to pay $69.92 per household (a one-time payment), which aggregated across almost 134 million households in 2014 yielded a total value of $9 billion. For households that actually visited the CINMS region to view whales, the average household willingness to pay was $24.04 per household; and when aggregated across 31,000 households, the total value was estimated at $755,000. Although whale valuation is only one small component of the total valuation of the resources in CINMS, it can nonetheless demonstrate the significant value of these resources to communities and the nation.

Bone et al. (2016) included the New Ecological Paradigm or New Environmental Paradigm (NEP) index to estimate economic values and found a strong positive statistical relationship for people's willingness to pay to protect whales. Aldrich et al. (2007) and Leeworthy et al. (2017) also used the NEP and found the same result. The NEP is a scientifically sound index of people's environmental attitudes and has been widely used (Dunlap et al. 2000, Dunlap and Van Liere 1978, and Dunlap 2008) to predict visitation at national parks and other types of special places around the world.

In addition to whale valuation, environmental attitudes can also be used as economic indicators to assess the status and trends for the ecosystem service sense of place. Gallup has been conducting scientifically sound public polls tracking people's environmental attitudes, with some going back to 1973. One question posed to the public since 1984 is: "How much protection of the environment should be given priority, even at the risk of curbing economic growth?" Answers have fluctuated over the years, but with an exception for the Great Recession, people have generally preferred environmental protection to economic growth (see Appendix I: Table App.I.1, Figure App.I.1). Another Gallup Poll question asked since 2000 is: "Do you think the U.S. government is doing too much, too little, or about the right amount in terms of protecting the environment?" Again, the answers have fluctuated over time, but the highest proportion of Americans from 2000 to 2017 responded "too little" with the next highest proportion being "about the right amount" and the lowest proportion being "too much" (see Appendix I: Table App.I.2, Figure App.I.2).

Real per capita income (adjusted for inflation) for the U.S., California, and the three-county area (Los Angeles, Santa Barbara, and Ventura) nearest to CINMS has increased from 2000 to 2015 in all three geographies and is forecasted to continue to grow for all three areas to 2030 (see Appendix C: Table App.C.3, Figure App.C.2).

Given the valuation numbers and trends in environmental attitudes and growth in real per capita incomes, the economic indicators suggest a status of Good with an increasing trend.

Non-Economic Indicators

The environmental attitudes cited above can also serve as non-economic indicators of the status and trend for sense of place for how people recognize and appreciate the atheistic and spiritual attraction of the resources in CINMS. There have been no other national studies measuring other non-economic human dimensions indicators.

In a survey of non-consumptive recreators in CINMS by LaFranchi and Pendleton (2008), 76% of respondents either strongly supported (48%) or supported (28%) the marine reserves (no-take zones) designated within the sanctuary. Almost all non-consumptive recreators believed that marine reserves would benefit them. Bone et al. (2016) asked "for hire" operators that specialized in whale watching, "How has the quality of whale watching changed in the past 10 years?" Eighty-five percent felt that the quality had become either much better (65%) or somewhat better (20%). The reason cited was a larger food supply keeping whales in the area year-round that led to more whale sightings, which is an indicator of an increasing trend for this service. Although there is limited information for non-economic indicators for sense of place, the data does suggest that the status is Good with an increasing trend.

Chumash people from the local indigenous community bring a unique and important perspective to the maritime heritage values they connect to the sanctuary environment. For this assessment, a group of Chumash community members connected to representatives on CINMS Advisory Council agreed to separately document the ecosystem values they take from these important waters. Their report will be included in the final version of this report; however, note that the report supplements, but is not part of the rating for this ecosystem service.

Resource Indicators

Several resource indicators from the State section of this report are related to resources that contribute to the sanctuary's sense of place. For example, eutrophic conditions (i.e., excessive plant and algal growth) were rated as "Good" and "Not Changing," and water quality that could affect human health was rated as "Good" and "Not Changing." Although many indicators describe the status of overall water quality for the sanctuary, harmful algal blooms (HAB) in particular may directly affect how users identify or value the sanctuary. HABs have been increasing in frequency since 2001, and unprecedented toxic blooms have resulted in shellfish fishery closures and/or consumption advisories in recent years (App.D.7.1–App.D.7.4). Some HABs have also been linked to marine mammal strandings.

Habitat integrity was rated "Fair" with a "Worsening" trend, and contaminants within habitats was rated "Good/Fair" and "Not Changing." Many visitors participating in water activities, such as snorkeling, diving, and kayaking, are likely expected to see thriving kelp forests and the myriad of life they support. Kelp forests are stable or growing at some sites in the sanctuary, but have been declining at others, contributing to an overall negative trend for the sanctuary for the past several years (App.E.10.1.3–App.E.10.1.9). A potential threat to key habitat-forming species, such as kelp forests, are non-indigenous species that are capable of causing declines, extirpations, or extinctions of native plants and marine life and altering habitats. The status of non-indigenous species was rated "Fair" and "Worsening," because certain alien species in the sanctuary could likely cause degradation to some attributes of ecological integrity. The increased presence of non-indigenous algal species within the sanctuary, particularly *Sargassum horneri* and more recently *Undaria pinnatifida*, raise concerns about potential adverse ecological impacts (App.F.14.1–App.F.14.4); however, such effects within the sanctuary, especially for newly discovered *Undaria pinnatifida*, are largely unknown at present.

Living marine resources were generally rated "Fair" and "Worsening" for all resources except biodiversity. Despite fishing and other human activities that have altered the community composition of the sanctuary (loss of ecosystem engineers, like abalone, and keystone species, like sea stars and otters), the sanctuary's biogeography along with increased protections from MPAs have contributed to the status of the native biodiversity ranking of "Fair." The trend of biodiversity remains undetermined due to the complex nature of the metric. For example, long-term monitoring of California sheephead (App.F.12.12–App.F.12.14) and spiny lobster (App.F.12.10–App.F.12.11), two iconic kelp forest inhabitants, show abundance increases at some islands. Similarly, annual surveys of kelp forest fish biomass that includes kelp rockfish, blue rockfish, kelp bass, Señorita wrasse, and blacksmith show that the average biomass of this fish community has generally increased over the last decade (Caselle et al. 2015, CINP, upubl. data, App.F.13.15–App.F.13.17). In contrast, another two iconic animals that many expect to see in habitats around the sanctuary are abalone (App.F.13.1–App.F.13.2, App.F.13.9–App.F.13.11) and sea stars (App.F.12.2–App.F.12.3, App.F.12.6-–App.F.12.9). Unfortunately, both have suffered devastating declines that are partially due to wasting disease outbreaks, with some evidence pointing to unusually warm temperatures.

Another indicator to consider is marine and beach debris within the sanctuary. Although no trends can be inferred from available data, reports indicate that marine debris is present and persistent despite some beach cleanup efforts, and that beach trash is accumulating on the islands (App.C.3.1–App.C.3.2), which has the potential to alter a visitor's view of the islands' aesthetic.

Seabirds and marine mammals, including whales, dolphins, seals, and sea lions, draw thousands of visitors to the sanctuary each year. Seabird monitoring for most species has been infrequent in the sanctuary since 2009, but some evidence suggests that brown pelican colonies have seen poor reproductive success, with the exception of 2016 (D. Mazurkieqicz, CINP, pers. comm). Across most of the marine mammals' ranges, species are depressed below historical levels due to harvesting, now prohibited, and have been slow to recover. California sea lions, harbor seals, northern elephant seals, and coastal bottlenose dolphin populations have been relatively stable or increasing through 2011–2012 (Carretta et al. 2016). Short-beaked and long-beaked common dolphin observations are highly variable in response to oceanographic conditions but tend to increase in abundance off California during warm water periods, which was reflected in 2014 where abundance estimates for both species were much greater than in previous years (Carretta et al. 2016). Gray whales in the eastern North Pacific, which includes those that migrate through the sanctuary and the Santa Barbara Channel, increased in population size through the early 2000s and have remained stable (Calambokidis et al. 2014). Humpback whale population estimates vary through time but have generally remained stable off the coast of California and Oregon; the Mexico breeding population that feeds off California is listed as threatened (NOAA 81 FR 62259). Lastly, the endangered eastern North Pacific stock of blue whales has also remained relatively stable.

Overall, visitors to the sanctuary are likely to encounter most of the species mentioned above in a relatively robust habitat, and some key species show signs of recovery. The primary degradation of any maritime archaeological resources in CINMS appears to be from natural processes; this may affect future assessments of sense of place, but is not a reason to downgrade the current rating. Considering natural indicators, sanctuary resources do not presently show significant degradation by providing the sense of place ecosystem service.

Summary of Economic, Non-Economic, and Resource Indicators for Sense of Place

Economic Indicators	Source	Figure or Table #	Data Summary
Gallup Poll, Attitudes towards the environment (national surveys)	Gallup News, 2018	Table App.I.1 and Figure App.I.1	With an exception for the Great Recession between 2007 and 2009, people have generally preferred environmental protection to economic growth.
Gallup Poll, attitudes towards the environment (national surveys)	Gallup News, 2018	Table App.I.2 and Figure App.I.2	From 2000 to 2017, the greatest proportion of respondents replied “too little” with the next highest proportion being “about the right amount” in terms of environmental protection.
Real per capita income		Table App.C.1.3 and Figure App.C.1.2	Real per capita income (adjusted for inflation) for the U.S., California, and the three-county area (Los Angeles, Santa Barbara, and Ventura) nearest to CINMS has been increasing from 2000 to 2015 in all three geographies and is forecasted to continue to grow for all three areas to 2030.
Non-Economic Indicators	**Source**	**Figure or Table #**	**Data Summary**
Not available	Not available	Not available	Not available
Resource Indicators	**Source**	**Figure or Table #**	**Data Summary**
Marine debris	SeaDoc; Ocean Defenders; P. Etnoyer, NOS NCCOS; MARE	Table App.C.3.1–App.C.3.2	*Status:* Marine debris is present and persists despite cleanup efforts. *Trend:* Assumed to be increasing in abundance, but no time series data available.
Beach debris	SB Adventure Co.	Table App.C.3.2	*Status:* Anecdotal evidence points to continual accumulation of beach trash. *Trend:* No scientific data available.
Domoic acid levels within the Santa Barbara Channel in invertebrate tissue	C. Culver, CA Sea Grant; McCabe et al. 2016	App.D.7.1–App.D.7.2	*Status:* Domoic acid is present within tissue samples of local fisheries species long after a toxigenic bloom event. *Trend:* Domoic acid events are increasing in frequency.

Pseudo-nitzschia abundance and concentration	Sekula-Wood et al. 2011; McCabe et al. 2016; Plumes and Blooms sampling, analysis by S. Amiri, CINMS; Krause et al. 2013; Cavole et al. 2016; McKibben et al. 2017	App.D.7.1, App.D.7.3, and App.D.7.4b	*Status:* Presence is cyclic and most frequent when upwelling anomalies are positive. 2015 bloom was unprecedented in abundance and spatial extent. *Trend:* Blooms became more pronounced starting in 2001. HAB events seem to be influenced by long-term climatic oscillations (e.g., PDO).
Domoic acid flux (e.g., HAB)	Sekula-Wood et al. 2011; Anderson et al. 2006, 2008, 2009, and 2016; McCabe et al. 2016	App.D.7.4a	*Status:* Presence is episodic. There have been no known human illnesses related to Santa Barbara Channel HABs; however, there have been a number of HAB-related health effects observed in other organisms with nervous systems. *Trend:* HABs are increasing in frequency and spatial distribution. Domoic acid presence peaks became more frequent starting in 2001.
Giant kelp	SBC LTER	App.E.10.13	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.
Giant kelp	Sprague/CINP	App.E.10.14	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.
Giant kelp	UCSB/ Cavanaugh and Bell	App.E.10.15–App.E.10.19	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.
Sargassum horneri observations	Marks et al. 2015b; Pacific Rocky Intertidal NIS interactive map	App.F.14.2–App.F.14.3	*Status: S. horneri* is established at three islands in CINMS, only drift has reached San Miguel Island, but no sightings of established individuals. *Trend:* Increasing in abundance and spreading to new locations in CINMS.
Sargassum horneri density	CINP	App.F.14.4	*Status and Trend:* Increasing abundance at Anacapa, Santa Cruz, and Santa Barbara islands.
Non-indigenous species abundance	Blanchette et al. 2015	App.F.14.1	*Status:* Six non-indigenous species observed at PISCO sites on islands. *S. horneri* is moving up into the intertidal as well.

California sheephead *Semicossyphus pulcher* abundance	PISCO	App.F.12.12	*Status:* Harvested. *Trend:* Density fluctuates over time, but no clear trend across islands.
California sheephead *S. pulcher* abundance	CINP	App.F.12.13	*Status:* Harvested. *Trend:* Recent increase in average density observed at all islands except San Miguel.
California sheephead *S. pulcher* abundance	SBC LTER	App.F.12.14	*Status:* Harvested. *Trend:* Abundance appears to be increasing at the island sites compared to the mainland sites.
Spiny lobster *Panulirus interruptus* abundance	PISCO	App.F.12.10	*Status:* Harvested; low density. *Trend:* Possible recent, gradual increase at Anacapa and Santa Cruz islands.
Spiny lobster *P. interruptus* abundance	CINP	App.F.12.11	*Status:* Harvested; low density. *Trend:* Recent, gradual increase at Anacapa, Santa Cruz, and Santa Barbara islands, no clear trend at San Miguel and Santa Rosa islands.
Kelp forest fish abundance	PISCO	App.F.13.15	*Status:* Harvested; for some species, density varies among islands. *Trend:* Most are stable (within variability of time series), but recent increases for some species at a few islands.
Kelp forest fish abundance	CINP	App.F.13.16	*Status:* Harvested; for some species, density varies among islands. *Trend:* Most are stable (within variability of time series), but recent increases for some species at a few islands.
Kelp forest fish abundance	SBC LTER	App.F.13.17	*Status:* Harvested; higher density at islands for three species. *Trend:* All within variability of time series for island sites.
Black abalone *Haliotis cracherodii* abundance and size structure	CINP; MARINe	App.F.13.1–App.F.13.2	*Status:* Very low abundance. *Trend:* Stable or slowly increasing.
Red abalone (*Haliotis rufescens*) abundance	PISCO	App.F.13.9	*Status:* All species at very low abundance. Higher densities observed at San Miguel Island. *Trend:* No trend.
Red and pink abalone (*Haliotis* spp.) abundance	CINP	App.F.13.10	*Status:* Both species at very low abundance. *Trend:* No increase, except red abalone at San Miguel and Santa Rosa islands.
Abalone (*Haliotis* spp.) abundance	SBC LTER	App.F.13.11	*Status:* Very low abundance. *Trend:* No trend.

Sea star (*Pisaster* and *Pycnopodia*) abundance	CINP	App.F.12.8	*Status:* Reduced abundance from 2014 to 2016 at all islands. *Trend:* Drastic declines from 2013 to 2014 at all islands.
Sea star (*Pisaster* and *Pycnopodia*) abundance	SBC LTER	App.F.12.9	*Status:* Reduced abundance from 2014 to 2015 at island and mainland sites. *Trend:* Drastic declines from 2013 to 2014.
California sea lion *Zalophus californianus* pup count and growth	NMFS; CCIEA	App.F.13.23–App.F.13.24	*Status:* High compared to late-1970s. *Trend:* Long-term increasing trend, recent decline likely due to recent unusual mortality event.
Harbor seal *Phoca vitulina* count	Carretta et al. 2016	App.F.13.25	*Trend:* Channel Islands abundance stable since late 1980s.
At-sea seabird abundance	Sydeman et al. 2015; CalCOFI	App.F.13.22	*Trend:* Long-term declining trend in seabirds density in southern California (1987–2011).
Cetacean density	Campbell et al. 2015	App.F.13.28	*Trend:* Two whales, two small cetaceans stable; fin whale increasing; Pacific white-sided dolphin decreasing off southern California from 2004–2013.

Consumptive Recreation

Consumptive recreation involves experiential opportunities that include recreation and community activities that result in the direct taking of natural or cultural resources. It also includes activities that involve extracting, taking, or incidentally harming natural or cultural resources for personal leisure, enjoyment, entertainment, or relaxation.

For example, common recreational activities involving harvesting or taking marine resources may include beachcombing for seashells or sharks' teeth; however, these activities are illegal in Channel Islands National Park. Within CINMS, consumptive recreation may include fishing for personal enjoyment. Recreational species within CINMS include lobster, kelp bass, mackerel, California sheephead, half-moon, and ocean whitefish, among others. Further, on occasion, while diving to explore kelp forest and other wildlife habitat, incidental damage to kelp and other living habitats may occur from fin kicks and dragging SCUBA gear, and this would be classified as consumptive.

The status of consumptive recreation is "Good/Fair" because performance of the service is considered acceptable even though human activity has caused changes that limit the capacity to fully provide the service. The trend is "Undetermined" because there is insufficient time series data beyond 2012 for economic indicators.

Economic Indicators

Commercial passenger fishing vessels (CPFV) – CPFV. Commercial passenger fishing vessels are for-hire boats that can be commissioned for a partial day, a full day, or multiple days. Depending on their distance from the shore, CPFV trips are for the day or overnight. It is possible to book these charter-fishing trips for the day as an individual or as a group. California Department of Fish and Wildlife

(CDFW) data collected from CPFV operators show that although there is variation from year to year in CPFV hours at sea, since the 1980s, the number of CPFV hours within CINMS has been increasing. For CPFV hours, there was an upward trend from 2008–2016, but it should be noted that from 2014–2016, there was a slight decline (App.I.4). The number of annual person-days from 2008–2012 increased (App.I.5). Data on expenditures and economic impacts show that from 2010–2012, the expenditures by CPFV passengers increased, in addition to the resulting economic contributions (jobs, income, value-added, and output) of their spending (App.I.3–App.I.5).

Economic Contribution/Impact on Local Economy of Spending

Definitions of Terms: **Output**: Total industry production, equal to shipments plus net additions to inventory. All sales plus government expenditures. **Value Added**: The value added during production to all purchased intermediate goods and services. This is equal to employee compensation plus proprietor's income plus other property income plus indirect business taxes. Often referred to as Gross Regional product. **Total Income**: Sum of employee compensation, proprietor's income, corporate income, rental income, interest and corporate transfer payments. **Employment**: Full- and part-time jobs. All measures include multiplier of ripple effects of spending.

Private/rental boats. CDFW annually estimates fishing effort from private and rental boats. Special estimates for spatial areas can be done with this data on fishing effort; for example, Chen et al. (2015d) used data on fishing effort to conduct a special estimate for CINMS from 2004 to 2012. Leeworthy and Schwarzmann (2015) reported on fishing effort, related expenditures, and the economic contributions associated with recreational fishing in CINMS on local economies. This study found that person-days of fishing effort fluctuated from 2006 to 2012 with dips during the Great Recession, but person-days increased from 2010 to 2012 (App.I.6–App.I.7).

Additionally, expenditures by private/rental boats and the economic contributions of this activity increased between 2010 and 2011, but no studies have been completed since 2012 (App.I.3-App.I.5).

Non-Economic Indicators

No information is available on human dimension non-economic indicators for consumptive recreation in CINMS, which reflects a major gap in socioeconomic research. Information on costs-and-earning, socio-demographic profiles of "for hire" operations that take people out for fishing would provide better information for assessing resilience to change. Importance-satisfaction ratings of important attributes that recreational anglers or divers care about would allow for an assessment of a non-dollar metric of people's preferences to assess relative importance of attributes (i.e., may lead to different rankings than dollar metrics).

Resource Indicators

Several resource indicators from the State section of this report are related to the health of fish and invertebrate stocks important to recreational fisheries. For example, while eutrophic conditions of water quality were rated as "Good" and "Not Changing," human health risks were rated "Good/Fair" and "Not Changing" due to harmful algal blooms (HABs) increasing in frequency and abundance. While no negative health effects have been observed in humans, HABs have negatively affected the health of wildlife, such as shellfish, seabirds, and marine mammals. Human health advisories for recreationally caught shellfish are now common; for example, most recently, the California Department of Public Health issued a warning for sport-harvested bivalves from April to June 2018 due to dangerous levels of naturally occurring paralytic shellfish poisoning toxins that can cause illness or death. Water quality climate drivers were rated “Fair” and “Worsening” and other stressors like plastic pollution were rated “Undetermined” in both status and trend. Increasing HABs, decreasing dissolved oxygen, ocean acidification, and increasing microplastics may affect the sanctuary’s capacity to support recreational fisheries via fishery closures and/or health effects (App.D.7.3).

In the habitat section, habitat integrity was rated “Fair” and “Worsening,” while contaminants in habitats were rated “Good/Fair” and “Not Changing.” Key habitat-forming species that indirectly support recreational fisheries, such as eelgrass and giant kelp, vary spatially within the sanctuary and undergo seasonal and interannual variation. Generally, giant kelp biomass appears to be slowly declining within CINMS (App.E10.13), although two of the five islands have seen recent spikes in kelp density (App.E10.14). Eelgrass beds have generally been stable through time; however, bed degradation may be caused in part by trap fishing, anchoring, and other sea floor disturbances (App.E10.23–App.E.10.25, Altstatt et al. 2014). For some areas within the sanctuary, a reduction in giant kelp and or eelgrass beds may negatively affect fished species (abundance and/or biomass) through the loss of habitat quality, or less directly via alterations to community or food web structures. Another potential threat to habitat-forming species are non-indigenous species that are capable of causing declines, extirpations, or extinctions of native plants and marine life and altering habitats. The status of non-indigenous species was rated “Fair” and “Worsening” because certain alien species in the sanctuary could likely cause degradation to some attributes of ecological integrity. The increased presence of non-indigenous algal species within the sanctuary, particularly *Sargassum horneri* and more recently *Undaria pinnatifida*, raise concerns about potential adverse ecological impacts (App.F.14.1–App.F.14.4); however, such effects within the sanctuary, especially for newly discovered *Undaria pinnatifida*, are largely unknown at present.

Living marine resources were generally rated “Fair” and “Worsening” for all except biodiversity, which had an “Undetermined” trend. More fish and shellfish species are fished recreationally than were assessed in the State section, but the information still provides insights into the ecological status of species that are the target of consumptive recreation. Fisheries metrics, such as biomass of maximum sustainable yield (MSY), may be appropriate for assessing consumptive recreation; however, fisheries metrics assess beyond sanctuary boundaries and were therefore not used to determine status and trends in this report. Long-term monitoring in the sanctuary has shown that California sheephead have been increasing, particularly within marine reserves (App.F.12.12–App.F.12.13). Urchin density has been increasing at the western islands, but decreasing at the eastern islands (App.F.12.5). Since 2009, average lobster densities throughout the Channel Islands have been mostly stable, but some sites show evidence of an upward trend beginning around 2014 (App.F.13.19-App.F.13.20). Also in 2014, visual surveys revealed that for a suite of demersal fish species (lingcod, sheephead, gopher rockfish, copper rockfish, and vermillion rockfish), abundances more than doubled compared to visual surveys from 2009 (App.E.8.18–App.E.8.19). In addition, trawl and hook and line surveys have shown stable and increasing numbers of various rockfish, indicating some species may be experiencing some degree of recovery from being previously overfished

(App.F.13.2–App.F.13.3). Further, several relevant kelp forest fish species like kelp rockfish, blue rockfish, and kelp bass have been identified as stable or increasing despite being below historic levels (App.F.13.15–App.F.13.17).

Although some recreationally fished species' populations have been depressed to levels of concern, there are stable as well as increasing abundances of species that are commonly caught for sport. Water quality, habitat, and living marine resource indicators do not provide evidence to dispute the rating of consumptive recreation as "Good/Fair" and the trend as "Undetermined."

Summary of Economic, Non-Economic, and Resource Indicators for Consumptive Recreation

Economic Indicators	Source	Figure or Table #	Data Summary
Commercial passenger fishing vessels (CPFV) hours	CA DFW	Figure App.I.4	*Status:* CPFV hours in 2016 were nearly 175,000. *Trend:* Although there are spikes in CPFV hours, over the past six years, there has been an increase in CPFV hours.
Commercial passenger fishing vessels (CPFV) person-days	CA DFW	Figure App.I.5	*Status:* There were about 53,000 CPFV person-days in 2012. Non-residents compose a smaller proportion of CPFV passengers. *Trend:* From 2010–2012, the number of CPFV person-days was increasing.
Commercial passenger fishing vessels (CPFV) expenditures	Leeworthy and Schwarzmann 2015	Table App.I.3	*Status:* The average annual trip-related expenditures from 2010–2012 for CPFV were $11.1 million. *Trend:* The average annual trip-related expenditures increased from 2010–2012.
Commercial passenger Fishing vessels (CPFV) economic contributions	Leeworthy and Schwarzmann 2015	Table App.I.4	*Status:* CPFV in CINMS supports jobs, income, output, and value-added in the local economy. *Trend:* Jobs, income, output, and value-added increased from 2010–2012.
Commercial passenger fishing vessels (CPFV) average economic contributions	Leeworthy and Schwarzmann 2015	Table App.I.5	*Status:* CPFV in CINMS supports jobs, income, output, and value-added in the local economy.
Private/rental boat fishing person-days	CA DFW	Figures App.I.6–App.I.7	*Status:* The overwhelming majority of private/rental boat fishing days in 2011 and 2012 were by California residents. *Trend:* The number of non-resident person-days using private/rental boats increased from 2010–2012.
Private/rental boat fishing expenditures	Leeworthy and Schwarzmann 2015	Table App.I.3	*Status:* The average annual trip-related expenditures from 2010-–2012 for private/rental boat fishing were $2.2 million.

			Trend: The average annual trip-related expenditures increased from 2010–2012.
Private/rental boat fishing economic contributions	Leeworthy and Schwarzmann 2015	Table App.I.4	*Status:* Private/rental boating in CINMS supports jobs, income, output, and value-added in the local economy. *Trend:* Jobs, income, output, and value-added increased from 2010-–2012.
Non-Economic Indicators	**Source**	**Figure or Table #**	**Data Summary**
Not available	Not available	Not available	Not available
Resource Indicators	**Source**	**Figure or Table #**	**Data Summary**
Domoic acid levels within the Santa Barbara Channel in invertebrate tissue	C. Culver, CA Sea Grant; McCabe et al. 2016	App.D.7.1–App.D.7.2	*Status:* Domoic acid is present within tissue samples of local fisheries species long after a toxigenic bloom event. *Trend:* Domoic acid events are increasing in frequency.
Pseudo-nitzschia abundance and concentration	Sekula-Wood et al. 2011; McCabe et al. 2016; Plumes and Blooms sampling, analysis by S. Amiri, CINMS; Krause et al. 2013; Cavole et al. 2016; McKibben et al. 2017	App.D.7.1, App.D.7.3, App.D.7.4b	*Status:* Presence is cyclical and most frequent when upwelling anomalies are positive. The 2015 bloom was unprecedented in abundance and spatial extent. *Trend:* Blooms became more pronounced starting in 2001. HAB events seem to be influenced by long-term climatic oscillations (e.g., PDO).
Domoic acid flux (e.g., HAB)	Sekula-Wood et al. 2011; Anderson et al. 2006, 2008, 2009, and 2016; McCabe et al. 2016	App.D.7.4a	*Status:* Presence is episodic. There have been no known human illnesses related to Santa Barbara Channel HABs; however, there have been a number of HAB-related health effects observed in other organisms with nervous systems. *Trend:* HABs are increasing in frequency and spatial distribution. Domoic acid presence peaks became more frequent starting in 2001.
Giant kelp	SBC LTER	App.E.10.13	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.
Giant kelp	Sprague/CINP	App.E.10.14	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.

Giant kelp	UCSB/ Cavanaugh and Bell	App.E.10.15–App. E.10.19	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.
Eelgrass beds — areal extent	UCSB/Altstatt	App.E.22–App.E.24	*Status:* Eelgrass extent is generally stable; potential losses at Anacapa. *Trend:* Stable with potential declines in non-protected areas off Anacapa Island.
Eelgrass beds — areal extent	NMFS	App.E.22, App.E.25	*Status:* Eelgrass extent is generally stable; potential losses at Anacapa. *Trend:* Stable with potential declines in non-protected areas off Anacapa Island.
Sargassum horneri observations	Marks et al. 2015b; Pacific Rocky Intertidal NIS interactive map	App.F.14.2–App.F.14.3	*Status: S. horneri* is established at three islands in CINMS, only drift has reached San Miguel Island, but no sightings of established individuals. *Trend:* Increasing in abundance and spreading to new locations in CINMS.
Sargassum horneri density	CINP	App.F.14.4	*Status and Trend:* Increasing abundance at Anacapa, Santa Cruz,and Santa Barbara islands.
Non-indigenous species abundance	Blanchette et al. 2015	App.F.14.1	*Status:* Six non-indigenous species observed at PISCO sites on islands. *S. horneri* is moving up into the intertidal as well.
California sheephead *S. pulcher* abundance	PISCO	App.E.7.12	*Status:* Harvested. *Trend:* Declining average density since 2009 but not below the levels observed in 2003-2008.
California sheephead *S. pulcher* abundance	CINP	App.E.7.13	*Status:* Harvested. *Trend:* Recent increase in average density observed at all islands, except San Miguel.
California sheephead *S. pulcher* abundance	SBC-LTER	App.E.7.14	*Status:* Harvested. *Trend:* Abundance appears to be increasing at the island sites compared to the mainland sites.
California sheephead *S. pulcher* abundance	MARE	App.E.7.16	*Status:* Currently reduced from pre-harvest levels. *Trend:* Average density has increased recently, mostly inside marine reserves.
Giant sea bass *Stereolepis gigas* abundance	PISCO	App.E.8.14	*Status:* Harvested. *Trend:* Too few observations to determine trend.
Spiny lobster *Panulirus interruptus* abundance	PISCO	App.E.7.10	*Status:* Harvested; low density observed since 2010. *Trend:* Recent gradual increase in density.

Spiny lobster *P. interruptus* abundance	CINP	App.E.7.11	*Status:* Harvested. *Trend:* Increasing at Anacapa, Santa Cruz, and Santa Barbara islands, stable at San Miguel and Santa Rosa islands.
Abundance of key forage fish (sardine, anchovy, myctophids, hake, rockfish spp., sanddabs)	CalCOFI; CCIEA	App.E.7.19	*Status:* Recent very low abundance of sardine and anchovy; average to high abundance of myctophids, rockfish, and sanddab. *Trend:* Mixed trend, species dependent.
Kelp forest fish abundance	PISCO	App.E.8.15	*Status:* Harvested. *Trend:* Four species are stable (within variability of time series) and one species is increasing (blue rockfish).
Kelp forest fish abundance	CINP	App.E.8.16	*Status:* Harvested; for some species density, varies among islands. *Trend:* Most are stable (within variability of time series), but recent increases for some species at a few islands.
Kelp forest fish abundance	SBC-LTER	App.E.8.17	*Status:* Harvested. Higher density at islands for three species. *Trend:* All within variability of time series for island sites.
Deep-reef fish abundance	NMFS-NWFSC Hook and Line Surveys	Table App.E.8.2	*Trend:* Mixed, short-term trends —12 species stable or increasing; four species declining.
Demersal fish abundance	NMFS-NWFSC Groundfish Trawl surveys	Table App.E.8.3	*Trend:* The 11 species sufficiently sampled in CINMS appear to have a stable or increasing trend.

Non-Consumptive Recreation

The status of non-consumptive recreation is "Good/Fair" because performance of the service is considered acceptable even though human activity has caused changes in the natural resources supporting this service that limit their capacity to fully provide the service. The trend is "Not Changing" because economic indicators are positive and stable, human dimension indicators are increasing or stable, and resource indicators do not indicate there is a decline in the natural resources supporting this service.

Efforts are needed to establish better trend data for economic and non-economic information. This could include collaboration with the California Marine Life Protection Act (MLPA) Research and Monitoring Program and increased sample sizes so estimates can be made for the sanctuary as a subset of the southern region.

Figure ES.2. The *Winfield Scott* is a sidewheel steamer that sank in 1853 in what is now Channel Islands National Marine Sanctuary. Today, the vessel serves as an artificial reef, harboring invertebrate and fish communities within the kelp forest. Photo: R. Schwemmer/NOAA

Patterns of Use

Understanding patterns of use is a key component to understanding the pressures and subsequent impacts on sanctuary resources. In 2007, visitors made 1,621 boat trips to the sanctuary and participated in 9,752 person-days (one person doing an activity for a whole day or any part of a day) in non-consumptive recreational activities from private boats (Leeworthy 2013). LaFranchi and Pendleton (2008) indicated the following preferences among the 2007 visitors who accessed CINMS via private boats:

- Just relaxing (86% of participants)
- Exploring using a dinghy (55%)
- Snorkeling and scuba diving (40%)
- Kayaking (40%)
- Birdwatching (23%)
- Surfing or wave riding (21%)
- Nature study/wildlife viewing (10%)

Importantly, 51% of these respondents also reported participating in consumptive recreational activities, reflecting multiple use preferences.

Surveys of "For Hire Operations" by Leeworthy et al. (2005) indicated the following patterns of use:

- Whale watching and other wildlife observation (62% of person-days)
- Non-consumptive diving (26%)
- Sailing (10%)

- Kayaking/island sightseeing (3%)

Related to the first bullet above, a more recent study by Bone et al. (2016) found that seven operators specializing in whale watching were looking for and viewing whales approximately 40% of the time. Additional trip types, reported by percentage of all trips, were comprised of "recreational cruises" (13.1%), fishing (10.4%), diving (8.3%), "wildlife cruises" (including wildlife watching other than for whales and bird watching) (19.2%), and island trips (1.7%).

Socioeconomic Information

Socioeconomic research for CINMS was limited prior to the process initiated in 1999 for creating the marine reserves. Summaries of prior work, and a newer study of non-consumptive recreation from "for-hire" operations, were conducted as part of the marine reserve process (Leeworthy et al. 2003, 2005). Other work since then, which was used in the analyses for this service, has included the development of a five-year social science plan (NOAA 2007); a 2007 survey of use, economic value, and knowledge, attitudes, and perceptions of management strategies and regulations (LaFranchi and Pendleton 2008, Loper 2008); a 2012–2013 study on non-consumptive recreation (Gornik et al. 2013); non-consumptive use levels estimated in 2007 by combining boat counts from CINMS Sanctuary Aerial Monitoring and Spatial Analysis Program (SAMSAP, Leeworthy 2013); and survey data from 2006–2007 on the number of people per boat and trip duration from LaFranchi and Pendleton (2008).

Due to the lack of time series data for non-consumptive uses, indicators for population, real per capita income and gas prices were used to assume trends in use (Appendix C: Table App.C.1.2, Table App.C.1.3, and Figure App.C.1.3). In addition, the relationships between ecological attributes and the economic value of non-consumptive recreation from Gornik et al. (2013), and the trends for the ecological indicators in the State section for the ecological attributes were used to arrive at the rating for both the status and trends of this ecosystem service.

Economic Indicators

Use estimates serve as the main economic indicators of the market and non-market economic use values for this ecosystem service.

In 1999, "for-hire" operators conducted 42,008 person-days of non-consumptive recreation in the sanctuary (25,984 for whale watching and wildlife viewing; 10,776 for SCUBA diving; 4,105 for sailing; and 1,233 for kayaking/sightseeing). In 2013, seven of the thirteen non-consumptive recreation operators who take passengers out in the Channel reported a total of 136,779 non-consumptive recreational person-days in the Channel Islands region.[20] Of that, whale watching accounted for 29,313 person-days, or 21% of the total non-consumptive recreational activity. Also, 19,986 recreational cruise and 12,759 diving/snorkeling person-days occurred. These operators also reported their spatial activity occurring within the CINMS boundary. Using reported operator spatial activity across the Channel region, including in CINMS, 11,780 total whale watching person-days over the previous year took place within CINMS; in other words, whale watching within the CINMS accounted for approximately 40% of the total whale

[20] These figures were analyzed using data collected from the Bone et al. (2013) study.

watching person-days in the Channel region in 2013. Additionally, 608 recreational cruise person-days (approximately 3% of total recreational cruise person-days in the region) occurred within the CINMS.

In 2007, it was estimated that people conducted 9,752 person-days of non-consumptive recreation from private boats (Leeworthy, 2013) for a total annual non-market economic value of $86,642 (Gornik et al. 2013) and a total annual spending in the local economy of $403,791 (LaFranchi and Pendleton). These estimates were considered underestimates because the SAMSAP surveys did not include Santa Barbara Island.

Gornik et al. (2013) created an index of biological qualities that combines fish abundance and richness with invertebrate abundance and richness. The authors found that marginal value for a one-unit change in the biological index generated $10.11 to $16.78 in the average willingness to pay for a person-day of non-consumptive recreation in CINMS.

The information captures data points for some economic and non-economic indicators from 1999, 2007, and 2013; however, these standalone data points cannot be used to determine a trend for non-consumptive recreation in the sanctuary alone and no other multiple-year or trend data exists. The California Marine Life Protection Act (MLPA) now requires CDFW to monitor and periodically estimate non-consumptive recreation by region; however, in CDFW's last application for the southern region, which includes the sanctuary, sample sizes were not large enough to accurately estimate use in the sanctuary (Chen et al. 2014). Furthermore, the SAMSAP ended in 2009, so no recent data are available to assess use preferences over time. Trends in the ecological indicators from the State section and the research done in Gornik et al. (2013) relating a biological index to non-market economic value was used to make inferences about the trends in non-consumptive recreation.

National Park Service (NPS) keeps visitor use data for Channel Islands National Park (CINP). CINP use can serve as a proxy for the trends of non-consumptive recreation because it includes direct use estimates in time series. CINP visitation is broken down into two components: people that visit the islands in CINP and people that only visit CNIP on boats (see Appendix C: Table App.C.1.8 and Figure App.C.1.4). People that visit the islands are known to participate in whale watching and other wildlife observation. These experiences are oftentimes complemented by interpretative services offered by the NPS concessionaire permitted to take people out to the CINP, as well as Channel Islands Naturalist Corps volunteers. GIven there are no direct studies of use in CINMS, CINP use (visitors ashore and on boats) is the best available proxy for non-consumptive recreation in the sanctuary. From 2009 to 2017, total visitation declined from 144,654 to 131,697 or about 9%. From 2012 to 2017, total visitation to CINP increased from 83,566 to 131,707 or 57.6%.

Generally, population size, per capita income, and gas and diesel prices are good indicators for the demand and value of recreation. For the U.S., California, and the tri-county area of Los Angeles, Santa Barbara, and Ventura, population from 1990 to 2015 had an annual growth rate of 1.15% in the U.S., 1.23% in California, and 0.62% in the tri-county area. Population is projected to continue to grow from 2015 until 2030 at an annual rate of 0.68% for the U.S., 1.06% for California, and 0.98% for the tri-county area (Table App.C.1.2, Figure App.C.1.1). Real per capita incomes also grew significantly for all areas from 1990 to 2015. Real per capita income grew at an annual rate of 2.04% in the U.S., 2.22% in California, and 2.30% in the tri-county area. Real per capita income is expected to continue to grow from

2015 to 2030 at an annual rate of 1.60% for the U.S., 1.45% for California, and 1.58% for the tri-county area (Table App.C.1.3, Figure App.C.1.2).

Retail gasoline prices for the U.S. and the West Coast have declined and stabilized from 2012 to 2018 (see Appendix C: Figure App.C.1.3). Here, it can be assumed that lower gas prices result in increases in boating activity in CINMS. In addition, all private recreational boats observed in CINMS in 2007 were 26 feet or greater in length (LaFranchi and Pendleton 2008). Boat registrations for boats 26 feet or greater in length in California have decreased from 41,135 in 2008 to 35,692 in 2016, which indicates a counter trend to that indicated by increasing population, real per capita income, and fuel prices (see Appendix I: Figure App.I.3). Overall, this data indicates that there are more people in the region with more money to engage in non-consumptive recreation. Further, as fuel prices declined and stabilized for the study period, this makes boating a less costly method of recreating.

Non-Economic Indicators

In a survey by LaFranchi and Pendleton (2008), 76% of respondents either "strongly supported" (48%) or "supported" (28%) the marine reserves in the sanctuary. Almost all non-consumptive recreators believed that marine reserves would benefit them. Bone, Meza, and Mills (2016) asked "for hire" operators that specialized in whale watching, "How has the quality of whale watching changed in the past 10 years?" Eighty-five percent felt that the quality had become either "much better" (65%) or "somewhat better" (20%). The reason cited was a larger food supply keeping the whales in the area year round, leading to more sightings by wildlife viewers. These indicators support an increasing trend over the past 10 years.

Resource Indicators

Several attributes of water, habitat, living, and maritime archaeological resource qualities evaluated in the State section are relevant for assessing the status and trends of non-consumptive recreation as an ecosystem service. Some affect non-consumptive recreation directly, while others affect ecological functions that are important to ecosystem attributes people indirectly care about for their non-consumptive recreation. For example, divers care about water clarity (visibility) while diving, and also the abundance and/or diversity of species. All three, therefore, have direct effects on the ecosystem service of non-consumptive recreation. Nevertheless, abundance and diversity depend on other conditions, such as productivity, which divers may seek in a dive experience, but are attributes with important indirect effects related to non-consumptive recreation. Attributes with either direct or indirect effects are considered in the rating of an ecosystem service status or trend.

Nutrient loads, which could negatively affect SCUBA diving, were rated "Good" in the State section of this report, and the trend was "Stable." Biodiversity (representing the opportunity to view many species while diving, whale watching, or other wildlife viewing) was rated "Fair" and the trend was "Undetermined." The abundance of marine mammals and seabirds was rated as "Stable" or "Improving," though sea lions and brown pelicans have suffered reproductive declines in part due to food shortages from reduced local abundance of sardines, anchovies, and market squid; however, due to uncertainty in future water temperature conditions, no conclusion was reached on whether this decline would persist.

Overall, there is no indication that the activities associated with the economic and non-economic benefits derived from non-consumptive recreation are significantly reducing the quality of the sanctuary's natural and/or maritime archaeological resources.

Summary of Economic, Non-Economic, and Resource Indicators for Non-Consumptive Recreation

Economic Indicators	Source	Figure or Table #	Data Summary
Population	Woods and Poole 2016	Table App. C.1.2	Population is expected to continue to increase throughout the sanctuary region.
Population	Woods and Poole 2016	Figure App.C.1.1	Population is expected to continue to increase throughout the sanctuary region.
Real per capita income	Woods and Poole 2016	Table App.C.1.3	Per capita income in the sanctuary region is expected to increase through 2030 at a rate higher than California and the U.S.
Real per capita income	Woods and Poole 2016	Figure App.C.1.2	Per capita income is expected to increase through 2030 at a rate higher than California and the U.S.
Channel Islands Park visitation	NPS 2017	Table App.C.1.8	The number of visitors on boats has declined from 2000–2016 and the number of island visitors has more than doubled since 2000.
Channel Islands Park visitation	NPS 2017	Figure App.C.1.4	The number of visitors on boats has declined from 2000-–2016 and the number of island visitors has more than doubled since 2000.
Non-Economic Indicators	**Source**	**Figure or Table #**	**Data Summary**
Not available	Not available	Not available	Not available
Resource Indicators	**Source**	**Figure or Table #**	**Data Summary**
Anomalies of nitrate concentrations	Plumes and Blooms	App.D.6.5, App.D.6.7b	*Status:* Fair. *Trend:* Brief decrease in 2014–2015, but the long-term trend (1997–2015) for nitrate values are increasing at depth, no trend detected in surface waters.
Anomalies for phosphate concentrations	Plumes and Blooms	App.D.6.6	*Status:* Fair. *Trend:* Brief decrease in 2014–2015, but the long-term trend (1997–2015) for phosphate values is increasing at depth, no trend detected in surface waters.
At-sea seabird abundance	Sydeman et al. 2015; CalCOFI	App.F.13.22	*Status and Trend:* Long-term declining trend in seabirds density in southern California (1987–2011).
California sea lion *Zalophus*	NMFS; CCIEA	App.F.13.23–App.F.13.24	*Status:* High compared to late-1970s.

californianus pup count and growth			*Trend:* Long-term increasing trend, recent decline likely due to recent unusual mortality event.
Harbor seal *Phoca vitulina* count	Carretta et al. 2016	App.F.13.25	*Trend:* Channel Islands abundance stable since late 1980s.
Cetacean density	Campbell et al. 2015	App.F.13.28	*Trend:* Two whales, two small cetaceans stable; fin whale increasing; Pacific white-sided dolphin decreasing off southern California from 2004–2013.
Abundance of key forage fish (sardine, anchovy, myctophids, hake, rockfish spp., and sanddabs)	CalCOFI; CCIEA	App.F.12.19	*Status:* Recent very low abundance of sardine and anchovy; average to high abundance of myctophids, rockfish, and sanddab. *Trend:* Mixed trend, species dependent.

Food Supply — Commercial Fisheries

Figure ES.4. Spiny lobsters can be found in Channel Islands National Marine Sanctuary. Photo: C. Fackler/NOAA

Food supply-commercial fisheries is the capacity to support market demands for nutrition-related commodities through various fisheries. For purposes of this report, this service is limited to commercial fisheries since the ecosystem service evaluation for consumptive recreation includes recreational fishing.

The status of food supply-commercial fisheries is "Good/Fair" because performance of the service is considered acceptable even though human activity has caused changes that limit the capacity to fully provide the service. The trend is "Undetermined" because economic indicators are predominantly positive and stable and resource indicators for most of the important commercial species are not available.

Economic Indicators (2009–2012)

For this condition report, 2012 is the most recent year in which commercial fishing data was reviewed to assess economic indicators for this ecosystem service (Leeworthy et al. 2014). Although California Department of Fish and Wildlife has more recent data, this assessment is based on information found in Leeworthy et al. 2014) due to limited ONMS capacity to receive and process that data.

Top species by pounds and value

Market squid was the number one ranked fishery in CINMS in 2012 based on both value and pounds, accounting for over $7.4 million or 40.4% of all harvest value from CINMS. This was followed by urchin at $4.2 million (23%), spiny lobsters at $2.9 million (16.2%), crab $1.2 million (6.4%), and prawn and shrimp at $721,000 (4.6%). These top five species/species groups accounted for more than 89% of the 2012 harvest value from CINMS (see Appendix I: Table I.6).

Commercial: Pounds and value trends 2000–2012

- Market squid: Pounds declined by 115,000, value declined by $12.4 million;
- Urchin: Pounds increased by 2.5 million, value declined by $1 million;
- Spiny lobster: Pounds increased by 50,000, value increased by $1.7 million;
- Crab: Pounds increased by 360,000, value increased by $646,000;
- Prawn/shrimp: Pounds decreased by 170,000, value decreased by $455,000; and
- Sardines and anchovies: Both sardines and anchovies have seen declines in pounds and values from 2000–2012 (see Appendix I: Figures App.I.19 - I.24).

Market squid, anchovies, and sardines

These species are impacted by water temperature events (e.g., El Niño), which are considered to be the main factor in explaining high variability in these fisheries through 2011 (CDFW 2013). Not reflected in the time period of economic information assessed here, there was a warm water event in the California Current Ecosystem that began in 2013. This heat wave coupled with an El Niño resulted in anomalous warm water that lasted through 2016. See the Resource Indicators section below for more information on how fisheries were affected.

Economic impact on local area economies

Leeworthy et al. 2014 estimated the economic impact on the local economies in a five-county area of Los Angeles, Orange, San Luis Obispo, Santa Barbara, and Ventura counties for years 2010, 2011, and 2012. Most of the impact occurred in the three county area of Los Angeles, Santa Barbara, and Ventura counties. A three-year average was developed to account for inter-annual variation for harvest revenues, output, value-added (Gross Regional Product), income, and employment generated in the local county economies, including the "ripple" or "multiplier" impacts. For harvest revenue (revenue received by fishermen), the three-year average was about $27.3 million. This generated almost $45.4 million in output, $30.9 million in value-added, $27.8 million in income, and supported 659 full and part-time jobs (see Appendix I: Table I.7).

Definitions of Terms: **Harvest Revenue**: What fishermen receive when they land their catch at various CA ports. **Output**: Total industry production, equal to shipments plus net additions to inventory. **Value Added**: The value added during production to all purchased intermediate goods and services. This is equal to employee compensation plus proprietor's income plus other property income plus indirect business taxes. **Total Income**: Sum of employee compensation, proprietor's income, corporate income, rental income, interest and corporate transfer payments. Employment: Full- and part-time jobs.

In 2012, there were 244 commercial fishing vessels operating in CINMS; this is a significant reduction from the 2000–2003 average of 473 vessels (Leeworthy et al. 2005). The reduction is largely the result of the State of California's Marine Life Management Act and other federal fishing regulations designed to address the issue of economic overfishing (i.e., too much capital and labor to catch the same amount of fish or economic inefficiency) (CDFW 2008, Hamilton et al. 2010 and PISCO 2013).

In 2012, 64 vessels (26.23% of vessels) received greater than $100,000 in harvest revenue from their catch in CINMS. This accounted for 78.4% of all harvest revenue from catch in CINMS. This data demonstrates dependence on sanctuary resources by commercial fishermen.

Another way to evaluate harvest revenue is vessel dependence on catch from CINMS versus all of California. In 2012, the 244 commercial fishing vessels received $76.1 million in harvest revenue from their catch in all of California versus $18.5 million from CINMS or 24.24% of their revenue. Over 43% received less than 3.5% of their total revenue from CINMS (Leeworthy et al. 2014). Generally, CINMS fishermen were not highly dependent on CINMS for their total harvest revenues.

Another way of looking at economic dependence is port dependence measured as the percent of total port landings from CINMS. The percent of pounds and value by species/species groups were evaluated for the top four ports where catch from CINMS was landed: Santa Barbara Harbor, Ventura, Port Hueneme, and Oxnard. These four ports accounted for 98.1%of the total value of landings from CINMS in 2012. The dependence of the four ports on CINMS in 2012 ranged from 30.38% to 66.94%. Oxnard had the highest dependency, 66.94%, followed by Santa Barbara Harbor, 64.21%, Port Hueneme, 35.45%, and Ventura, 30.38%. Dependency for many species was above 90%. Santa Barbara's most valuable species, urchin, had a 98.5% dependency on the sanctuary.

Socioeconomic monitoring conducted by CDFW over a five-year (CDFW 2008) and 10-year period post-establishing the marine reserves (no-take areas) found very small socioeconomic impacts from the reserves (Hamilton et al. 2010, PISCO 2013). Over a five-year monitoring period, the initial projected declines in commercial fisheries did not occur pre or post-establishing the marine reserves. Specifically, seven fisheries were monitored, and of those, four increased and three declined. The three that declined, however, were relatively small fisheries and more likely impacted by environmental shifts, market forces, and fishery regulations than the establishment of the marine reserves.

Non-Economic Indicators

No information is available on human dimensions non-economic indicators for the commercial fisheries in CINMS, which reflects a major gap in socioeconomic research.

Information on fishermens' knowledge, attitudes, and perceptions of sanctuary management strategies, regulations, and status of resource conditions along with their socio-demographic profiles, and cost-and-earnings can help assess fishermens' abilities to adjust to management and policy changes. Information about the information sources used and trusted by fishermen is important for education and outreach efforts.

Resource Indicators (2009—2016)

Above, economic data for fisheries has been analyzed through 2012. In the State section of this condition report, ecological indicator data was assessed through 2016, and thus, more weight was given to ecological indicators in rating the 2016 status and trend for food supply. In cases like this, where economic and non-economic information is limited or unavailable, ecological indicators can be used to indirectly assess the ecosystem service in question. Although a less robust conclusion should be drawn from these data alone, ecological indicators can still provide insight into the status and trend of the sanctuary's ability to support commercial fisheries, and be further informed by any economic and non-economic information available.

Several ecological indicators from the State section of this report on water quality, habitats, and living marine resources are related to the health of fish stocks and invertebrates important to commercial fisheries. Here, descriptions of the status and trend of indicators most relevant to food supply are provided. In the water quality section, eutrophic conditions and water-quality-related health risk were rated as "Good" and "Not Changing." Harmful algal blooms (HABs) are only one of many indicators used to evaluate water quality as a whole; however, HABs that have the potential to impact human health via shellfish poisoning, such as those that produce domoic acid, have been increasing in frequency and intensity since 2001 (App.D.7.1–App.D.7.4). In 2015–2016, recreational and commercial rock crab fisheries were closed for three months due to an unprecedented toxic bloom that spanned the West Coast, including the Channel Islands (OST 2016a, CDFW 2015, CDFW 2016c). If this trend continues, HABs could hinder sanctuary commercial fisheries. Shellfish, lobster, and crab consumption advisories, and even fishery closures, are now common due to shellfish-poisoning toxins that can cause illness or death.

In the habitat section, habitat integrity was rated "Fair" and "Worsening," while contaminants in habitats were rated "Good/Fair" and "Not Changing." Key habitat-forming species that indirectly support commercial fisheries, such as eelgrass and giant kelp, vary spatially within the sanctuary and undergo seasonal and interannual variation. Generally, giant kelp biomass appears to be slowly declining within CINMS (App.E.10.13–App.E.10.19), although two of the five islands have seen recent spikes in kelp density (App.E10.14). Eelgrass beds have generally been stable through time; however, bed degradation may be caused in part by trap fishing, anchoring, and other sea floor disturbances (App.E.10.22–App.E.10.25, Altstatt et al. 2014). For some areas within the sanctuary, a reduction in giant kelp and or eelgrass beds may negatively affect fishery species (abundance and/or biomass) through the loss of habitat quality, or less directly via alterations to community or food web structures. Another potential threat to habitat-forming species are non-indigenous species that are capable of causing declines, extirpations, or extinctions of native plants and marine life and altering habitats. The status of non-indigenous species was rated "Fair" and "Worsening" because certain alien species in the sanctuary could likely cause degradation to some attributes of ecological integrity. The increased presence of non-indigenous algal species within the sanctuary, particularly *Sargassum horneri* and more recently *Undaria pinnatifida*, raise concerns about potential adverse ecological impacts (App.F.14.1–App.F.14.4); however, such effects within the sanctuary, especially for newly discovered *Undaria pinnatifida*, are largely unknown at present.

Living marine resources were generally rated "Fair" and "Worsening" for all except biodiversity, which was rated "Undetermined" for the trend. Using fisheries metrics, such as biomass of maximum sustainable yield (MSY), may be an appropriate metric for assessing food supply; however, fisheries metrics are assessed beyond the sanctuary's boundaries and were therefore not used to determine status and trends in this report. The following ecological indicators focus primarily on various fish and shellfish species, because they are relevant to food supply. As stated above, the top five commercially harvested species from CINMS include market squid, urchin, spiny lobster, crab, and prawn and shrimp. Market squid abundance in southern California, and within CINMS, has been below the long-term average since 2013 (App.F.12.20). Low abundances may reflect a change in the population's distribution possibly driven by warm water anomalies, and it is unknown if this trend will persist. Red urchin densities have been decreasing at the eastern islands, but have been increasing at the western islands (App.F.12.5). Spiny lobster densities are relatively stable but show evidence of a rising trend beginning around 2014 (App.F.12.10–App.F.12.11). Unfortunately, there are no fishery-independent data available to assess the status and trends for crab, shrimp, or prawn species that are fished at CINMS.

Other commercially valuable species caught within CINMS include a number of forage species and bottom-dwelling fish, like lingcod and rockfish. Similar to market squid, sardine and anchovy have seen below average abundances over the past several years (App.F.12.19). Visual surveys in 2014 showed that the abundance of a suite of demersal fish (lingcod, sheephead, gopher rockfish, copper rockfish, and vermillion rockfish) had more than doubled compared to similar visual surveys from 2009, with several commercial species of rockfish contributing to the overall trend (App.F.13.18–App.F.13.19). Further, hook and line as well as trawl surveys for demersal fish, some commercially harvested, showed that many sampled species were stable or increasing (Table App.F.13.2–Table App.F.13.3). Recent increases of demersal fish species, especially rockfish, indicate that there may be some degree of recovery happening for species that were previously overfished, perhaps in response to increased protections, such as the implementation of essential fish habitat (EFH) and the Rockfish Conservation Area (RCA) in southern California.

In summary, many species are depressed relative to historic records, and some remain overfished. Further, some commercially important species have declined locally in recent years, such as forage fish and market squid, potentially in response to anomalous warm water. Others such as demersal species are increasing or stable, and still others like red urchin and spiny lobster are variable across the sanctuary. Fishing is one of several contributors to habitat degradation, and can also result in the inadvertent capture of non-target species; however, bycatch has not been identified as a problem in the sanctuary. Overall, commercial fishing in the sanctuary is well managed via fishery management plans and marine protected areas. Fishing combined with stressors like other human activities and climate change have had negative impacts on water quality, living resources, and habitat; however,t the economic benefits of food supply alone do not appear to be substantially degrading the sanctuary ecosystem. Therefore, a rating of "Good/Fair" is supported, but the trend is "Undetermined" since, in this assessment, there is a mismatch in the temporal scale of economic and ecological information. More economic and non-economic information is required to determine the trend of food supply.

Summary of Economic, Non-Economic, and Resource Indicators for Food Supply

Economic Indicators	Source	Figure or Table #	Data Summary
Pounds and values of commercial fisheries	CA Department of Fish and Wildlife and Leeworthy et al. 2014	Table App.I.6	The top five species/species groups in CINMS — squid, urchin, spiny lobster, crab, and prawn and shrimp — accounted for more than 89% of the 2012 harvest value.

Commercial fisheries catch and value	CA Department of Fish and Wildlife and Leeworthy et al. 2014	App.I.19-App.I.24	From 2000–2012: Market squid: Pounds declined by 115,000, value declined by $12.4 million; Urchin: Pounds increased by 2.5 million, value declined by $1 million; Spiny lobster: Pounds increased by 50,000, value increased by $1.7 million; Crab: Pounds increased by 360,000, value increased by $646,000; and Prawn and shrimp: Pounds decreased by 170,000, value decreased by $455,000, both sardines and anchovies have seen declines in pounds and value from 2000–2012.
Economic impacts of commercial fisheries	CA Department of Fish and Wildlife and Leeworthy et al. 2014		From 2010–2012, the three-year average was about $27.3 million; this generated almost $45.4 million in output, $30.9 million in value-added, $27.8 million in income, and supported 659 full and part-time jobs
Non-Economic Indicators	**Source**	**Figure or Table #**	**Data Summary**
Not available	Not available	Not available	Not available
Resource Indicators	**Source**	**Figure or Table #**	**Data Summary**
Domoic acid levels within the Santa Barbara Channel in invertebrate tissue	C. Culver, CA Sea Grant; McCabe et al. 2016	App.D.7.1–App.D.7.2	*Status:* Domoic acid is present within tissue samples of local fisheries species long after a toxigenic bloom event. *Trend:* Domoic acid events are increasing in frequency.
Pseudo-nitzschia abundance and concentration	Sekula-Wood et al. 2011; McCabe et al. 2016; Plumes and Blooms sampling, analysis by S. Amiri, CINMS; Krause et al. 2013; Cavole et al. 2016; McKibben et al. 2017	App.D.7.1, App.D.7.3, App.D.7.4b	*Status:* Presence is cyclical and most frequent when upwelling anomalies are positive. The 2015 bloom was unprecedented in abundance and spatial extent. *Trend:* Blooms became more pronounced starting in 2001. HAB events seem to be influenced by long-term climatic oscillations (e.g., PDO).
Domoic acid flux (e.g., HAB)	Sekula-Wood et al. 2011; Anderson et al. 2006, 2008, 2009, and 2016; McCabe et al. 2016	App.D.7.4a	*Status:* Presence is episodic. There have been no known human illnesses related to Santa Barbara Channel HABs; however, there have been a number of HAB-related health effects observed in other organisms with nervous systems. *Trend:* HABs are increasing in frequency and spatial distribution. Domoic acid

			presence peaks became more frequent starting in 2001.
Giant kelp	SBC LTER	App.E.10.13	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.
Giant kelp	Sprague/CINP	App.E.10.14	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.
Giant kelp	UCSB/ Cavanaugh and Bell	App.E.10.15–App.E.10.19	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.
Eelgrass beds — Areal extent	UCSB/Altstatt	App.E.22–App.E.24	*Status:* Eelgrass extent is generally stable; potential losses at Anacapa. *Trend:* Stable with potential declines in non-protected areas off Anacapa Island.
Eelgrass beds — Areal extent	NMFS	App.E.22, App.E.25	*Status:* Eelgrass extent is generally stable; potential losses at Anacapa. *Trend:* Stable with potential declines in non-protected areas off Anacapa Island.
Sargassum horneri observations	Marks et al. 2015b; Pacific Rocky Intertidal NIS interactive map	App.F.14.2–.F.14.3	*Status: S. horneri* is established at three islands in CINMS, only drift has reached San Miguel Island, but no sightings of established individuals. *Trend:* Increasing in abundance and spreading to new locations in CINMS.
Sargassum horneri density	CINP	App.F.14.4	*Status and Trend*: Increasing abundance at Anacapa, Santa Cruz, and Santa Barbara islands.
Non-indigenous species abundance	Blanchette et al. 2015	App.F.14.1	*Status:* Six non-indigenous species observed at PISCO sites on islands. *S. horneri* is moving up into the intertidal as well.
Market squid *Doryteuthis opalescens* abundance	CalCOFI; CCIEA	App.F.12.20	*Status:* Average to reduced abundance. *Trend:* Declining trend.
Red and purple sea urchin abundance	PISCO	App.F.12.5	*Status:* Purple urchins are not harvested; red urchins are harvested. *Trend:* The 2014–2016 density of both species declined at eastern islands and increased at western islands.

Spiny lobster *Panulirus interruptus* abundance	PISCO	App.F.12.10	*Status:* Harvested. *Trend:* Possible recent, gradual increase at Anacapa and Santa Cruz islands.
Spiny lobster *P. interruptus* abundance	CINP	App.F.12.11	*Status:* Harvested. *Trend:* Recent, gradual increase at Anacapa, Santa Cruz, and Santa Barbara islands, no clear trend at San Miguel and Santa Rosa islands.
Abundance of key forage fish (sardine, anchovy, myctophids, hake, rockfish spp., and sanddabs)	CalCOFI; CCIEA	App.F.12.19	*Status:* Recent very low abundance of sardine and anchovy; average to high abundance of myctophids, rockfish, and sanddab. *Trend:* Mixed trend, species dependent.
Demersal fish abundance	MARE	App.F.13.18 – App.F.13.19	*Status and Trend:* Demersal fish abundance increased substantially in recent surveys (2014 and 2015) compared to the 2005–2009 baseline.
Deep-reef fish abundance	NMFS NWFSC	Table App.F.13.2	*Trend:* Mixed short-term trends; 12 species stable or increasing; four species declining.
Demersal fish abundance	NMFS NWFSC	Table App.F.13.3	*Trend:* The 11 species well sampled in CINMS appear to have a stable or increasing trend.
Entanglement	NMFS WCRO PRD	App.C.4.10	*Trend:* From 1982–2015, the number of reports of large whale entanglements (primarily humpback whales and gray whales) in fishing gear and other man-made lines (e.g., buoy lines) is increasing in California.

Maritime Heritage

The maritime heritage ecosystem service is the recognition of historical or heritage legacy. The status of maritime heritage is “Fair” because performance of the service is compromised, and existing management must be enhanced to enable acceptable performance. The trend is “Stable” because economic indicators are positive and stable, human dimension indicators are increasing or stable, and ecological indicators do indicate there is a decline in the cultural resources related to this service, but it is not widespread. Efforts are needed to establish better data for economic and non-economic information. One option could be the preparation of a cultural landscape analysis for both shipwrecks and the cultural resources for Native American cultural identity (MPA FAC 2011, Ball et al. 2015).

Economic Indicators

There have not been any studies identifying the use or economic value of the cultural resources supporting the maritime heritage service for CINMS. A study done on the Graveyard of the Atlantic (Mires 2014), which includes Monitor National Marine Sanctuary, found that people’s willingness to pay for maritime heritage increased by expanding the number of shipwrecks protected; the level of investments in museum exhibits, educational workshops on maritime heritage, and training in maritime archaeology; and Maritime Heritage Trails, including virtual trails using video and mobile phone technology.

The ship and aircraft wreck remains in CINMS reflect the diverse range of activities and nationalities that traversed the Santa Barbara Channel. European sailing and steam vessels, California-built ships of Chinese design called "junks," American coastal traders, vessels engaged in island commerce, commercial fishing vessels, and military aircraft have all been lost in sanctuary waters.

Researchers have identified 30 historic ship and aircraft wrecks in CINMS, and 110+ historic wrecks are yet to be discovered. Four of the largest lumber schooner wreck sites (George E. Billings, Dora Bluhm, J.M. Colman, and Comet) have been characterized. Two examples of vessels engaged in the passenger trade have been found, the passenger-cargo steamer Cuba, which stranded off San Miguel Island in 1923, and the California Gold Rush side-wheel passenger steamer Winfield Scott, which stranded in 1853 off Anacapa Island. The Winfield Scott is listed on the National Register of Historic Places.

In addition, submerged cultural materials from Native American terrestrial nearshore sites have been found and some in deep water may exist, but have not yet been discovered.

Non-Economic Indicators

Cultural landscape analysis tells the story of how a place has developed and its character and cultural identity. Hoyt et al. (2014) completed such an analysis for the Graveyard of the Atlantic.

Twelve museums/visitor centers have artifacts or tell the stories of some of the shipwrecks in CINMS.

- Santa Barbara Maritime Museum, Santa Barbara, California: Shipwreck exhibits *Winfield Scott* and *Cuba* including artifacts, videos, and presentations of CINMS Maritime Heritage Program (MHP).
- Outdoor Santa Barbara Visitor Center, Santa Barbara, California: Chumash heritage
- California State University,Channel Islands Boating and Safety Center, Oxnard, California: Shipwreck game, kiosk, and interpretive displays
- CINMS University of California Santa Barbara main office, Santa Barbara, California: Kiosks with CINMS MHP content
- Santa Barbara Harbor Patrol, Santa Barbara, California: Kiosks with CINMS MHP content
- TY Warner Sea Center, Santa Barbara, California: Kiosks with CINMS MHP content
- Stearns Wharf, Santa Barbara, California: Kiosks with CINMS MHP content
- Oxnard California Welcome Center, Oxnard, California Kiosks with CINMS MHP content
- Ventura Visitors Center and Convention Bureau, Ventura, California: Kiosks with CINMS MHP content
- Island Packers Company, Ventura, California: Kiosks with CINMS MHP content
- Cabrillo High School Aquarium, Lompoc, California: Kiosks with CINMS MHP content
- Aquarium of the Pacific, Long Beach, California: Kiosks with CINMS MHP content

From 2007 to 2017, there were 85 media news stories highlighting ship and aircraft wrecks at CINMS. In 2012 alone, 65 news stories highlighted the discovery of the shipwreck*, George E. Billings*. In addition, there were 75 million impressions (the opportunity for someone to see a story) worldwide with an estimated value of $500,000 for this shipwreck discovery. In 2017, CINMS funded a RV *Shearwater* expedition for the shipwreck USCG *McCulloch* (located outside of CINMS), which yielded 5,200 news stories and an estimated 312 million impressions worldwide for an estimated value of $8 million.

Numerous articles and academic papers have been published in the following magazines, journals, and conference proceedings:

- *Alolkoy* — CINMS quarterly (discontinued)
- *Maritime Currents* — Santa Barbara Maritime Museum
- *News from Native California* — Magazine
- *Mains'l Haul* — Journal of the Maritime Museum of San Diego
- *Diver Training*— Magazine
- California Islands Symposium Proceedings
- Society for Historical Archaeology
- Society for California Archaeology
- California Islands Symposium
- Symposium on the Maritime Archaeology and History of Hawaii and the Pacific
- California and World Ocean Conference

With 30 archaeological ship and aircraft wreck site locations inventoried and in various stages of survey, plus the 110+ yet to be discovered, there is a positive future stream of benefits forthcoming to support this service.

Chumash people from the local indigenous community bring a unique and important perspective to the maritime heritage values they connect to the sanctuary environment. For this assessment, a group of Chumash community members connected to representatives on the CINMS Advisory Council agreed to separately document the ecosystem values they take from these important waters. Their report is included as a part of this condition report, but the report is not part of the rating of the Maritime Heritage Ecosystem Service.

Resource Indicators

In the State section of this condition report, the integrity of maritime archaeological resources is rated "Fair" and "Worsening." The rating is largely due to naturally degrading conditions in the shallow marine environment. Some degradation is due to divers, but that is not considered a major contributing factor. The rating is "Good/Fair" and "Not Changing" for contaminants within the shipwrecks posing a hazard since none of the wrecks within CINMS were known to be carrying hazardous materials; therefore, neither is reason to downgrade the current ecosystem service rating.

Science

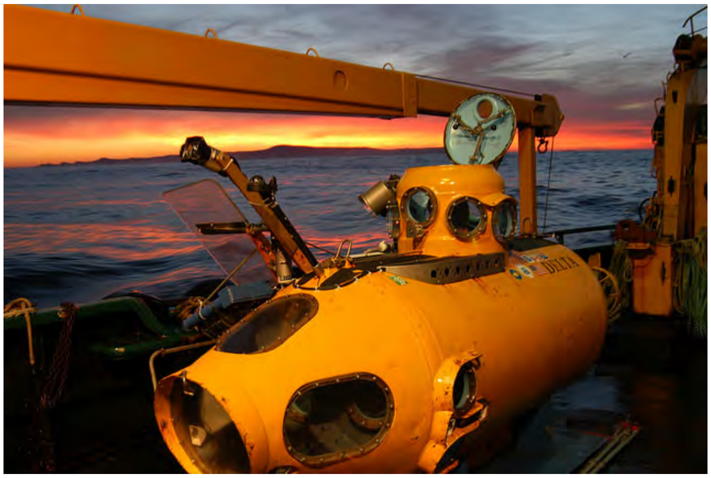


Figure ES.4. The Delta Submersible, also known as "the Jeep of the Seas," has performed more than 7,000 deep-water dives, mostly off Channel Islands National Marine Sanctuary. Photo: R. Schwremmer/NOAA

The ecosystem service of science is defined as the capacity to acquire and contribute information and knowledge. Currently, there is an absence of information on the economic value of science and research within CINMS; however, there are many non-economic indicators that may be used to measure and track science within the sanctuary.

The rating for this ecosystem service is "Good" because the capacity to provide the ecosystem service has been either enhanced or remained unaffected. The trend is "Stable" because economic indicators are positive and stable, human dimension indicators are increasing or stable, and ecological indicators do not indicate there is a decline in the resources related to this service.

Economic Indicators

At this time, there are no studies that seek to quantify the economic value of research. ONMS is in the process of exploring various economic techniques to fill this research gap.

Non-Economic Indicators

Quantifying research effort in the sanctuary is difficult because not all research conducted within the sanctuary requires a permit; understanding and enforcement of noncompliant (unpermitted) research is limited; and research compliant with sanctuary regulations (not requiring a permit) may not be reported to the sanctuary. Researchers apply for permits to conduct research within the sanctuary when research activities trigger sanctuary prohibitions. Using published primary literature as a measure of research activity in the sanctuary, it is estimated that only 25% of research occurring within the sanctuary operates under a permit (based on estimates that from 2009–2014, only 25% of all research required a permit, Freedman and Herron 2015). From 2006 to 2016, permit issuance activity increased. The number of permits issued increased in 2006 and 2016 with variation in the intervening years (see Appendix I: Figure App.I.9). Using Freedman and Herron 2015, the largest portion of all research occurring within the sanctuary from 2009–2014 was focused on fisheries ecology (see Appendix I: Figures App.I.10 and App.I.11, Freedman and Herron 2015). From 2009-–2014, there were 116 research projects permitted in CINMS (Freedman and Herron 2015).

Another indicator is the number of days spent on CINMS research vessels based on vessel accomplishment reports and vessel calendars (note that this does not include the number of days spent on other NOAA ships). The number of days at sea between 2008 and 2017 ranged from 99 to 171 days, averaging 109 days (Appendix I: Figure App.I.12); data were unavailable for 2009. The data, however, do not necessarily reflect trends, as large annual fluctuations can be caused by the number of available boats, changes of personnel (e.g., research coordinator, vessel operations coordinator), boat maintenance issues, changes in funding for research projects, or differences in annual base funding appropriations. In addition, researchers frequently use different platforms to access the islands (e.g., University of California Santa Barbara boats). These data were not compiled for this condition report but are available and could be useful for future assessments.

Resource Indicators

Science is different from some other ecosystem services in that the provision of the service does not substantially affect the state of natural and cultural resources; therefore, there is no reason to alter the ecosystem service rating. In fact, science can help managers and policymakers, like in CINMS, develop strategies to protect and restore natural and cultural resource conditions. The body of scientific work in CINMS has significantly contributed to the state of knowledge of resource conditions and the design and implementation of policies and management strategies to protect and restore resource conditions.

Summary of Economic, Non-Economic, and Resource Indicators for Science

Economic Indicators	Source	Figure or Table #	Data Summary
Not Available	Not available	Not available	Not available
Non-Economic Indicators	**Source**	**Figure or Table #**	**Data Summary**
Research topics	Freedman and Herron 2015	Figure App I.9	The number of sanctuary permits issued increased from 2006–2016.
Research permit topics	Freedman and Herron 2015	Figures App.I.10–App.I.11	The largest portion of permitted research occurring within the sanctuary from 2009–2014 focused on fisheries ecology.
Vessel time	Sanctuary Correspondence 2018	Figure App.I.12	Since 2008, the number of days at sea fluctuated without a consistent trend, ranging from 99 to 171 days.
Resource Indicators	**Source**	**Figure or Table #**	**Data Summary**
Not Available	Not available	Not available	Not available

Education

When people derive benefits from educational experiences in or products related to CINMS, this is considered an ecosystem service. CINMS's educational audiences include families, K–12 school children, teachers, college students, adults, volunteers, island visitors, boaters, divers, fishermen, and other stakeholders. Education may take place within the sanctuary, at visitor centers, in local schools, at community events, or remotely through online experiences. Using in-person education, visitor centers, and exhibits throughout the local region, information is disseminated to CINMS audiences. Technological advancements have increased access to CINMS and other remote locations that no longer require a person to be physically present in the sanctuary to experience and learn about its natural, historical, cultural, or archeological features.

Wide varieties of education and outreach programs have been developed at CINMS, reaching a range of target audiences and involving numerous partners from formal education program support (e.g., teacher training, curriculum development) that reaches students of all grade levels, to a variety of non-formal educational products and programs to reach sanctuary visitors and stakeholders (brochures, exhibits, signs, kiosks, volunteers interacting with visitors, etc.). In general, the sanctuary environment serves as a focal point for student and community learning, and as an inspiration to promote greater ocean literacy and stewardship. The assessment of the education ecosystem service provided by CINMS is based on a review of select sanctuary-related programs and activities that offer the type of data amenable to this analysis.

The ecosystem service for education is rated “Good” because the capacity to provide the ecosystem service has been either enhanced or remained unaffected. The trend is “Not Changing” because economic indicators are positive and stable, human dimension indicators are increasing or stable, and resource indicators do not indicate there is a decline in the resources related to this service.

Economic Indicators

Although there are no economic valuation studies specific to CINMS for the education ecosystem service, in 2017, ONMS completed a study estimating the economic value of the Ocean Guardian School (OGS) Program (Schwarzmann et al. 2017). This grant-based program is aimed to teach students about ocean conservation and stewardship of local watersheds and special ocean areas, like national marine sanctuaries. Although this is a national program managed by ONMS, most schools that receive funding are located within California. The program has five pathways (areas of focus): (1) Refuse/Reduce/Reuse/Recycle/Compost, (2) Marine Debris, (3) Watershed Restoration, (4) Schoolyard Habitat/Garden, and (5) Energy and Ocean Health. Among these, the study indicated that the highest valued attribute of the OGS program was Habitat/Garden. Parents were willing to pay $59 annually per student so that their children could engage in habitat restoration and school gardening projects. The subject with the second highest willingness to pay (WTP) level, averaging $44.79, was Watershed Restoration — learning about local watersheds and participating in projects to improve the local watershed, such as removing invasive species, planting native species, or improving fish habitat. In regards to the remaining three subjects, Energy and Ocean Health, Marine Debris, and Recycling had the third, fourth, and fifth highest marginal WTP levels per attribute, respectively. The study found that the marginal WTP for Energy and Ocean Health was $34.24, Marine Debris was $25.50, and the average marginal WTP was $21.41 for Recycling.

In addition, CINMS volunteers significantly contribute to improving sanctuary programming, including public education and outreach services. According to Independent Sector, the value of a volunteer hour in California in 2016 was $28.46. Based on the number of sanctuary volunteers and the service hours they contribute, the annual value of this time can be estimated. From 2008–2016, the value that volunteers added to the sanctuary increased by over $200,000, rising from $566,073 to $783,700 (see Appendix I: Figure App.I.13).

Non-Economic indicators

Each year, CINMS is represented at over 35 community events located in Santa Barbara, Ventura, and Los Angeles counties that draw over 450,000 in total public attendance. This includes events like Santa

Barbara's Earth Day Festival, Earth Day and NOAA Day at the Long Beach Aquarium of the Pacific, the U.S. Coast Guard Safe Boating Expo, the Santa Barbara Harbor's Seafood Festival, and the Ventura County Fair.

NOAA's B-WET (Bay Watershed Education and Training) funds are used to support outdoor and classroom training for K–12 students to support learning related to watersheds and ocean health. One program that B-WET funds support is the Multicultural Education for Resource Issues Threatening Oceans (MERITO) program. This program has supported the CINMS education mission since 2004, and has received partial support from several B-WET grants over time. The number of students per school year exposed to this educational opportunity has increased from the 2006–2007 school year to the 2016–2017 school year (Figure H.14). Further, this program supports mainly Title 1 schools, which serve low-income communities. Students participating in MERITO Academy programs take a survey before and after their involvement to gauge their knowledge about environmental, scientific, and conservation issues that are part of the curriculum. From 2006 through 2017, these surveys reveal a positive increase in student knowledge ranging from 25% to 43% above pre-program levels of understanding.

Throughout the region, several partner venues host interactive touch-screen kiosks that feature educational information about the sanctuary. Partner venue sites include the Channel Islands Boating Center, Ventura Visitor and Convention Bureau, Island Packers, Santa Barbara Harbor Patrol, Santa Barbara Sea Center, California Welcome Center in Oxnard, and the Santa Barbara Maritime Museum. Based upon kiosk data that records the number of unique visitors to the kiosk, it is clear that over time, the number of visitors to the kiosks increased from 2013–2017 (see Appendix I: Figure App.I.15).

Many whale watch operators have naturalists onboard providing educational services. The Channel Islands Naturalist Corps (CINC) is a volunteer program that is co-managed by CINMS and Channel Islands National Park to provide interpretation on local whale watch and concessionaire vessels as well as outreach at community events. One-hundred-forty CINC volunteers donate an average of 32,000 hours annually and informally reach over 350,000 visitors annually. CINC volunteers educate passengers onboard local whale watch vessels (marine excursion vessels with more than 49 passengers) departing out of Santa Barbara, Ventura, and Channel Islands harbors. Seasons include gray whale watch trips from December to May, and summer blue and humpback whale watch tours from May to October.

Island Packers brings K–12 educational program participants to various locations within and around the Channel Islands. From the 2005–2006 season to the 2016–2017 season, there was a slight decline in the total number of participants who visited the Channels Islands for educational trips (see Appendix I: Figure App.I.16); however, visits to the Scorpion and Prisoner's sites at Santa Cruz Island increased. Regardless, it should be noted that during this period, facility closures had negative impacts on visitor numbers at two specific sites. In 2015–2016, Scorpion saw a dip because of a temporary pier closure, and in the 2016–2017 season, Frenchy's Cove at Anacapa Island was closed due to the loss of the trail to the tidepools. This information represents one company that takes out school-age children and does not include other operations that may take school groups out to the sanctuary.

Volunteers and volunteer hours is also a metric that can be used to monitor education. Although the number of volunteers has remained constant from 2008-–2016, the number of volunteer hours has increased. This means that volunteers are donating more hours of their time to the sanctuary and sanctuary programs (see Appendix I: Figure App.I.17).

Social media use provides another metric for education. Since September 2015, the number of CINMS's Facebook and Twitter followers has grown. Specifically, CINMS's number of Facebook followers has grown by 84% and the number of Twitter followers has grown by 187%. In September 2015, the number of Facebook and Twitter followers was 4,913 and this number has grown to 9,554 (see Appendix I: Figure App.I.18). Although not reflected in the number of followers, there are times when the number of impressions or views of sanctuary content spike. A prime example are Ocean Exploration Trust's *Nautilus* Live cruises to CINMS. During these cruises, ship-to-shore interactions and broadcasts are hosted including many live, interactive sessions where audience members could ask questions to the scientists and researchers onboard. In 2017, there were 314,838 page views on the *Nautilus* Live website during a three-week Channel Islands leg of the expedition, and over 2.2 million impressions through 32 news stories.

Resource Indicators

Education is different from some other ecosystem services in that the provision of the service has a limited potential to affect the state of natural and cultural resources; therefore, resource conditions do not justify a change in the rating for this ecosystem service. Instead, education is focused on the development and distribution of products and services. The body of educational work in CINMS has significantly contributed to the state of knowledge of resource conditions and the design and implementation of educational programs and initiatives.

Summary of Economic, Non-Economic, and Resource Indicators for Education

Economic Indicators	Source	Figure or Table #	Data Summary
Value of volunteer time	Sanctuary Correspondence	Figure App.I.14a	The economic value of volunteer time increased from 2008–2016.
Non-Economic Indicators	**Source**	**Figure or Table #**	**Data Summary**
Students	MERITO	Figure App.I.14a	
Change in knowledge	MERITO	Figure App.I.14b	Knowledge and stewardship as per students' pre- and post-evaluation surveys.
Kiosk visits	ONMS Kiosk Data 2018	Figure App.I.15	The total number of kiosk visitors increased from 2013–2017.
Education-related visits to Channel Islands	Island Packers 2017	Figure App.I.16	From the 2005–2006 season to the 2016–2017 season, there was a slight decline in the total number of participants visiting the islands on educational trips.
Number of volunteers and time	Sanctuary Correspondence	Figure App.I.14b	The number of volunteers has remained fairly constant from 2008–2016, the number of volunteer hours has an increasing trend.
Social media followers	Sanctuary Correspondence	Figure App.I.18	Since September 2015, the number of Facebook followers has grown by 84% and

			the number of Twitter followers has grown by 187%.
Resource Indicators	**Source**	**Figure or Table #**	**Data Summary**
Not Applicable	Not applicable	Not applicable	Not applicable

Ecosystem Services Status and Trends Summary

Four of the seven ecosystem services evaluated for CINMS (sense of place, consumptive recreation, non-consumptive recreation, and food supply) were rated "Good/Fair." Two of the ecosystem services were rated "Good" (science and education) and one ecosystem service was rated "Fair" (maritime heritage). For the trends ratings, five of the seven ecosystem services were rated "Stable" or "Not Changing" (sense of place, non-consumptive recreation, maritime heritage, science, and education) and two were rated as "Undetermined" (consumptive recreation and food supply). The main reason for the undetermined rating was the lack of fishery independent data for the main species of fish and invertebrates that each of these services depend.

Ecosystem Services	Rating	Description of Findings	Basis for Judgement
Sense of place	Good/Fair –	Unable to fully provide the ecosystem service due to prior or existing human activity, but performance is acceptable.	Economic indicators are positive and stable, human dimensions indicators are increasing or stable and resource indicators do not indicate there is a decline in the natural or maritime archaeological resources related to this service.
Consumptive recreation	Good/Fair ?	Unable to fully provide the ecosystem service due to prior or existing human activity, but performance is acceptable.	Economic indicators are positive and stable, human dimensions indicators are increasing or stable, but resource indicators do not cover many important species supporting this service.
Non-consumptive recreation	Good/Fair –	Unable to fully provide the ecosystem service due to prior or existing human activity, but performance is acceptable.	Economic indicators are positive and stable, human dimensions indicators are increasing or stable, and resource indicators do not indicate there is a decline in the natural resources supporting this service..
Food supply	Good/Fair ?	Unable to fully provide the ecosystem service due to prior or existing human activity, but performance is acceptable.	Economic indicators are positive and stable, human dimensions indicators are increasing or stable, but resource indicators do not cover many important species supporting this service.
Maritime heritage	Fair –	Ability to provide this ecosystem service is compromised, and existing management would require enhancement to enable acceptable performance.	Economic indicators are positive and stable, human dimensions indicators are increasing or stable and resource indicators do indicate there is a decline in the cultural resources related to this service, but it is not widespread.
Science	Good –	The capacity to provide the ecosystem service has been either enhanced or remained unaffected.	Economic indicators are positive and stable and human dimension indicators are increasing or stable.

Education	Good –	The capacity to provide the ecosystem service has been either enhanced or remained unaffected.	Economic indicators are positive and stable and human dimensions indicators are increasing or stable.

** Note that a confidence score was not assigned to the Ecosystem Service ratings because subject matter experts were not consulted in a workshop setting on these ratings.*

CHUMASH ECOSYSTEM SERVICES ASSESSMENT

Introduction to Chumash Ecosystem Services Assessment

NOAA/ONMS respects the seniority of Indigenous and Tribal groups, and believes that understanding Chumash perspectives on natural resources, as well as cultural and maritime heritage, is important for managing CINMS. Therefore, representatives of the Chumash were invited to provide their perspectives on ecosystem services for CINMS. As a part of this process, ONMS and the Chumash representatives who authored this assessment agreed that it would not be subject to any peer review or editing by NOAA. Accordingly, the assessment included in this report appears in its final version unaltered by NOAA, as submitted by its authors to CINMS in November 2018. These Chumash community perspectives, as documented in the authors' own words, align with principles found within the 2015 multi-agency, *Guidance Document for Characterizing Tribal Cultural Landscapes*[21], which NOAA/ONMS helped develop.

The Chumash perspective on ecosystem services is different from that presented elsewhere in this report. Authors of the Chumash contribution do not consider all of the ecosystem service categories used herein to be consistent with the way they perceive the relationship between humans and their surroundings. Seeking to understand the Chumash point of view, however, we all gain an enhanced appreciation for ways of knowing and relating to the marine environment that are built over thousands of years of history.

Chumash Ecosystem Services Assessment[22]

Authored by:

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It is only possible to convey values of any culture (especially a marginalized culture) by first bringing the layers of that culture into context: its history, languages, and sociological norms; its political systems and economies; its cosmology and religious systems; and its interrelationship with local ecology and geography.[23] Where possible, this section on Chumash values will parallel the framework of the values

[21] The Guidance Document for Characterizing Tribal Cultural Landscapes can be accessed here: https://www.boem.gov/2015-047/

[22] The text and images of this section were provided in November 2018 by the Chumash Community representatives for the Channel Islands National Marine Sanctuary Advisory Council and the Chumash Women's Elders Council, in consultation with a broad cross-section of the Chumash community. This text is presented here as-received; no editing was applied by NOAA or its affiliates.

[23] Using the language of the dominant culture to convey ideas that are not typical of that dominant culture can be cumbersome. Language depends on common reference points and shared understanding. Because of these difficulties, new terms come into the lexicon to attempt to bridge these conceptual gaps – terms like historic trauma, settler colonialism, indigenous traditional

discussed in the overall CINMS ecosystem services assessment, but given the fundamentally different worldviews, there will be places where alignment feels contrived. In those places, we will provide cultural context to bring to light how our stake in the sanctuary reflects our commitment to traditional ecological knowledge and practice, and how our traditional fisheries practices go beyond preservation or even conservation. For clarity, text boxes are used: blue for terms and definitions, green for extended quotes from indigenous sources.

It is also important to note that the diverse Chumash communities represent a wide variety of perspectives. There are over 8,800 Chumash people currently living in the United States (US Census Bureau, 2013).[24] The broader Chumash Nation is comprised of family groups, clans, bands, and tribes including the Barbareño Band of Chumash Indians, Barbareño Chumash Council, Barbareño/Ventureño Band of Mission Indians, Chumash Indian Council of Bakersfield, Coastal Band of the Chumash Nation, Northern Chumash Tribal Council, Salinan-Chumash Nation, San Luis Obispo County Chumash Council, Santa Clara River Turtle Clan, Santa Ynez Band of Chumash Indians, Southern Owl Clan, and Yak Tityu Tityu Yak Tilhini Northern Chumash Tribe.[25] There are also a number of non-tribally-affiliated Chumash-led non-profit organizations including Apanish Foundation, Chumash Maritime Association, and Wishtoyo Chumash Foundation. While no single document can claim to represent the full scope of Chumash perspectives and values, the generalities explained herein are derived from a broad cross-section of the Chumash community.

Settler colonialism is a distinct type of colonialism that functions through the replacement of indigenous populations with an invasive settler society that, over time, develops a distinctive identity and sovereignty. Settler colonial states include Canada, the United States, Australia, and South Africa.

https://globalsocialtheory.org/concepts/settler-colonialism/

Chumash Place-Based Values in Context

Since time immemorial, the Chumash people have lived in relationship with the waters, lands, and the living and non-living beings of the Santa Barbara Channel. "Time immemorial" is a phrase meaning a time which is indefinitely ancient and extends beyond memory, record, or tradition.[26] As there is no memory of a time before the Chumash belonged to the Channel Island region, not in living memory and not in any form of documented or oral history, this phrase is appropriate here. Conversely, settler colonial culture is rooted in multiple cultural histories of leaving behind relationships to traditional homelands and

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knowledge, indigenous communities of practice, and relationship tending. Until these terms and their related concepts become more widely understood by general audiences, effective communication often necessitates lengthy (potentially cumbersome) explanations or additional background information. Definitions for uncommon terms are included where relevant.

[24] According to the US Census, there were 8,868 Chumash people in the United States in 2010.

[25] This is a partial list of Chumash tribes which includes the federally recognized tribe, tribes on the Native American Heritage Commission list, and other Chumash tribes in California.

[26] *Time immemorial* is also used in English law to refer to a custom, property, or benefit which has been enjoyed for so long that its owner does not have to prove how they came to own it.

in attempts to recreate lifestyles and traditions in a foreign land. Settler colonial culture, therefore, has developed a different relationship with the land, waters, and living things based on a fundamentally different type of connection and concept of belonging.

Autochthonous people

A concept that comes from the Greek, auto- (self) and khthon (soil). It describes the *original* people of an area – literally, the people who *originate* from the land itself (rather than the first people to migrate to an unpopulated land).

The Chumash people originate directly from this region in deep time. The oldest human remains documented in North America were found on the Channel Islands and are estimated to be about 13,000 years old (Johnson, 2016). For temporal perspective, this Chumash ancestor lived on the large island of Santa Rosae before it was divided by sea level rise into the modern channel islands. Using standard estimates of average human generation time,[27] seafaring people have been living along the mainland and islands of the Santa Barbara Channel for more than 520 generations.[28] Over these millennia, California's flora, fauna, and even the land and waters have developed and changed together with its people. The Chumash peoples, including Chumash culture, values, cosmology, lifeways, epistemologies, and languages have thus emerged specifically from the lands and waters of the Santa Barbara Channel and have continued to develop and change in relationship with them.

Kitsepawit's grandfather told him that all animals are related and that an old man told him that we are all siblings, and our mother is one: this mother earth. He has always believed what the old people told him when he was a boy —that the world is God.

December's Child: A Book of Chumash Oral Narratives

All of the gifts that have shaped and sustained Chumash people and society for thousands of years are provided by traditional lands and waters. To this day, Chumash ancestors and ancient villages are still present underground, below the ocean itself, and in the minds, hearts, traditions and oral histories of the Chumash peoples. Held within Chumash cosmology is a fundamental gratitude to the land, waters, and living beings of this area for our existence, sustenance, and wellness. Embedded in this gratitude is a sacred responsibility to protect, care for, and live in deeply knowledgeable, reciprocal, and regenerative relationship with these relatives.[29] As autochthonous people of the region, Chumash genealogies both originate from and return to our lands and waters.

This essential contrast between Chumash and colonial worldviews is not due to superstition, naiveté, or lack of sophistication of indigenous people (Smith, 1999) – it is, in large part, due to divergent histories, relationships with place and people, and depth of ancestral ties with these lands and waters. Settler colonial relationships with the Santa Barbara Channel began with the 1769 Portola Expedition, the outset

[27] Average human generation time is estimated to be about 25 years.

[28] The recent and controversial Cerutti mastodon site shows evidence of possible human habitation in Southern California as long as 130,000 years ago (5,200 generations) (Holen et al, 2017).

[29] Chumash worldview holds that all living and non-living beings are relatives. This includes plants, animals, water, land, fire, wind, etc. Humans are neither at the apex nor the center of this worldview, but are part of a large extended family.

of the military occupation of California (about 250 years ago/10 generations ago) (Figure 1). California became a state in 1850 (about 170 years ago/7 generations ago). With few exceptions, settler colonists did not adopt or assimilate into local, place-based culture. They rarely embraced or attempted to understand Chumash values and worldview, nor become educated in the accumulated knowledge and practices of Chumash people. They therefore did not benefit from these deeply rooted relationships, responsibilities, or intimate local knowledge that Chumash collectively developed over each lifetime, using knowledge accumulated and rigorously tested over millennia. Because of these fundamentally divergent cultural ways of seeing the same region, it is necessary for the Chumash section of the ecosystem services assessment to be longer and to more explicitly present Chumash worldviews in context.

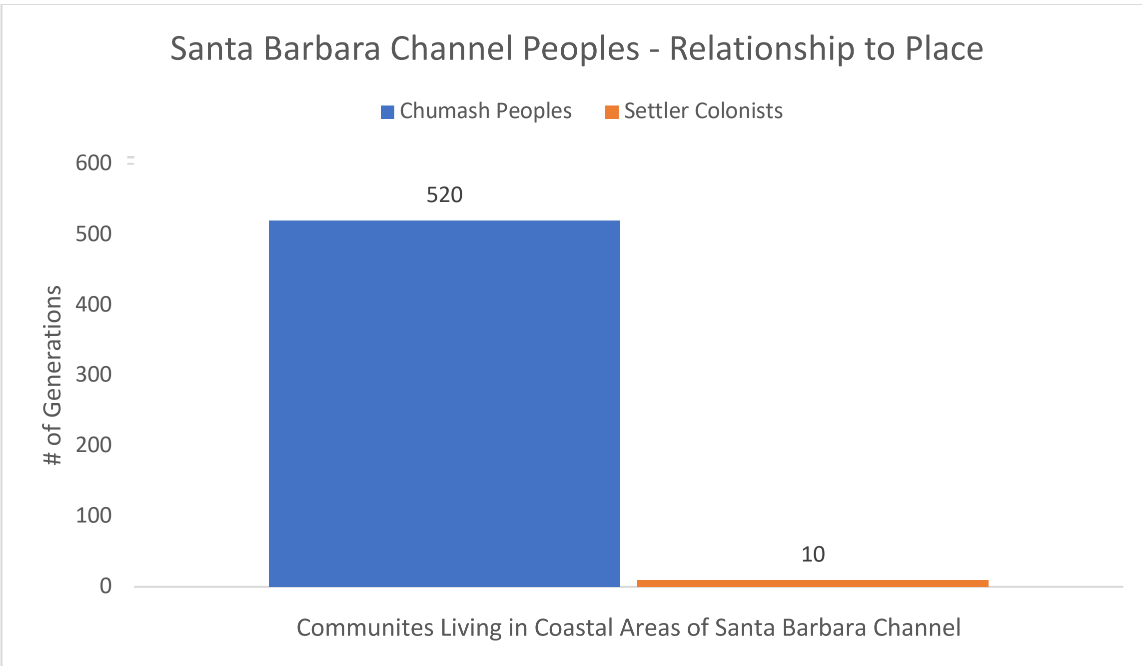

Figure 1. A conservative side-by-side comparison of time spent developing relationship to place. Chumash numbers are based not on the actual first people, but on the earliest remains found on the channel islands. Settler colonist numbers are based on the earliest settlers, although the ancestors of most settler colonists arrived to the region more recently.

Ecosystem Services & Chumash Worldview

The Chumash have an intrinsically integrative worldview that intimately ties together what are, in mainstream culture, separate disciplines of study. Chumash community-based value systems are based on this recognition of fundamental interdependence. Therefore, it is difficult to articulate a Chumash assessment of ecosystem services[30] provided by the CINMS in a way that parallels the categories outlined in other parts of this report.

Chumash traditional ecological practitioners (as well as a growing number of mainstream biologists) understand that the islands and their surrounding waters are intertwined systems with species interdependency which blurs the boundaries between the aquatic and terrestrial. Therefore, the CINMS waters and the National Parks Service and The Nature Conservancy islands, although regarded as distinct regions by public and private interests, are, in fact, physically and conceptually inseparable in terms of ecology as well as culture, spirituality, and history.

Within such a view, the anthropocentric distinction between "final services" (services directly valued by people) and "intermediate services" (ecological functions that support final services) invokes a sense of separation that is not only inaccurate, but potentially harmful in that it implies a false sense of independence from the natural world. In fact, the word "services" itself is in conflict with the Chumash core value of reciprocity. Also, Chumash worldviews do not differentiate between "consumptive" and "non-consumptive" services because that would be inconsistent with the idea of regenerative exchange. Likewise, in Chumash traditional ecological practices, "cultural" and "provisioning" services are one and the same.

Reciprocal, Regenerative Relationship is an indigenous concept that can be counterposed with colonial *resource management*. Resource management is often seen as a zero-sum system where gains for people necessitate losses for the environment. Whereas the concept of "reciprocal, regenerative relationship" combines the ideas of *reciprocity* (mutually beneficial roles in an interdependent system), *regenerative* interactions (which foster increases in resource health and abundance), and *relationship* development (built on gratitude, reverence, and traditional knowledge). In reciprocal, regenerative relationships humans play an integral, *but not central*, role.

An economic assessment of the natural world is incompatible with the Chumash worldview which places high value on the intangible and the sacred. Monetizing Chumash homewaters and lands dis-integrates their intertwined physical, spiritual, and psychological importance. Modern indigenous culture views commodification as disrespectful, misguided, and potentially dangerous (Kimmerer, 2013), especially in light of the catastrophic effect such dis-integrated thinking has had on Chumash homelands and the biosphere of planet earth itself.[31]

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[30] Ecosystem services are defined as benefits that humans receive from natural and cultural resources.

[31] It is possible to observe, in real time, the harm and damage done to peoples, lands, and waters as the fruit of extractive commodification of creation. There is a deep sense of frustration in the Chumash communities as settler colonists lament the damage done to irreplaceable places and species while they continue to damage them by speaking the language of commodification.

> The loss of a species such as white abalone or wild southern steelhead salmon has dramatic cultural significance that transcends mere economic or commercial value for the animal. The ceremonial significance of the animal may also fade in time with the loss of the presence of the animal as a distinct but interdependent part of the greater circle of animals, plants and insects.
>
> -Tribal Marine Protected Areas: Protecting Maritime Ways and Practice, 2004

Figure 2. Endangered species and endangered lifeways are inextricably intertwined. Chumash Elders remember a time when our abalone relatives were abundant, thriving, and easily gathered for cultural and subsistence purposes. Largely as a result of commodification and subsequent overharvesting, the vast majority of today's Chumash youth have never seen nor interacted with any species of living abalone. Photo Credit: Mati Waiya

Even if a solely economic assessment were made by Chumash communities, the "economic" and "non-economic" indicators would necessarily be re-integrated due to traditional interdependent conceptions of economy (Kimmerer, 2013). However, it is vital to note that the historical disenfranchisement and modern economic marginalization of the Chumash people artificially deflates the calculated "value" placed on "ecosystem services." For example, the theoretical amount of money each Chumash household would be willing to pay to protect their traditional homewaters is not indicative of how much value Chumash people place on them. Those kinds of calculations are not representative of "value" for people who do not have disposable income.

In addition to the standard categories addressed in overall ecosystem services assessment – sense of place, heritage, science, education, food supply, and ornaments – the Chumash perspective includes community wellness and psychological, spiritual, and physical health as ecosystem services. Also, because of the integrative nature of the Chumash worldview, these categories are circumscribed somewhat differently. For example, the separate categories of science, education, food supply, and ornament, are combined in this section into the category "Indigenous Traditional Knowledge & Practice."

Chumash Sense of Place & Heritage

In the CINMS assessment, "Sense of Place" is defined as the aesthetic and spiritual attraction, and the level of recognition and appreciation given to efforts to protect a place's iconic elements. The category "Heritage" is defined as the recognition of historical or heritage legacy. These are integrated categories in the Chumash experience and are therefore being considered here as a single category. The ineffable value Chumash people place on the islands, their surrounding waters, and their ecosystems is beyond measure.

Chumash Islands of Origin

The Channel Islands region is central to Chumash cosmology as the place of origin of the Chumash people and to their connection to the ocean and all of the living things within it (see Rainbow Bridge Story).

Hulmesmu' hil Wishtoyo (The Rainbow Bridge)

A long, long time ago, the people we know as Chumash lived only on the islands we now call the Channel Islands. The People were happy and healthy on the islands and lived a long time. Soon the islands became very crowded and Kakunupmawa (the Mystery Behind the Sun) saw that this was not healthy for the islands or for the people. So, some people were chosen to move to the Big Land. Hutash (the spirit of the Earth) and Kakunupmawa made a Rainbow Bridge for the people to cross over. Some of the people looked down from the rainbow bridge and fell into the sparkling ocean. They fell down, down into the deep and Hutash had compassion for the people and called to Kakunupmawa to save them. So the people dying below the ocean were changed into dolphins. Chumash People tell this story to remind us that the dolphins are our very close relatives.

The retelling of this story was first told to me by my father, Joseph John Moreno, who was born in 1897 and died in 1991.

-Luhui (Georgiana Valoyce Sanchez)

Chumash Dispossession

In the early 1800s, Chumash people were removed from the Islands and relocated to the mainland and missions (Arnold, 1990). The legality of the land seizure and subsequent private and public "ownership" of the Channel Islands continues to be an area of legal and ethical contention. In Chunie v Ringrose (1986), the 9th Circuit US Court of Appeals refused to recognize Chumash rights of indigenous title to the Northern Channel Islands and their surrounding waters. This decision was based on the US Supreme Court landmark decision, Johnson v M'Intosh (1823) which held that Native Americans did not hold rightful ownership of land. This decision, in turn, was based on the Doctrine of Discovery, a religious, quasi-legal creation of European colonial conquest. The Doctrine of Discovery recognizes claims to land "discovered" by Christian European monarchs and denies the land ownership rights of any non-Christian Nations (Newcomb, 2008).[32] Thus, the courts held that the Spanish (not the Chumash) held rightful claims to Chumash homelands, and that those claims to the land and water around the Channel Islands were transferred to Mexico in 1821 when Mexico won independence from Spain. The claims were subsequently transferred to the United States in 1848 through the Treaty of Guadalupe Hildago. It is particularly notable that even in 1986, the US court's reasoning was still based on archaic, foreign,

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[32] In recent times, many Christian religious groups, including Catholics, have publicly repudiated and called for the dismantling of the Doctrine of Discovery. Indigenous nations throughout the world are advocating for its rejection as well (Rotondaro, 2015).

religious doctrine that denies indigenous people the rights of ever having owned their own homelands (Newcomb, 2008).[33] Dispossessing people of access to their land lies at the heart of early North American capital accumulation (Hall, 2015).

Regardless of the current legal status, it should also be made clear that the Chumash people never lost a war over the Channel Islands region, never signed over rights to the land and waters via treaty or any other method, and never sold rights to any public or private entity. So, from the Chumash perspective, the Channel Islands (and surrounding waters) have always been, and will ultimately always be unceded Chumash territories.

Chumash Heritage, Settler Colonial Wealth

Dispossession, displacement, and historic trauma have created colonial systems of economic oppression and marginalization that have affected Chumash families for generations. Stolen land and stolen labor became wealth for settler colonists and poverty for the First Peoples of the region. Compounded over generations, this has created not only a huge economic disparity, but has also created a society in which Chumash people have been pushed to the margins and have very little influence in their own homelands. For example, to this day, housing insecurity is a huge challenge for Chumash communities. As the cost of living in Chumash homelands continues to skyrocket, the beneficiaries of colonialism enjoy the privilege of living and recreating on traditional lands while Chumash people are being “priced out” of their own homelands.

Specific to the Channel Islands, the land (including submerged land) and surrounding waters have, for settler colonists, generated a vast legacy of wealth, both public and private, in the form of land value, ranching, minerals, fishing, tourism, recreation, concessions, jobs, and research.[34] Although this wealth rarely trickles into the predominantly economically disadvantaged Chumash community, its value is still relevant to Chumash socio-economics. Reparations are measures taken by the state to redress gross and systematic violations of human rights law or humanitarian law, such as dispossession from traditional territories and state sponsored genocide.[35] The financial losses to the Chumash people and the financial gains of the settler colonists are significant and theoretically calculable. But even so, there is no amount of money that represents the value of the Channel Islands region to the Chumash. There can be no economic “even trade” for something so deeply linked to the Chumash culture.

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[33] This is also related to the legal term *terra nullius*, literally translated as “no one’s land.” The fallacious notion of empty, unpopulated land “was used as an implicit justification to expropriate indigenous peoples’ lands in North America.” (Samson, 2008)

[34] Even Chumash remains and artifacts have been commodified: both illegally through black-market sales and legally through income generated via anthropological research careers.

[35] When California Governor Brown proclaimed September 25, 2015 as Native American Day, he wrote about state-sponsored genocide of California’s Native Peoples: “The contact between these first Californians and successive waves of newcomers over the three succeeding centuries was marked by the utter devastation of Native American people, families and society. The colonial regimes of Spain and Mexico, through disease and slavery, reduced the indigenous population by more than half. Then the Gold Rush came, and with it a wave of new diseases and outright violence that halved the population again in just two years. The newborn State of California institutionalized violence against Native Americans, enacting policies of warfare, slavery and relocation that left few people alive and no tribe intact. In his 1851 address to the Legislature, our first Governor, Peter Hardeman Burnett, famously stated, ‘That a war of extermination will continue to be waged between the two races until the Indian race becomes extinct, must be expected.’”

It is also important to note that in a conventional ecosystem services assessment, the economic value for the majority of Chumash people would primarily be classified as “non-use” or “passive economic value.” Due to the systemic poverty in the Chumash community, the vast majority of Chumash people living today do not have the opportunity to travel across the Channel, have never been on or in sanctuary waters and have never set foot on any of the Channel Islands. This is both a social and environmental justice concern (Figure 3).

Figure 3. The Chumash community works to overcome systemic barriers which disrupt relationships to traditional homelands. Luhui Isha Waiya and students from Wishtoyo’s First Nations Youth Summer Field Studies program engage with the rocky intertidal on Limuw (Santa Cruz Island). Photo Credit: Wishtoyo Chumash Foundation

Chumash Concept of Reciprocal Belonging

When Chumash people refer to “our land” and “our ocean,” this encompasses much more than economic and legal ownership. Although it does not translate directly into English, Chumash languages reflect a different kind of belonging, one that is more inclusive and reciprocal. For example, the Šmuwič[36] language morpheme “kiyis” is a uniquely inclusive, relational, and reciprocal “our.” It can be seen in the word “kiyis’skamin” (our ocean) and can possibly most easily be understood inter-culturally through the mission-era usage in Kiyiswot Xesu Kilistu (Our Lord, Jesus Christ) (Applegate, 2015). It is a mutual state of belonging. People belong to the land and waters; the land and waters belong to the people. Not just belonging as ownership, but as a sense of responsibility to not only protect, care for, and love – but also to make decisions and choose actions reflective of those responsibilities. The Chumash ideal is to be

[36] One of many Chumash languages, Šmuwič is the language spoken along the mainland coast of the Santa Barbara Channel.

in relationship (collective, regenerative, reciprocal relationship) with the land, air, waters, and all beings in this interdependent system and to be mindful that all of their gifts, and even their very existence, originate from and return to this system.

Psychological Services & Community Wellness

There is a deep sense of loss in the Chumash community which is rooted in historical dispossession of the Islands and exacerbated by the barriers Chumash people face in meeting the cultural mandate to take care of and stay in intimate relationship with the marine and terrestrial ecosystems, sacred sites (including submerged sites within the CINMS), and natural cultural resources which are the basis of Chumash maritime culture. It may seem out-of-place to discuss historical trauma in the context of "ecosystem services" but it is through coming to terms with this intergenerational trauma that communities can achieve the healing and wellness associated with intergenerational clarity and resilience (Ward-Olmstead, 2018). Loss of access to traditional spaces through historic injustices, land grabs, convoluted permitting procedures, and economic disadvantages, prohibit Chumash People from engaging in healthy relationships with the marine ecosystems around the islands which causes psychological distress rooted in the collective trauma of past generations and continued in the intergenerational trauma inherited by present generations.

Historical Trauma and Unresolved Grief

Historical trauma is cumulative emotional and psychological wounding over the lifespan and across generations, emanating from massive group trauma as observed among Native populations, Jewish Holocaust survivors and descendants, Japanese American internment camp survivors and descendants.

(Brave Heart & De Bruyn, 1998)

Cultural Disruption & Ongoing Sense of Displacement

Studies of indigenous communities show that the denial of a Peoples' efforts to maintain cultural practices in traditional landscapes creates an ongoing sense of displacement. Collective community stress results from restricted access from conducting appropriate cultural activities which is described as a deeply painful experience for the affected community (Norgaard, 2014). It is especially poignant and disturbing when, like the Channel Islands, that place is the center of creation of the People themselves. In

For American Indians, land, plants, and animal are considered sacred relatives, far beyond a concept of property. Their loss becomes a source of grief.

-Brave Heart and DeBruyn, 1998

the same manner, policy and management developed according to non-Native values and philosophy are associated with the continuing experience of threats to culture and lifeways (Norgaard, 2014). "These emotional impacts of the impaired social and ecological activities that ripple through the community, are thus examples of stressors that proliferate over the life course and across generations" (Norgaard, 2014).

Role Strain & Chronic Community Stress

Awareness of ecosystem decline is a chronic stress for people from all walks of life. Within Chumash communities, however, there is added stress from feelings associated with failure to meet culturally mandated responsibilities for traditional ecosystems as well as the awareness that ecosystem health is declining because of exploitation by private interests and regulation by agencies, both of which are often active agents in Chumash disenfranchisement. Humans universally understand feelings of powerlessness associated with not being able to help a loved one in dire circumstances and the shame of failing to uphold moral responsibilities. For Chumash people, the Channel Islands and surrounding waters are this cherished family and thus their well-being is a moral responsibility. Therefore, any barriers to meeting these responsibilities and upholding these sacred birthrights cause both acute and chronic psychological distress.

Similarly, role strain is the frustrating sense of not being able to meet the normal expectations of one's roles and has negative consequences for identity, personal pride and general mental well-being. In this context, strain comes from the inability to fulfill obligations, not only to environment, but also to the human community and to the Creator. When people are unable to carry out these practices it generates a powerful threat to one's sense of self.

> [Karuk] People describe how their moral responsibilities are being blocked and their obligations rendered impossible to fulfill. People described how the situation represents extreme harms to traditional conceptions of moral life itself, literally denial of someone's being able to do what is right to them. The overall position of being unable to carry out culture practices and responsibilities is understood in the context of genocide, contributing to yet another level of emotional harm.
>
> -Karuk Tribe Department of Natural Resources, 2014

Denied Access to Traditional Management & Barriers to Co-Management

No external management plans or policies can end Chumash People's ongoing culturally and ancestrally mandated responsibilities. And since they originate in ancient times and extend into the future

> Not only are ties to the natural world particularly strong for many Native people, but there are extensive disruptions of social, cultural and spiritual systems from both ecological change and denied access to management…Grief from the loss of species, and stress from the inability…to manage the ecosystem in accordance with their cultural practices and spiritual responsibilities is expressed vividly…in terms of emotions of grief, shame, stress and powerlessness. The impact of each of these categories of experiences is underscored by their invisibility and the corresponding lack of legitimacy or recognition within the dominant culture – what Ken Doka calls "disenfranchised grief."
>
> -Karuk Tribe Department of Natural Resources, 2014

indefinitely, there is no condition of environmental health or degradation that will alleviate those responsibilities.[37] Indeed, what many contemporarily view as an idealized, untouched, wild, and pristine California landscape prior to European colonization was in fact a result of thousands of years of reciprocal relationship, tending, and cultivation by the Native peoples of these areas. For the Chumash people who have inherited a deep and unending responsibility to care for a place – restoring and maintaining traditional relationships creates integrated health both within and between the ecological and human communities. The consequences of denied access to traditional management are profound.

Healing from Historic Trauma

Native communities live with chronic stressors from threats to meaning systems and identity combined with role strain and powerlessness in the face of denied access to traditional management (Norgaard, 2014). This contributes to the collective historic trauma and Adverse Childhood Experiences (ACEs) that manifest in affected communities as higher rates of physical and mental illness, substance abuse, domestic violence, suicide, and incarceration (Ward-Olmstead, 2018). Some tribes have successfully responded to these crises in their communities via ecological restoration of traditional spaces and reestablishing integrated, community-level, reciprocal relationships with natural cultural resources (Mozingo, 2017). In Chumash country, there has been an increase in collective healing as the community has strengthened their maritime culture with modern and ancestral Chumash tomol (canoe) traditions (Figure 4); reestablished relationships with traditional medicines and foodways; acquired “seats at the table” related to managing homelands and waters; and fought for protections against potential harms to ecosystems and traditional lifeways.

[37] In some cases, the lands and waters have been damaged beyond recognition, and in best cases they have been protected and restored. While preservation in perpetuity has a value that is beyond measure, it is important to note that damaged ecosystems are no less valuable and sacred in the Chumash worldview.

Figure 4. Tomols hold a central role in Chumash maritime culture. These traditional redwood plank canoes are built and navigated by the modern Chumash community. Photo Credit: Wishtoyo Chumash Foundation.

Community Gatherings & Annual Pilgrimage

The annual Chumash tomol crossing is a collective practice of community healing. Arriving at Limuw[38] via traditional tomol or Island Packers boat, Chumash people are warmly welcomed home by their own community though songs, ceremony, gifts, and loving greetings. Elders, children, and everyone in between experience modern village life together for several days in a community camp at the traditional village site of Swaxił.[39] The crossing itself is regarded as a spiritual pilgrimage back to the Chumash island of origin – a symbolic and sacred completion of the circle of the Rainbow Bridge story in which Chumash people were created on Limuw, crossed to the mainland on the rainbow bridge, and now return through the channel each year to reconnect with the ancestors. The welcoming ceremony is a deeply spiritual and healing experience. The Limuw community onshore looks out over the viewshed from the island, across the channel to the mainland. While they wait for the boats to appear, they pray and sing together with the ancestors for the safety of the paddlers and the health of the ocean. The paddlers themselves are in ceremony together as they traverse the channel waters (Figure 5). They say that every pull of the paddle through the water is a prayer. The crossing also brings to mind some painful ancestral memories of Chumash dispossession and the associated intergenerational trauma. As Chumash people leave the island, the community gathers to say goodbye, sing songs, and make plans for the future. Many hearts are heavy with thoughts of the time that the ancestors said their last goodbyes to the island as they were uprooted from their homes and lifeways to instead be forcibly assimilated into lives of colonial

[38] Santa Cruz Island

[39] Scorpion Anchorage and Campground

violence, slave labor, and involuntarily confinement in the unsanitary living conditions of the missions. Processing this burden of sadness while surrounded by the support of loving family and community is an essential part of healing from this historic trauma.

Figure 5. The Limuw community onshore prays and sings for the safety of the paddlers and the health of the ocean. For paddlers, every pull of the paddle through the waters is a prayer. Photo Credit: Robert Schwemmer.

The Channel Islands National Marine Sanctuary, and the islands within it, are "sites of conscience" for the Chumash community, creating opportunities to learn about this history, consider its lasting impacts, and work together to move forward for community healing and positive change.

Sites of conscience are places where memory is turned into action -- history is interpreted through the site, dialog on social issues is stimulated, opportunities are made for involvement in positive action related to issues raised at the site, and justice and universal cultures of human rights are promoted.

Co-Management & Community Wellness

The rights to traditional homelands and waters have been taken away from Chumash people and remain in the purview of settler colonists. Access has been restricted or denied, but Chumash people work toward a future where their community voices and practices are integrated as an essential and central part of caring for traditional homelands and waters. Community healing and wellness depend on this. Examples of strides the Chumash have made in this direction are: the inclusion of Chumash voices in reports such as this, the establishment of the Chumash seat on the CINMS advisory council, the success of the Chumash

Tribal Marine Protected Area education program, the development of the white paper "Tribal Marine Protected Areas: Protecting Maritime Ways and Practice," the organizing of the Chumash Community Coalition, the protection of sacred sites on Limuw from cell tower development, the monitoring of cultural sites on the islands and mainland, the proposal of the Chumash Heritage National Marine Sanctuary, the annual tomol crossing and resurgence of Chumash maritime culture, Chumash Eyes on the Water (a community science program), Wishtoyo's California Naturalist Certification Program (in partnership with the University of California), and Wishtoyo's lawsuits to safeguard the channel from offshore fracking and protect culturally-significant endangered species like humpback whales and steelhead trout.

Indigenous Traditional Knowledge & Practice

Although often treated separately in conventional ecosystem assessments science[40], education[41], foods[42], and material resources (like ornament)[43] are innately tied together in the Chumash assessment through indigenous traditional knowledge and practice.

Indigenous Traditional Knowledge (aka Traditional Ecological Knowledge)

Traditional Ecological Knowledge (TEK) is a knowledge system or worldview of human-environment relations that incorporates spirituality, cultural values, ethics, and the basic norms of society, and is passed down through generations, often through oral tradition. TEK is a living body of knowledge that includes environmental observations and experiences that occur in places and within an indigenous cultural context; as such, TEK is embedded in culture and cannot be separated from the people and places where it is generated.

Traditional and Local Knowledge – A Vision for the Sea Grant Network, 2018

Consider a typical Chumash community cultural practice like fishing. In order to fish, there is a significant set of skills required – netmaking, line and hook making (Figure 6), boat making, etc. These all require gathering and preparing fiber plants like dogbane, milkweed, and cherry bark; acquiring and working shell materials for hooks; and processing the redwood logs that drift ashore. Gathering any of these materials requires knowledge of where, when, and under what conditions to find them; what kind of ecosystem management is necessary for producing healthy, abundant, usable materials; and how to manage these resources in an adaptive way such that current and potential future needs and conditions are accounted for to create regenerative resilience, abundance, and endurance for these systems. For example, since Chumash abalone gatherers are well aware that abalone reproduce via water-broadcast eggs and

[40] Science – defined in the ecosystem services assessment as the capacity to acquire information and knowledge.

[41] Education – defined in the ecosystem services assessment as the capacity to provide intellectual enrichment.

[42] Food – defined in the ecosystem services assessment as the capacity to support market demands for nutrition related commodities through various fisheries.

[43] Ornament – defined in the ecosystem services assessment as resources collected for decorative or aesthetic purposes.

sperm and therefore require dense colonies to ensure reproductive success, the traditional method of gathering does not thin the population by selecting only the choicest and most marketable, but instead gathers in narrow strips, leaving behind dense colonies of abalone to regenerate and fill in harvested areas.

Figure 6. Crafting abalone fish hooks is an example of the integrated Chumash maritime practices and Traditional Ecological Knowledge (TEK) which are embedded in culture and cannot be separated from the people and places where it is generated. Photo Credit: Wishtoyo Chumash Foundation.

Indigenous community of practice is a concept that can be used to describe the traditional setting in which the transmission of indigenous knowledge naturally takes place. Indigenous traditional knowledge is acquired, shared, and refined through cultural community-based practices like tending, gathering, and preparing materials. This collaborative and intergenerational process requires time and sustained interaction on a regular, seasonal basis with both people and place (indigenous community and traditional homelands). Diaspora-in-place and denied access to interactive relationships with homelands disrupts indigenous communities of practice and adversely impacts indigenous systems of knowledge.

Where does this type of knowledge come from, where does it reside, and who are the teachers? This is community-held knowledge that comes from generations of observation, experiment, and applied theory. It is passed intergenerationally through oral and recorded history, direct mentorship, and general community immersion. This is accomplished via relationship building – among peers, between elders and youth, and with specialized knowledge bearers. But humans are not the only teachers and keepers of knowledge. Some of the very best teachers are found through building intimate relationship with non-human relations. These relationships are built over time via hands-on caretaking, making nuanced observation, recognizing patterns, asking questions, and incorporating these materials into day-to-day life for food, medicine, shelter, recreation, and other cultural and spiritual practices.

This inherent cultural integration of knowledge, education, practice, people, place, and natural cultural resources is so tightly interwoven that they are essentially one and the same.

> While the non-Native world sees "people" as separate from "nature," and "knowledge" as an abstraction that can be transferred across generic landscapes or multiple "users," Karuk knowledge of the landscape is inseparable from the practice of Karuk culture. For Karuk knowledge is embedded in and emerges from the practice of traditional management. Knowledge and management are about culture.
>
> -Karuk Tribe Department of Natural Resources, 2014

Colonial Epistemicide

> **Colonial epistemicide** refers to the systematic destruction of the knowledge base (and ways of knowing) of colonized peoples.

Colonial epistemicide (Lebakeng, 2011) occurs through an array of factors including: dispossession of colonized peoples from access to their land, implicit assumptions of the intellectual inferiority of colonized peoples, forced assimilation and re-education into dominant culture, establishment of unequal knowledge hierarchies, and the maintenance of formalized institutional barriers that privilege settler colonial knowledge and ways of knowing. Barriers to cultural practices and denied access to traditional homelands not only impact community health but also impede the transmission and renewal of indigenous traditional knowledge and lead to further loss of cultural lifeways and authochthonous knowledge systems.

Too often Indigenous people who have successfully acquired a "seat at the table" find themselves in the position of needing to communicate complex and unfamiliar ideas during short windows of time in the midst of an already packed agenda. Generally, the best-case scenario is that even when these ideas are communicated successfully, other parties already "at the table" often don't know what to do with these new understandings because they do not fit into the preexisting frameworks and conceptual structures. Worst-case (and unfortunately the more common) scenario is that any input that doesn't explicitly match up with the dominant culture's ways of knowing is automatically dismissed as invalid.

Indigenous Diaspora: Out of Place in Place

Indigenous diaspora
to be ***out of place yet in place***
a displacement
causing a mind-body-spirit dis-ease
with symptoms no doctor can identify
there will be no diagnosis of an illness
due to being placeless today

The spectrum of diaspora doesn't cover this
the experience of reconfigured landscapes and loss
while you are forced to stand by and watch
has no fancy concept to back it up
no diagnostic description under the DSM
so we fly under the radar yet again

You see,
there are stories just beneath the city streets
that your bones are trying to remember
there are trail ways laying just behind those barbed wire fences
that you just can't reach
there are ancestors' bodies in these manicured landscapes
that have mixed and mingled with the earth
knowing this, you try to listen closely in these trafficked spaces
holding breath, keeping silent
knowing that a blood memory might be trying to speak
These losses accumulated result in a type of trauma known only by the dispossessed
something intangible that you don't have the words for and don't know how to grieve

The landscape continues to shift
gets a facelift according to Eurocentric definitions of beauty
These acts
redefine connection to land to that of owner to property
We know that these waters had dominion over themselves
long before man ever had the audacity to plug up the rivers with dams
or the stupidity to turn the potable into poison
Water has a long term memory
every place tells a story
There are still attempts at the erasure of our history
by the continued writing of stories overtop of our own
In the form of buildings and pavilions
through roadways and oil rigs
through the creation of structures that act as a testament
of our absence

Out of place in place…

-Helen Knott (Dane Zaa/Nehiyaw)

Re-affirming Indigenous Knowledge Systems

There has been an increasing interest among conservationists and resource managers to incorporate indigenous traditional knowledge and practices in their management plans. Because these knowledge systems are inherently different, efforts to integrate them can be challenging. Some resource managers have attempted to extract knowledge from indigenous culture bearers in order to use this information without directly maintaining an ongoing collaboration with indigenous communities of practice. These approaches have been unsuccessful for two reasons: 1) traditional knowledge is collectively held, practice based, and culturally informed, hence, it cannot be separated from community, 2) native communities are wary of the colonial practice of taking indigenous knowledge from native communities while continuing to contribute to the erasure of indigenous people and denial of access to traditional homelands. As time goes on there are greater numbers of successful examples of investment in meaningful collaborations and ongoing partnerships with indigenous communities. These include the Sea Grant Network's recent Traditional and Local Knowledge visioning work (Sea Grant Network, 2018) and UCANR's California Naturalist program.[44]

Cognitive justice recognizes epistemic diversity and the right of multiple forms of knowledge to co-exist. It advocates facilitating dialog rather than competition between even incommensurable knowledge systems.

Restoring cognitive justice necessitates removing barriers to relationships between indigenous people and their homelands including creating access for the restoration of traditional land tending practices, reintegrating dispersed indigenous communities, and ultimately repatriating sizable areas of traditional lands and waters. Even two generations ago, these goals seemed unrealistic and unreachable, but today indigenous people around the world and here in California are making great strides in this area. What was once thought to be impossible is already a reality for some Nations. For example, the Kashia Band of Pomo Indians (Sonoma County) were able to regain ownership of 688 acres of their traditional coastal homelands and are active in marine conservation and education (Krol, 2018).

Muptemi (Ancestral Memory)

For Chumash people, the Channel Islands and the surrounding National Marine Sanctuary hold a value that is beyond measure. Chumash people originate from the islands themselves. The island and marine ecosystems co-evolved with the Chumash and their culture. Chumash maritime culture has been and continues to be intimately shaped by that connection. Even though the Chumash have been dispossessed of their islands and surrounding waters, they always have been and will always be there. They are there in the ecosystems shaped by untold generations of Chumash traditional tending. They are there as protectors of the buried ancestors and villages. And they are there through the prayers of people longing for reconnection with their home. Their relatives exist there too – dolphins, foxes, oaks, olivellas, abalone. The Chumash *are* the islands and the waters. Tending that relationship is the collective birthright and sacred responsibility of all Chumash people (Figure 7). Their cultural, spiritual, psychological, and

[44] University of California Agriculture and Natural Resources Division partners with Wishtoyo Chumash Foundation to offer indigenous-led, culturally-based community capacity building for California's Coastal Native Nations.

physical wellness depend on meeting that responsibility. The islands remember the people. The lands and waters have been in intimate relationship with the Chumash people for millennia and that trajectory will continue into the future far longer than the lifespan of any individual or government. The value of that enduring relationship is truly too great to be described with words.

Figure 7. Native youth are empowered with conventional scientific methodology and traditional cultural knowledge to develop relationship with and protect Chumash traditional homelands. Photo Credit**:** Wishtoyo Chumash Foundation.

Currents like blood flowing in our veins
Looking through the eyes of the ancestors
Carrying that in our blood toward our future
We don't live in the past

Plankton on the waters on a moonlit night
Those same cells that created us
Singing on the tomol,
The sound echoing off the cliff, reflected back at you
your past and future

Humble
insignificant
you are in a huge body of water filled with so many creatures
your feet not on the ground
in space
can't see happiness of spirits singing back at you

All the women singing
Brings so much value to the continuum of existence
Triggered our *muptemi*
deep connections to ancestors, ocean, islands

How important the tomol is
That broke through the stagnant level of our existence into a higher level of consciousness
Being in another dimension
The ancestors are right next to us
experiencing all of the senses
smells, actions, sights
Touching base with the past

-Mati Waiya (Chumash)

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RESPONSE TO PRESSURES

The Driving Forces and Pressures section of this report describes a variety of issues and human activities occurring within and beyond the sanctuary that warrant attention, tracking, study, and in some cases, specific management action. Addressing any of these issues requires participation by and coordination with a variety of agencies and organizations. The Office of National Marine Sanctuaries (ONMS) is fortunate to be able to work with many entities that contribute to managing human activities and addressing marine conservation issues. Central to that collaborative approach is the Channel Islands National Marine Sanctuary Advisory Council (CINMS AC), a community-based advisory body established to provide advice and recommendations to the CINMS superintendents on issues including management, science, service, and stewardship (see text box).

The setting of the sanctuary is also optimized for a collaborative approach to management. For example, Channel Islands National Park adjoins and partially overlaps the sanctuary (from mean high water to one nautical mile), contributing valuable marine monitoring programs and essential marine patrol law enforcement services. In addition, the State of California manages and helps to protect approximately 47% of the sanctuary (the state waters portion), while NOAA's National Marine Fisheries Service has established Essential Fish Habitat areas that bolster the sanctuary's and state's network of marine reserves and conservation areas. Numerous other partners play important roles, with ONMS often serving to coordinate activities and build collaborative approaches to the management of marine resources. The indigenous Chumash community is also actively involved in stewardship activities related to the waters surrounding the Channel Islands (see the Chumash Assessment for more information).

Advisory Council

The Channel Islands National Marine Sanctuary Advisory Council was established in December 1998 to assure continued public participation in management of the sanctuary. Since its establishment, the council has played a vital role in the decisions affecting the sanctuary, bringing valuable community advice and expertise to the task of assuring effective sanctuary management. The council provides a public forum for consultation and community deliberation on resource management issues affecting the waters surrounding the Channel Islands. The council consists of 21 voting members and 21 alternates that represent the general public, tourism, business, recreational fishing, commercial fishing, non-consumptive recreation, education, research, conservation and Chumash community interests, as well as local, state and federal government agencies. The council meets in public sessions every other month.

For each of the main issues and human activities presented in the Driving Forces and Pressures section of this report, this Response Section provides a summary of related activities and management actions that ONMS has led or coordinated. The activities described below are not exhaustive of all the ways the sanctuary serves the community and the marine ecosystems surrounding the Channel Islands, but highlights significant contributions that are responsive to known or emerging pressures.

Recommended future response actions are not presented in this section; however, in 2019, ONMS will begin updating the sanctuary's management plan, and the findings of this condition report will serve as an important foundation to build new action plans designed to address priority needs.

Responses

Described below is a summary of actions that ONMS has taken, primarily since 2009, to address the issues and human activities that were described in the Driving Forces and Pressures section of this report.

Vessel Traffic

Given the sanctuary's offshore location, visitation and human activities are primarily boat-based. Vessel activities affect the sanctuary's environment, adjacent waters, and sanctuary users in several ways, including:

- Ship strikes on whales, including endangered whale species
- Air pollution via greenhouse gas emissions
- Increased ocean noise impacting living marine resources
- Discharge of oil, sewage, non-native species, and non-biodegradable materials
- Anchor damage to seafloor habitats (e.g., eelgrass, corals) or maritime heritage resources (e.g., shipwreck sites)
- Changes in sanctuary wildlife behavior
- Navigational safety concerns: Spills, debris wreckage, and habitat degradation from vessel collisions, groundings, and sinkings

Reduction of Ship Impacts: Whale Strike Risk, Air Pollution, and Noise

Since 2007, ONMS has been working to reduce the risk of ships fatally colliding with endangered whales that seasonally feed in and adjacent to the sanctuary (Figure R.VT.1). Many partners have been involved, coordinated by ONMS, and the work has been significantly supported and guided by CINMS AC. In 2009, the advisory council endorsed a range of strategies to reduce the risk of ship strikes (Abramson et. al 2009). In 2016, the council's Marine Shipping Working Group produced a comprehensive report containing information and advice regarding regional marine shipping issues, including ship strikes on endangered whales, air pollution and greenhouse gas emissions, navigational safety concerns, and conflicts among ocean users (Marine Shipping Working Group 2016).

Figure R.VT.1. In the sanctuary and adjacent waters, feeding blue whales seasonally share the same waters as busy shipping traffic. Photos: J. Morten/NOAA

In 2013, the International Maritime Organization approved a NOAA-proposed shift in the location of the south-bound shipping lane within the Santa Barbara Channel, moving the lane northward and further away from a known feeding hotspot for endangered blue whales (Figure R.VT.2).

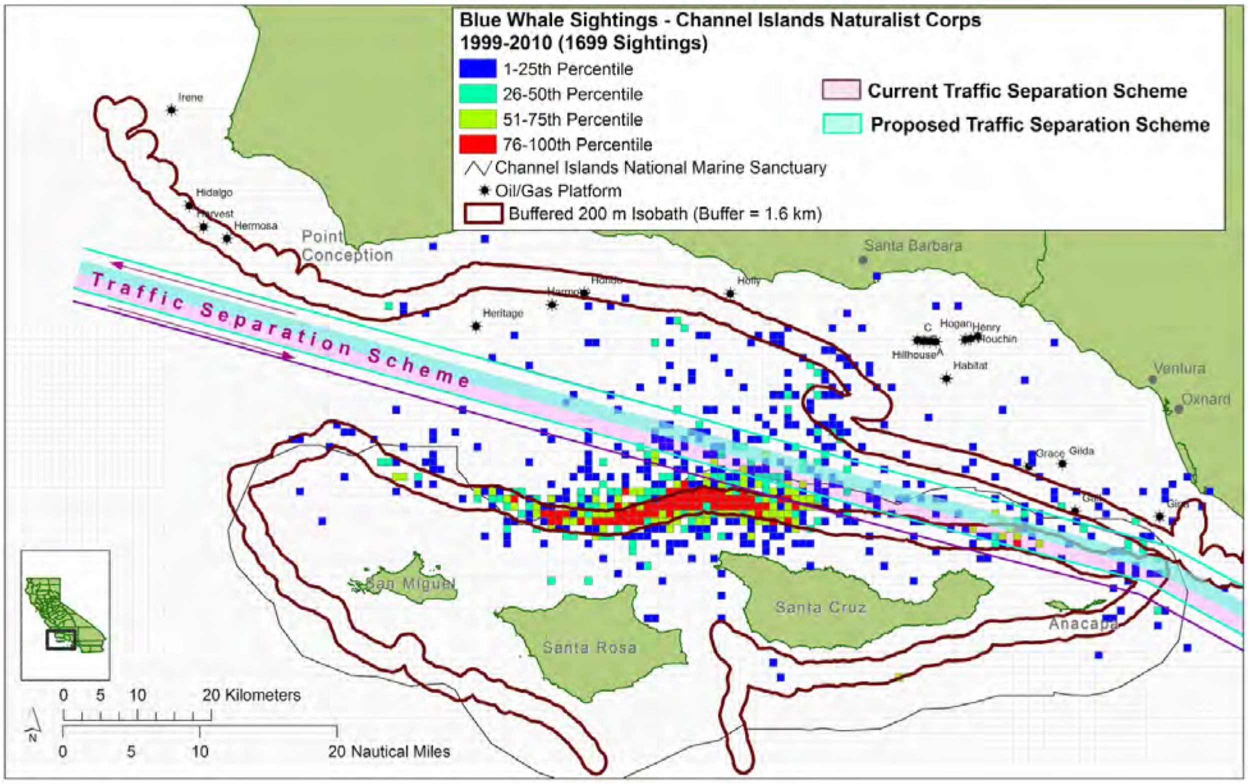

Figure R.VT.2. A northward repositioning of the south-bound shipping lane in the Santa Barbara Channel Traffic Separation Scheme was proposed (as shown here) and subsequently approved by the International Maritime Organization in 2013. A basis for the change was formed by blue whale sightings recorded by sanctuary volunteers from 1999-–2010 (also shown here), along with sightings data from the Cascadia Research Collective. Map and data: NOAA

ONMS also led efforts to improve and streamline data collection on local whale sightings, transitioning trained volunteers away from the use of paper data sheets to Spotter Pro, a mobile application that results in the recording and transmission of more accurate and timely whale sightings information. This development was followed by the creation of a similar mobile application, Whale Alert, which the general public uses to report whale sightings. ONMS and partners host the Whale Alert-West Coast outreach web portal (http://westcoast.whalealert.org/), and Whale Alert also generates automated email alerts for recent whale sightings (Figure R.VT.3).

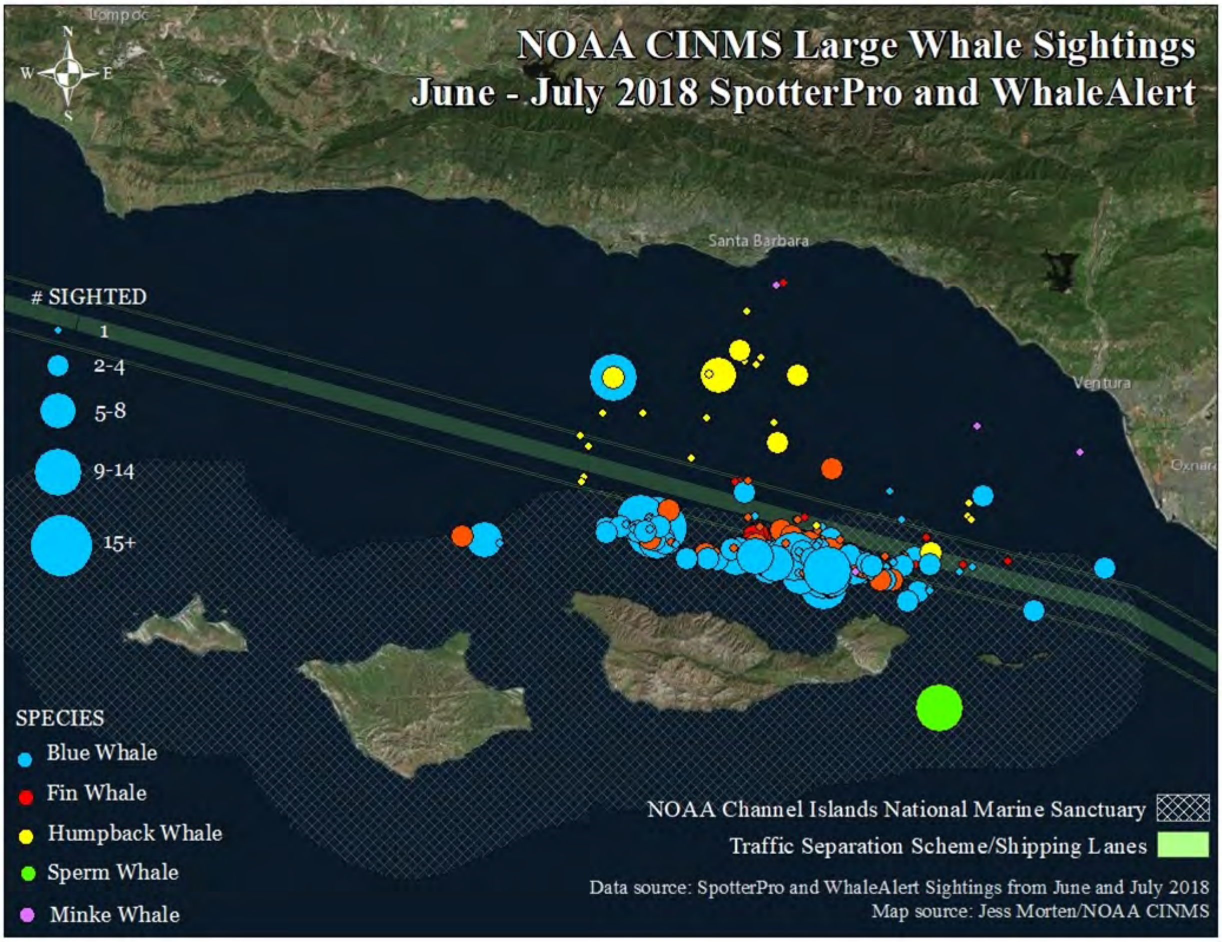

Figure R.VT.3. The Spotter Pro mobile application used by trained sanctuary and National Park Service volunteers, and the Whale Alert app used by the general boating public and other mariners, contributes valuable data, as depicted in this map of whale sightings for a two-month period in 2018.

Since 2007, ONMS has worked with staff from NOAA's National Marine Fisheries Service, the U.S. Coast Guard, and National Weather Service to provide seasonal notices to mariners that warn them about the presence of whales within and around the Santa Barbara Channel and Channel Islands, and ask for their voluntary cooperation with ship speed reduction. Based on annual reviews of ship speeds using Automated Identification System (AIS) data, this approach was not considered effective. Nevertheless, tracking ship speeds within and adjacent to the sanctuary has been fundamental to working on ship strike risk reduction, with ONMS leading efforts to expand the range of AIS data receivers in this area, including the installation and maintenance of an important station on Santa Cruz Island (Figure R.VT.4).

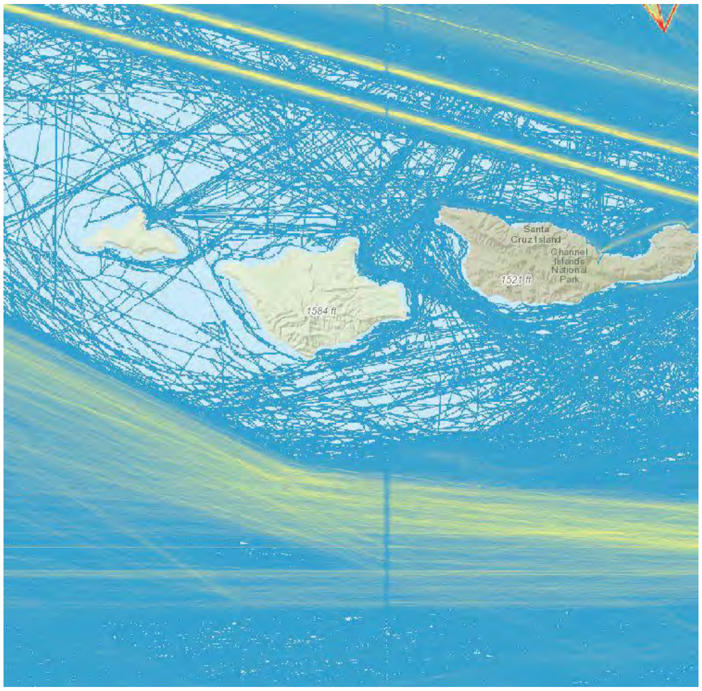

Figure R.VT.4. Automated Identification System (AIS) data from ship traffic allows for traffic patterns, vessel speeds, and other factors to be understood, as shown here with 2011 data on cargo vessel density. Yellow tracks show areas of higher vessel transit density, blue tracks indicate lower density vessel transits. ONMS led efforts to get an important AIS receiving station installed and running on Santa Cruz Island, allowing for ship traffic in the area to be well tracked. Traffic patterns have changed over time, and AIS data processing helps with the tracking and understanding of those changes. Map: SeaSketch, Safe Passage project (For additional traffic pattern maps over time, see also Figure DP.VT.2 in the Driving Forces and Pressures section.)

In an effort to improve voluntary cooperation with ship speed reduction requests, starting in 2014, ONMS began working with local air pollution control districts and other partners to create a voluntary Vessel Speed Reduction (VSR) program that offers incentive payments to participating shipping lines that slow down their vessels to requested speeds, which could reduce whales struck by ships. Another benefit is that the program provides positive recognition and media messaging to the industry. The VSR program was repeated in 2016, 2017, and 2018, growing in scope geographically (now also including the San Francisco Bay region and central coast national marine sanctuaries), and is experiencing increases in the amount of non-federal funding received and number of vessels registered. Because slower ships emit less air pollution, the success of the VSR program has also shown that this approach can produce measurable reductions in nitrogen oxide (NOx) and greenhouse gas emissions (Figure R.VT.5).

2014	2016	2017
Santa Barbara Channel	*Santa Barbara Channel & South of Channel Islands*	*Santa Barbara Channel, South of Channel Islands & San Francisco Bay Area*
7 Shipping Lines **27 ship transits** incentivized	10 Shipping Lines **50 ship transits** incentivized	11 Shipping Lines **143 ship transits** incentivized
Emission Reductions: **12.4 tons NOx** **500+ metric tons GHG**	Emission Reductions: **25.6 tons NOx** **1,000+ metric tons GHG**	Emission Reductions: **83.5 tons NOx** **2,630+ metric tons GHG**

Figure R.VT.5. Vessel Speed Reduction Program geographic changes, participation levels, and emission reduction benefits over time. NOx = Nitrogen oxide. GHG = Greenhouse gases. Image: NOAA

In addition, ONMS has partnered with the Scripps Institution of Oceanography, National Marine Fisheries Service, and others to place and maintain a range of autonomous underwater recorders (hydrophones) within and around the sanctuary; this data has helped ONMS and its partners better understand vessel noise in the sanctuary and its impacts to sanctuary resources, like whales (McKenna et al. 2012, McKenna et al. 2013, Haver et al. 2018). These and other studies suggest that slower ships produce less noise, so the VSR program also has the potential to reduce noise levels in and around the sanctuary (For more information about related sanctuary activities, see the section below on Ocean Noise.).

Reduction and Control of Vessel Discharges

Vessels can introduce pollution into the marine environment from spills, blowing or drifting trash (e.g., plastics), faulty equipment, and other mishaps or poor waste control practices. The sanctuary is afforded protective federal regulations designed to safeguard marine water quality (see sanctuary discharge regulations at 15 C.F.R. § 922.72(3)(i)); however, regulations alone do not ensure that clean boating practices are followed, and it can be challenging to detect and enforce discharge regulations in an offshore environment like the sanctuary. ONMS focuses programmatic efforts on boater education to help encourage clean practices that are compliant with regulatory requirements. These efforts include regular emphasis and reminders to members of the CINMS AC, who in turn help boaters understand the rules in place within the sanctuary. Enforcement officers from several cooperating agencies are particularly helpful for teaching boaters about the need to prevent pollution discharge within sanctuary waters, and frequently distribute a sanctuary-designed brochure called *Protecting Your Channel Islands* (Figure R.VU.2). The Channel Islands Boating Center at Channel Islands Harbor features an exhibit hall, including interactive displays, that promotes safe and environmentally friendly boating practices (Figure R.VT.6). ONMS also regularly communicates clean boating practices to a wide variety of audiences, including teachers, during educational and outreach talks and workshops. The sanctuary's discharge regulation requirements are often emphasized in interagency consultations as well. Similarly, each time ONMS receives a permit application to conduct a prohibited activity in the sanctuary (e.g., for a research project), this prompts a review of the sanctuary's discharge regulation as applied to that activity, as well as other requirements. With regard to trap loss from fishing vessels, see the Marine Debris section that follows for response activities.

Figure R.VT.6. The Channel Islands Boating Center in Oxnard, California is located at Channel Islands Harbor, and features an extensive array of sanctuary-designed display panels, interactive kiosks, and other exhibits that help boaters learn how to safely access and enjoy the marine sanctuary. Photo: California State University Channel Islands

Another type of discharge that boaters can inadvertently bring into the sanctuary is the release of non-native species. For example, as mentioned elsewhere in this report, the invasive algae *Undaria pinnatifida* was discovered in 2016 near Anacapa Island, and it was likely introduced by a vessel. See the Introduced Species section that follows for details about related sanctuary activities.

Vessel Anchoring

While vessel anchoring is not prohibited by federal sanctuary regulations, it is possible that this activity could damage sensitive benthic habitats. Anchoring can also disturb protected maritime heritage resources within the sanctuary, in particular shipwreck and aircraft wreck sites found in anchor-depth waters (Figure R.VT.7). Further, improper anchoring can lead to grounded vessels within the sanctuary, often introducing wreckage, debris, and water pollution.

Figure R.VT.7. In 2011, ONMS discovered that the shipwreck site of the historic *Winfield Scott* at Anacapa Island was disturbed. ONMS suspects this disturbance was caused by vessel ground tackle/anchoring. Photo: R. Schwemmer/NOAA

Figure R.VT.8. Eelgrass beds within the sanctuary, while limited in extent, are ecologically important for many species and sensitive to contact disturbance. Photo: R. Schwemmer/NOAA

When consulting with other agencies, reviewing permit applications, or fielding inquiries from large vessel owners (e.g., cruise ships, expedition vessels, or large yachts), ONMS often shares information with sanctuary users about areas that are particularly sensitive to possible anchor damage based on habitat type or the presence of submerged historic resources. This information exchange often results in vessels avoiding anchoring in these locations.

Eelgrass beds are not plentiful within the sanctuary, but are very important ecologically (Figure R.VT.8) and also are particularly sensitive to damage from anchors and mooring chains (Figure R.VT.9). ONMS has consulted with the National Park Service to promote consideration of ways to avoid eelgrass beds when siting mooring locations within the park and sanctuary, and has encouraged the use of special buoy systems that help limit the amount of mooring chain that lies on the seafloor, thus reducing the extent of chain dragging over eelgrass.

Figure R.VT.9. A mooring ball at Santa Cruz Island is being used by the National Park Service. Photo: P. Smith

As mentioned above in the Reduction and Control of Vessel Discharges section, boater education is an important response to this issue. ONMS focuses programmatic efforts on boater education to help encourage responsible practices. This includes promoting a "know-before-you-go" approach to visiting the sanctuary by boat, supported by real-time marine weather information provided at nine different interactive touch-screen interactive kiosks. Additionally, safe and responsible boating is a primary theme featured in sanctuary-designed exhibits on display at the Channel Islands Boating Center (Figure R.VT.6). ONMS also serves on a planning committee and attends a National Safe Boating Expo at the U.S. Coast Guard's Station at Channel Islands; this is an annual event held each May to provide safe boating information and best practices to boaters.

ONMS also provides recurring messages about safe boating practices, and the importance and sensitivity of eelgrass beds, as part of educational and outreach talks given to a wide variety of audiences, and during discussions with the CINMS AC. By compiling statistics on vessel groundings within the sanctuary, and regularly working closely with vessel assistance organizations and the Coast Guard, ONMS understands that improper anchoring technique is a primary cause for these accidents. As such, in 2018, ONMS began assisting TowBoatUS with development of a tutorial video on proper anchoring techniques.

Wildlife Disturbance from Vessels

To help reduce or prevent vessel activities that disturb marine wildlife (Figure R.VT.10), sanctuary regulations include a prohibition on the unauthorized "take" of marine mammals, seabirds, and sea turtles (see 15 C.F.R. § 922.72(9)) and a prohibition on the operation of motorized personal watercraft within 1 nautical mile of island shores (see 15 C.F.R. § 922.72(13)). While these regulatory prohibitions are important, other complementary, non-regulatory approaches have also been utilized in order to promote boating and shipping practices that reduce the risk of adversely impacting wildlife. As mentioned above, ONMS working with partners, has put considerable effort into reducing the risk of ships fatally colliding with endangered whales. Additionally, following training and proper credentialing, ONMS has assisted NOAA's National Marine Fisheries Service in the field with whale disentanglement rescue missions, which often involve helping to track entangled animals and remove fishing gear. Understanding that kayaks are also popular, ONMS also participates in training sessions for kayak guides, emphasizing the importance of not disturbing wildlife, such as seabirds in sea cave environments. Attention to limiting wildlife disturbance from vessel operations is also an important consideration when issuing sanctuary permits for research activities. Sanctuary education and outreach programs, materials, and messaging promote ocean etiquette, as do displays at the Channel Islands Boating Center.

Figure R.VT.10. The operation of vessels, personal watercraft, or low-flying aircraft in close proximity to marine life can cause disturbances. For example, resting seabirds can be flushed. Photo: R. Schwemmer/NOAA

Vessel Navigational Concerns: Groundings and Collisions

With the extent of vessel activity occurring within the sanctuary, and the challenging marine weather conditions that can often be encountered in the Santa Barbara Channel, small craft groundings are common, while ships and other larger vessels pose a risk of collisions or groundings that could produce spills and wreckage.

Since 1991, the International Maritime Organization has provided additional protection against the risk of large vessel collisions or groundings with the declaration of an Area To Be Avoided (ATBA) that overlaps the sanctuary, except for the portion currently designated as a Traffic Separation Scheme. Based on a review of AIS data, compliance with this ATBA is high (Redfern et al. 2017). Additionally, sanctuary regulations restrict large vessels (>300 gross registered tons) from approaching within 1 nautical mile of island shores (see 15 C.F.R. § 922.72(6)), thus reducing the risk of groundings or collisions in areas of sensitive nearshore habitats and vessel hazards. This requirement is discussed with relevant applicants when reviewing sanctuary permit applications.

Smaller vessels regularly run aground at the Channel Islands, and ONMS plays a role in coordinating emergency and cleanup responses. Working together with the National Park Service and U.S. Coast Guard, and in cooperation with vessel assist or salvage companies, ONMS helps to coordinate quick response to impaired vessels, those at risk of grounding, or those that have recently run aground (Figure R.VT.11). With changing tides, swell, and weather, quick response is essential in order to prevent boats from breaking up and/or sinking, which can lead to habitat damage and pollution, and sometimes result in a vessel that becomes unrecoverable. For other activities related to this issue, see the Vessel Anchoring section above.

Figure R.VT.11. ONMS frequently helps coordinate multi-agency responses to vessels that run aground in the sanctuary. In 2015, the fishing vessel *Angel's Gate* ran aground at Skunk Point on Santa Rosa Island, and was subsequently removed by tow after a complex recovery operation. Photo: U.S. Coast Guard

By monitoring vessel use within the sanctuary, ONMS is better able to assess traffic patterns and potential associated risks. AIS navigational data and analysis help ONMS understand the routes that ships take as they pass by the Channel Islands, and allows ONMS to detect incursions within either the ATBA or the area within 1 nautical mile of island shores that is off limits to vessels larger than 300 gross registered tons. In addition, CINMS has recently teamed up with University of California, Santa Barbara (UCSB) and other partners to develop shore-based marine radar systems that can continuously track and record vessel traffic (Figure R.VT.12). As of 2018, two radar systems are in place, with plans for more.

Figure R.VT.12. Installed in 2018, a new radar station on Santa Cruz Island is uploading data to a cloud-based system, and allowing ONMS and partners to assess accumulated data on vessel traffic and patterns of human use. Photo: S. Hastings/NOAA

Ocean Noise

ONMS is increasingly researching the possible adverse effects of anthropogenic noise on marine species within the sanctuary's ocean environment. CINMS AC first raised concerns about noise impacts in 2004 when it reviewed and adopted a comprehensive report on the topic (Polefka 2004). Since then, ONMS has collaborated with colleagues from the Navy, National Marine Fisheries Service, Scripps Institution of Oceanography, and others to monitor and understand sources of noise within and around the sanctuary. In addition, as previously mentioned, the Vessel Speed Reduction program could potentially lower noise levels emitted from participating ships.

In 2018, ONMS increased its capacity to monitor the sanctuary soundscape through the use of newly deployed hydrophones that measure sound-producing sources, including relative contributions of human-produced noise, marine wildlife (invertebrates, fish, and mammals), and geophysical sources (wind, waves). Monitoring the sanctuary soundscape will improve understanding and characterization of marine life presence, man-made noise (including vessel noise), and acoustic habitats (Figure R.ON.1).

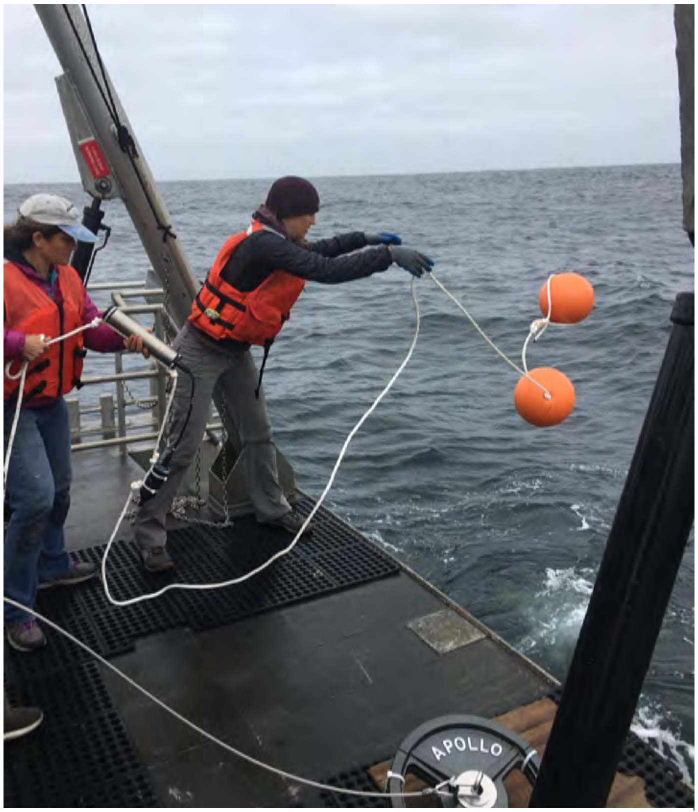

Figure R.ON.1. In recent years, ONMS and its partners have been deploying and retrieving hydrophones in the sanctuary, as shown here in 2018 aboard the research vessel *Shearwater*. Photo: L. Duncan/NOAA

Although not originally created to reduce shipping noise levels, the designated Area To Be Avoided (ATBA) that overlays with the majority of the sanctuary has shown to provide quieter ocean habitat for marine species, including whales, compared to the adjacent Traffic Separation Scheme used by transiting ships (Redfern et al. 2017). Ships transiting past the sanctuary have shown a high degree of compliance with the ATBA request. Collaborative work between ONMS, NOAA partners and others resulted in the 2014 installation of a passive acoustic recorder within the sanctuary as part of a national network of ocean noise reference stations. Data analyzed by Haver et al. 2018 from this station reveals patterns of ambient sound levels, and indicates that the acoustic footprint of shipping traffic extends into the sanctuary (a portion of which includes a shipping lane).

Non-Native Species

As noted in the Pressures section of this report, some non-native marine species may be environmentally benign, while others can become “invasive” and cause ecological or economic harm. Invasive marine species can result in declines, extirpations, or extinctions of native plants and marine life, reduce biodiversity by competing with native organisms for limited resources, and alter habitats.

Within the sanctuary, the release of introduced species is prohibited by sanctuary regulations (15 C.F.R. § 922.72(12)). Additionally, an Area To Be Avoided that overlays most of the sanctuary (except the Traffic Separation Scheme) helps keep merchant ships (with ballast waters that could be harboring non-native species) mostly out of sanctuary waters. The Channel Islands National Park’s biosecurity management measures have also contributed to a setting that poses lower risks of shore-side species introductions into the sanctuary as compared to mainland coastal areas.

Regardless, species introductions are still possible through other vectors, such as small vessel traffic. The invasive algae *Sargassum horneri* is present at three of the northern Channel Islands (Anacapa, Santa Cruz, and Santa Barbara) (Figure R.NIS.1), and in 2016, *Undaria pinnatifida* was discovered near Anacapa Island (Figure R.NIS.2). Following the *Undaria* sighting, ONMS engaged in discussions with multiple agencies and entities, and with the CINMS AC, to gather more information and to identify and consider management options. Diaz et al. 2018 researched *Undaria* management strategies globally, and presented case studies and management ideas to the CINMS AC in 2018. Although the complete extirpation of *Undaria* within the sanctuary is likely to be infeasible, Channel Islands National Park, with help from sanctuary divers, is tracking and characterizing the colonies of plants, looking for any signs of spread or ecological impact. Additionally, ONMS is working with local harbor users and other partners to develop strategies to educate boaters and harbors users about the risk of transporting this species, or others like it, and preventative steps that can be taken.

Figure R.NIS.1. In 2009, the invasive, non-native algae, *Sargassum horneri*, was discovered at the northern Channel Islands in sanctuary and park waters.. Photo: R. Schwemmer/NOAA

Figure R.NIS.2. In 2016, divers from Channel Islands National Park discovered the non-native algae *Sargassum horneri* in waters off Anacapa Island. Photo: Channel Islands National Park/NPS

Commercial and Recreational Fishing

Environmental protections afforded by sanctuary regulations help maintain high water quality and protect marine habitats that support the most productive and diverse fishing grounds found in California (Figure R.CRF.1). Fisheries within the sanctuary are directly managed by the State of California and National Marine Fisheries Service. ONMS works in partnership with these agencies, as needed. ONMS also regularly tracks fisheries developments that could affect sanctuary resources, and plays an active role in influencing management actions and policies. For example, in 2012, ONMS representatives were appointed to a special advisory group that helped the State of California adopt a California Spiny Lobster Fishery Management Plan. Similarly, the CINMS superintendent served on an Abalone Advisory Group from 2011 to 2012, that assisted the state in developing a feasibility assessment related to the possible reopening of a limited red abalone fishery at San Miguel Island.

Figure R.CRF.1. Recreational fishing is a popular sanctuary activity. Photo: R. Schwemmer/NOAA

CINMS, working in partnership with the California Department of Fish and Wildlife and consulting closely with marine stakeholders and scientists, co-led efforts that resulted in the establishment of a network of state- and NOAA-designated marine reserves and marine conservation areas in 2004, 2006, and 2007 (Figure R.CRF.2). For a summary of ecological effects attributed to the protection provided by the network of marine reserves and conservation areas within the sanctuary, see the "MPA Effects" textbox at Question 3 in the State of Drivers and Pressures section of this report.

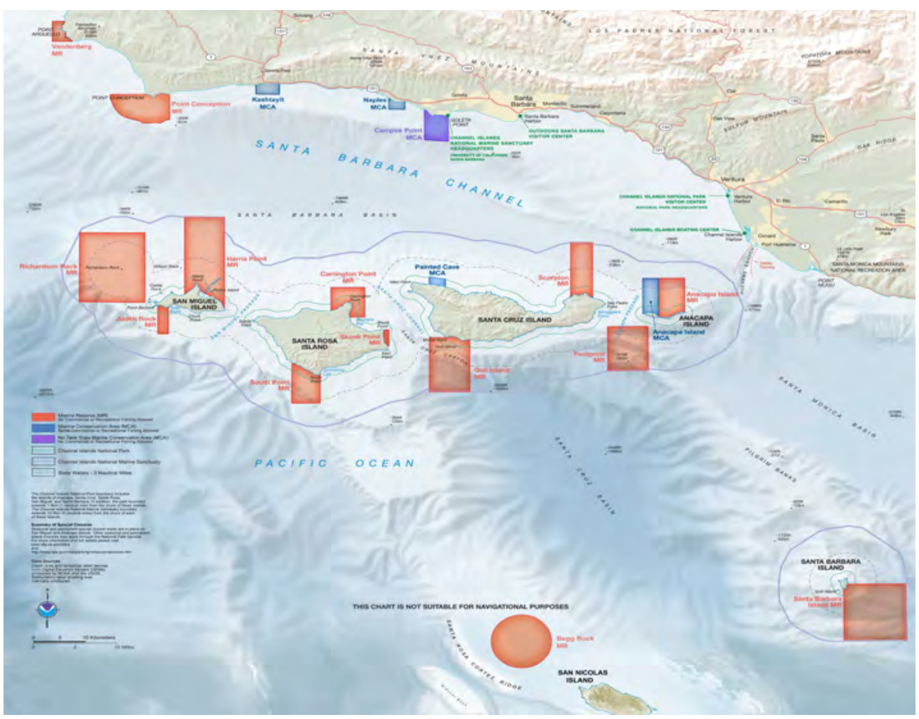

Figure R.CRF.2. Map of marine reserves and conservation areas within the sanctuary.

Law enforcement agencies have increasingly made the Channel Islands MPA Network an enforcement priority, including through on-water and in-air efforts of the National Park Service, U.S. Coast Guard, California Department of Fish and Wildlife, and NOAA. ONMS has helped to advance enforcement and support officers in the field by leading the development and deployment of a pilot mobile application known as the electronic Fisheries Information Network System (eFINS). This is a data collection and sharing application that allows participating marine enforcement partners to electronically record, store, reference, and share geospatial data taken during patrols as they conduct compliance checks with commercial and recreational users of the sanctuary (Figure R.CRF.3).

Figure R.CRF.3. ONMS led efforts to develop the mobile application eFINS as an enforcement tool that is used in the field by law enforcement officers, and helps agencies with overall enforcement assessment and management efforts. Photo: J. Morten/NOAA

Sanctuary staff have also worked collaboratively with the local commercial lobster fishery to jointly address the issue of trap loss. Traps are frequently lost within the sanctuary, and have the potential to continue to cause fishing mortality, damage, or remove sensitive species, and degrade the quality of shoreline and benthic marine habitats. Local veteran lobster fishermen, working with CINMS, helped with the production of a training film aimed at teaching novice fishermen how to reduce trap loss.[45] Additionally, lobster fishermen have been actively removing traps and other marine debris from sanctuary shorelines in cooperation with CINMS (Figure R.CRF.4).

[45] The video, Protecting Blue Whales and Blue Skies, is available for viewing online at https://www.youtube.com/watch?v=ryrM-PpA2wg.

Figure R.CRF.4. Since 2017, commercial lobstermen have been working with CINMS to retrieve lost fishing gear and other marine debris from sanctuary shorelines. Photo: C. Fackler/NOAA

NOAA ONMS has been working closely with recreational fishing interests to identify and pursue joint actions that can be taken to benefit this important user group, while supporting the goals of national marine sanctuaries. One area of focused cooperation has been to jointly promote training sessions and workshops that educate fishermen about the use of rockfish descender devices. When used during catch and release fishing, these devices can help rockfish recover from barotrauma experienced when being quickly brought up from deep water to the surface, causing gas inside its body to expand with the water's decreasing atmospheric pressure. Descending the rockfish to depths allows the gas to recompress, taking pressure off the organs, and helping the fish to survive.

Energy Development Activities

Exploration, development, and production of offshore oil and gas activities is prohibited within the sanctuary (see 15 C.F.R. § 922.72(1)[46]); however, there are several operating oil platforms and active wells immediately adjacent to the sanctuary (Figure R.ED.1), and as such, ONMS is prepared to respond to possible oil spills (see Pollutants section that follows). In 2015, ONMS utilized its emergency preparedness training to work with multiple agencies responding to the Refugio Beach Oil Spill.

[46] Pursuant to this regulation, the following exception applies: "except pursuant to leases executed prior to March 30, 1981, and except the laying of pipeline pursuant to exploring for, developing, or producing hydrocarbons" (15 C.F.R. § 922.72(1).

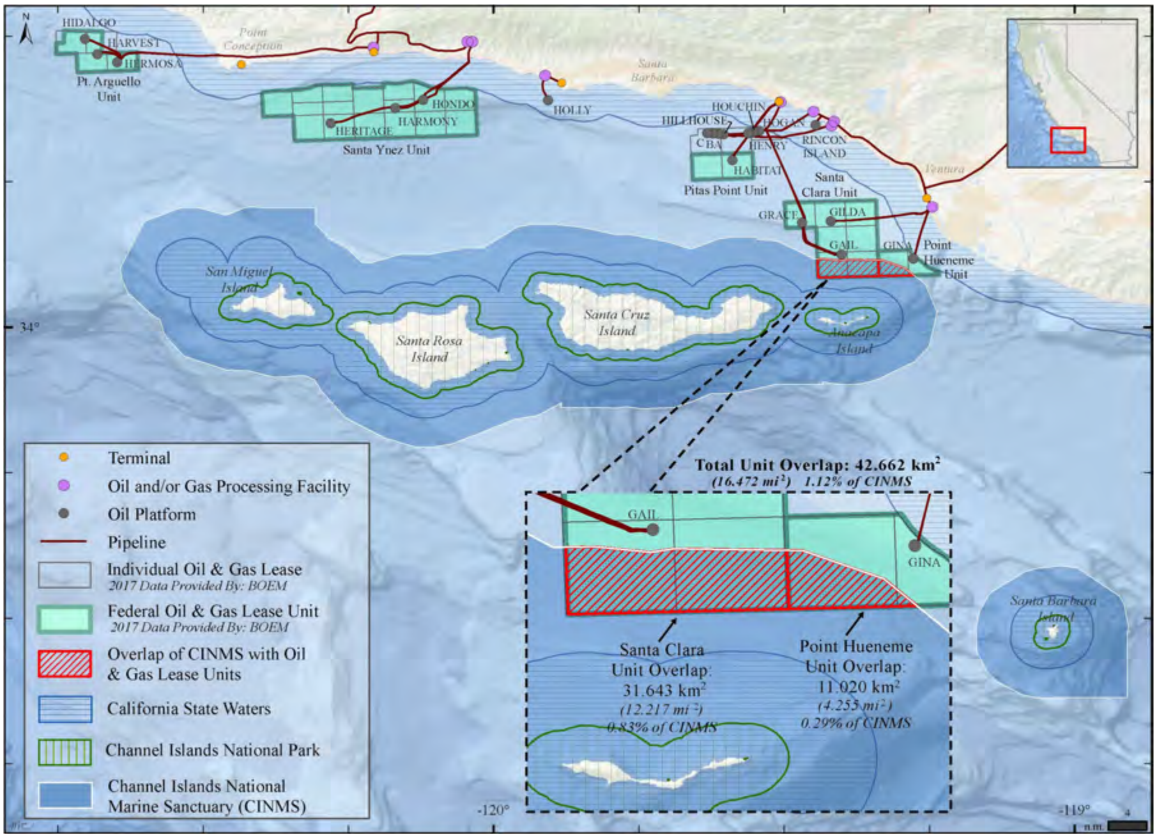

Figure R.ED.1. Offshore oil and gas infrastructure in federal waters of the Santa Barbara Channel adjacent to the sanctuary. Map prepared by CINMS; Data source: Bureau of Ocean Energy Management, 2017

ONMS also tracks and reviews proposals for the potential placement of offshore renewable energy facilities, including wind and wave technologies, that could potentially affect sanctuary resources. To date, proposals in the regional area that have begun to be reviewed by agencies have been sighted outside the sanctuary's boundaries. The sanctuary-led multi-agency Southern California Seafloor Mapping Initiative has collected significant amounts of high resolution seafloor habitat data within the sanctuary and across vast areas of the southern California Bight (Figure R.ED.2) that is highly important to assess ongoing regional questions contemplating the potential siting of offshore renewable energy infrastructure.

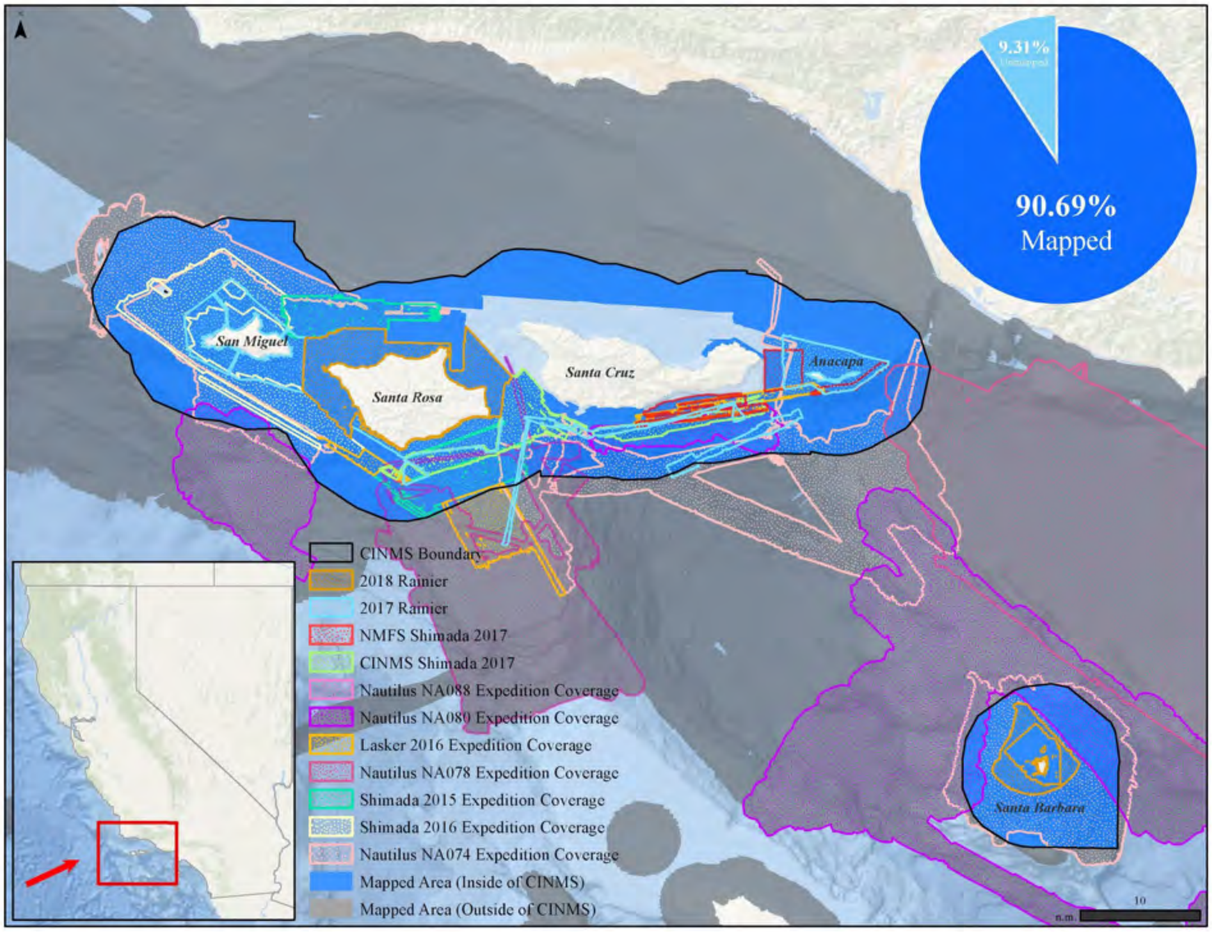

Figure R.ED.2. Through 2018, the mapping efforts that have been coordinated by CINMS since 2015 have resulted in high resolution maps of 90% of the sanctuary's seafloor habitats. Source: NOAA

Pollutants

As noted in the Pressures and Drivers section of this report, and assessed more thoroughly in the State of Sanctuary Resources section (Water Quality Questions 6–9), water quality in the sanctuary can be affected by:

- Contaminated sediments
- Runoff from land-based sources
- Climate drivers (e.g., sea surface temperature, acidity, upwelling, dissolved oxygen)
- Discharge from large and small vessels
- Pollution from offshore oil and gas production facilities
- Nutrient inputs
- Harmful algal blooms
- Marine debris

The sanctuary's offshore location helps to buffer it from many water quality issues experienced along or originating from the mainland coast; however, certain wind and circulation conditions can transport contaminated coastal waters to the sanctuary. Some mainland-based pollutants can leave a significant and long-lasting effect on the health of sanctuary resources, such as DDTs and PCBs that were released into the ocean through wastewater discharged off the southern California coast from the late 1940s to the early 1970s. Most of the DDT came from the Montrose Chemical Corporation and ended up settling on the Palos Verdes shelf off White Point. These toxic chemicals accumulated in plants and animals throughout the foodweb, becoming more concentrated in higher predators, and contaminating fish and birds, such as bald eagles and California brown pelicans from the Channel Islands. Several decades later, more than 110 tons of DDTs and 11 tons of PCBs remain in the sediments at the ocean bottom (NOAA Montrose Settlements Restoration Program 2018).

In general, to help protect the sanctuary's water quality, CINMS engages in the following types of activities:

- Works with several law enforcement partners to inform users and uphold the discharge standards set by sanctuary regulations.
- Works with a variety of monitoring partners, providing scientific support and research vessel services, to track pollutant levels in sanctuary sediments, water samples, and fish tissues.
- Focuses education and outreach messaging, programming, signage, exhibits, curricula, and other tools on best practices to reduce or avoid ocean pollution.
- Prepares for possible hazardous substance spills through training and drills, and participates with several agencies in the event of actual incidents, such as oil spills.
- Guides a large group of sanctuary volunteers that collect water samples used to help detect harmful algal blooms.

Examples of these sanctuary activities are described below.

Tracking legacy pollutants within the sanctuary's food web, or detecting emerging pollutants of potential concern, requires recurring monitoring and sample analysis. Since 1998, CINMS, and the sanctuary's research vessel, have participated in the multi-organizational Southern California Bight Regional Monitoring Program coordinated by the Southern California Coastal Water Research Project (SCCWRP). CINMS's involvement has helped to ensure that ocean water samples, fish tissues, and sediments from within the sanctuary are collected, assessed, and reported every five years. This work has served to provide a critical tool to help CINMS understand the sanctuary's overall marine water quality, and detect the lingering presence of legacy pollutants as well as new sources of pollutants (Figure R.P.1). In addition to regularly participating in this important program, in 2010, CINMS was the recipient of a comprehensive Water Quality Characterization Report that identified a range of water pollution sources and threats that could affect the sanctuary (SBCK and Engel 2010).

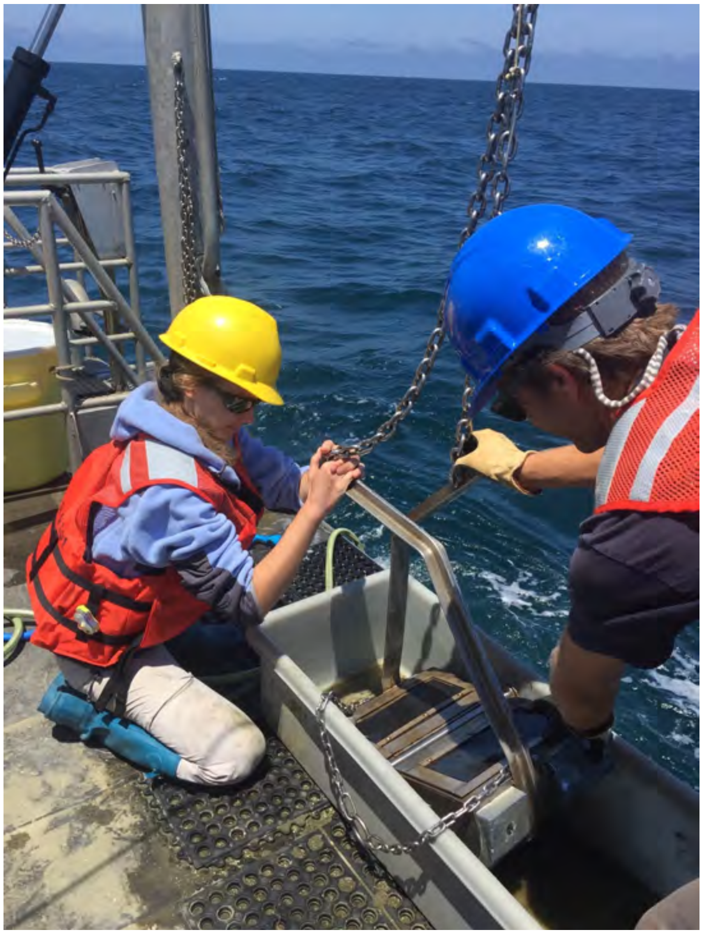

Figure R.P.1. This image depicts sediment sampling in the sanctuary aboard the research vessel *Shearwater* during implementation of the 2018 Southern California Bight Regional Monitoring Program. Photo: J. Bertetto/NOAA

Figure R.P.2. Platform Gail, located directly adjacent to the sanctuary's north-eastern boundary area, operates at a water depth of 739 feet. Photo: R. Schwemmer/NOAA

Since 1996, CINMS has provided its research vessel to support the UCSB Plumes and Blooms monitoring program . Through the regular (usually monthly) collection of water samples within and adjacent to the sanctuary, and the use of satellite-acquired data, this program aims to understand the ocean color roles of sediment plumes and phytoplankton blooms. The Plumes and Blooms program helps explain the seasonal, inter-annual and long-term variability of water components in the Santa Barbara Channel.

In addition to SCCWRP and Plumes and Blooms, there are also other important monitoring programs and partners helping to track and understand water quality and related ecosystem dynamics within and around the sanctuary. CINMS has collaborated with, supported with investments of time, helped by providing research vessel services, or otherwise utilized the work of these partners, which include but are not limited to: California Cooperative Oceanic Fisheries Investigations (CalCOFI), Southern California Coastal Ocean Observing System (SCOOS), Santa Barbara Channel Marine Biodiversity Observation Network (SBC MBON), Santa Barbara Channelkeeper, and the Kelp Forest Monitoring Program and Intertidal Monitoring Program at Channel Islands National Park. A more complete list of partners and collaborators can be found in the references to the State of Sanctuary Resources section (Water Quality Questions 6–9)

Pollution from boats and ships is an issue of ongoing concern that CINMS has worked to address using both regulatory and educational approaches (See section on Reduction and Control of Vessel

Discharges). Minimizing these discharges is a priority for CINMS as evidenced through its discharge regulation (see 15 C.F.R. § 922.72(3)), and education and outreach messaging and tools.

Another potential source of marine pollution is oil and hazardous substances transported by ships or produced as part of operations at offshore oil and gas platforms adjacent to the sanctuary (Figure R.P.2). While sanctuary regulations prohibit new exploration for or development of offshore oil and gas resources (15 C.F.R. § 922.72(a)(1)), spills from adjacent activities are still a possibility. To be ready for possible spills, sanctuary staff receive regular training on emergency response, participate in drills and exercises, and participate with multiple agencies in a regional Area Contingency Planning forum focused on preparedness and coordinated response. In 2015, several sanctuary staff assisted with response to the Refugio Beach Oil Spill response.

One of the services provided by the Channel Islands Naturalist Corps, a group of more than 130 well-trained volunteers that are jointly managed by the sanctuary and Channel Islands National Park, is to regularly collect water samples that are used to detect the presence of harmful algal blooms (HABs).

The Vessel Speed Reduction program (mentioned previously) has been contributing to lessening the amount of NOx and greenhouse gasses emitted from participating shipping lines (Figure R.P.3).

Figure R.P.3. Thousands of cargo ships transit the Santa Barbara Channel each year, passing through a portion of the sanctuary. Photo: R. Schwemmer/NOAA

Marine Debris

Although the offshore location of the sanctuary and undeveloped nature of the islands provides a buffer from some of the types of trash and debris that is produced along the mainland coast, there are still marine debris issues to contend with in the sanctuary. Floating plastic debris can travel great distances and wash onto island shorelines, and gear is sometimes lost during fishing operations. With financial support from the NOAA Marine Debris Program, in recent years, CINMS has been working closely with veteran lobster fishermen to address the problem of lost traps. An instructional video has been created to train novice fishermen, and CINMS has fishermen to remove marine debris and traps from several shoreline areas of the sanctuary (Figure R.MD.1).[47] Additionally, under permit by the sanctuary, periodic SCUBA diving operations are made by the Sea Doc Society's California Lost Fishing Gear Removal Project, removing, repurposing and recycling lost traps, line, and net fragments. Similarly, the sanctuary has issued permits to the Ocean Defenders Alliance to periodically remove lost fishing gear using SCUBA-based operations at various locations throughout the sanctuary.

Figure R.MD.1. Sanctuary staff, partners, and local lobster fishermen have been working together to clean marine debris and lost traps off sanctuary shorelines. Photo: M. Murray/NOAA

Microplastics in the water column are an emerging concern for the sanctuary that has not yet been addressed, although studies at the Channel Islands are underway by researchers from California State University Channel Islands.

Visitor Use

CINMS encourages responsible visitor use within the sanctuary. Visitors, including volunteers, often feel a sense of stewardship toward the sanctuary and can help address certain resource protection issues. For example, volunteers and other visitors help collect data on whale sightings by logging information into two mobile applications that CINMS helped to develop and deploy (Spotter Pro and Whale Alert). Sanctuary visitors are often the first to report an incident of concern that is witnessed, such as pollution, low overflights, close approaches to marine mammals, or fishing within a marine reserve. Additionally,

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[47] The video, *Leave No Traps Behind*, produced by Earth Media Lab, is available for viewing online at https://www.youtube.com/watch?v=eQPF1zx252E&t=23s.

there are many sanctuary-affiliated education programs that help students and teachers visit the sanctuary and teach them how to care for the marine life and habitats they learn about, including the MERITO Foundation (Figure R.VU.1), NOAA's Bay Watershed Education and Training (BWET) program, the Office of National Marine Sanctuary's Ocean Guardian Schools program, and more. Trained volunteers with the Channel Islands Naturalist Corps interact with visitors year-round on marine excursion vessels, on the islands, and at community events, also promoting visitor best practices as they share a wealth of information about the sanctuary and Channel Islands National Park.

Figure R.VU.1. Students from Montalvo Elementary School (Ventura, California) participating in an educational field excursion conducted by the MERITO Foundation, pose at Santa Cruz Island during a 2014 visit to the sanctuary and Channel Islands National Park. The MERITO Foundation, a close sanctuary partner for many years, facilitates education, conservation, and scientific research opportunities for multicultural youth and their communities, and inspires a diversity of students to pursue ocean-related science, technology, and engineering careers. Photo: R. Lozano Knowlton.

Visitors and the activities in which they engage can often be the source of many possible resource impacts. These impacts can include boat-based visitor impacts such as groundings, wildlife disturbance, pollutant discharge, or poor anchoring practices (see the Vessel Impacts sub-sections on Reduction and Control of Vessel Discharges, Vessel Anchoring, and Wildlife Disturbance from Vessels, and Vessel Navigational Concerns: Groundings and Collisions). Visitor impacts and related sanctuary programs created to prevent or mitigate these impacts are also discussed in the sections on Commercial and Recreational Fishing section, and Non-Native Specie*s*.

A suite of sanctuary regulations help to discourage visitor practices that could be harmful to the protected natural and cultural resources found within the sanctuary. These include prohibitions and restrictions on:

- Discharge of pollutants (see 15 C.F.R. § 922.72(3))
- Large vessels (>300 gross registered tons) approaching within 1 nautucal mile of island shorelines (see 15 C.F.R. § 922.72(6))
- Unauthorized "take" or possession of marine mammals, seabirds, or sea turtles (see 15 C.F.R. § 922.72(9) and (10))
- Aircraft flight below 1,000 feet when within 1 nautical of island shores (see 15 C.F.R. § 922.72(7))
- Disturbance or removal of historical resources (see 15 C.F.R. § 922.72(8))
- Abandoning structures (e.g., a boat) or other material in the sanctuary (see 15 C.F.R. § 922.72(5))
- Introducing or releasing non-native species in the sanctuary (see 15 C.F.R. § 922.72(12))
- Operating a motoring personal watercraft (e.g., jetski) within 1 nautical mile of island shores (see 15 C.F.R. § 922.72(13))
- Taking any marine life or other resource from a marine reserve (see 15 C.F.R. § 922.73(a))
- Taking prohibited marine life of other resources from a marine conservation area (see 15 C.F.R. § 922.73(b))

Staff, volunteers, and enforcement partners help visitors learn about and follow sanctuary regulations. These efforts are supported by frequent use of the sanctuary-designed public brochure, *Protecting Your Channel Islands*" (Figure R.VU.2). This popular product is printed on water-resistant paper, used heavily in the field, reproduced in bulk every year, and distributed to tens of thousands of people via volunteers, agency partners, law enforcement officers, staff, and local businesses.

Figure R.VU.2. Above, portions of the sanctuary's brochure, *Protecting Your Channel Islands*, which is a widely used product that helps visitors safely enjoy the sanctuary and Channel Islands National Park while respecting wildlife, habitats, and associated rules.

In addition, CINMS has designed, placed, and maintained over 30 interpretive signs located at harbors, partner facilities, and island piers that help visitors properly interact with sanctuary resources. Similarly, exhibits and interactive touch-screen kiosks placed at strategic locations (harbors, boat ramps, museums, visitor centers, etc.) help the public prepare for sanctuary visits, learn about and appreciate what the sanctuary has to offer, use best practices, and follow sanctuary regulations. As stated earlier, volunteers with the Channel Islands Naturalist Corps are skillfully deliver these same messages to thousands of visitors each year.

ONMS has developed a national "Ocean Etiquette" initiative. The purpose of the initiative is to promote responsible encounters with marine wildlife and their habitats in national marine sanctuaries. A variety of educational and outreach materials have been produced and are distributed to key audiences. These products include pocket-cards that provide marine wildlife viewing guidelines (Figure R.VU.3), and a variety of related reports, handbooks, and features on business certification programs.[48]

Figure R.VU.3. Ocean etiquette guidelines for marine wildlife viewing are used by ONMS and volunteers to promote best practices.

Climate Variability

Shifts in ocean conditions driven by climate change represent the most challenging pressures to deal with at a sanctuary-scale level. The forces driving global oceanic change cannot effectively be stopped or regulated by the sanctuary; however, ONMS understands that it is increasingly important to do whatever may be possible at a smaller scale to understand, detect, and track the onset of changes and impacts driven by climate change, and to be well informed and prepared to adapt management activities and approaches in response. ONMS also works to bring attention to these oceanic climate change effects to help others consider the broader implications and options for addressing this global challenge.

CINMS and the CINMS AC took an early interest and lead in raising awareness about ocean acidification (CWG 2008, Lott et al. 2011). In collaboration with many partners, including the NOAA Ocean Acidification Program, CINMS has pioneered approaches to providing effective public communication

[48] Information about the Ocean Etiquette initiative is available online at https://sanctuaries.noaa.gov/protect/oceanetiquette.html.

and education about ocean acidification, making a wide variety of services, tools, and other resources available to local, national, and international audiences.

CINMS has also partnered with local researchers, such as Dr. Gretchen Hofmann (UCSB), to help provide them access to the sanctuary so that local nearshore pH readings and other measurements can be collected and analyzed over space and time, to better understand changing and dynamic levels, system gradients, and the role of habitats, such as kelp and eelgrass beds (Kapsenberg and Hofmann 2016). Additionally, in partnership with NOAA's Integrated Ecosystem Assessment program, CINMS recently developed and will work with a new thermal indicator modeling tool to help evaluate management strategies in response to dynamic conditions driven by climate change. Similarly, CINMS has collaborated with and provided vessel support to the Santa Barbara Sediment Trap Time-series Program, which has been collecting and analyzing sediments from the Santa Barbara Channel since 1993. This monitoring program is helping advance understanding of the impact of ocean acidification on plankton calcification in Santa Barbara Basin during the last 100 years.

Through staff time and research vessel support, CINMS has also provided assistance to, and benefited from the findings of, the Santa Barbara Coastal Long-term Ecological Research Program. This interdisciplinary program, based out of UCSB, is determining how natural and human drivers, including climate change effects, influence giant kelp dynamics and alter the long-term structure and function of kelp forest ecosystems.

CINMS has also worked closely with NOAA's National Centers for Coastal Ocean Science (NCCOS) and other partners to discover, survey, and assess the condition of deep-sea corals, with an interest in discerning possible adverse climate change effects (Etnoyer et al. 2017, Gómez et al. 2018) (Figure R.CV.1). THe ability to monitor deep-sea coral habitats and the impacts of climate change has been greatly enhanced by the Southern California Seafloor Mapping Initiative, a multi-agency effort conducted aboard NOAA hydrography ships and the exploration vessel, *Nautilus*. Since 2014, this initiative has produced high resolution bathymetric mapping and habitat typing for an additional 9,717 square kilometers (3,752 square miles) of seafloor in the southern California Bight, of which 3,174 square kilometers (1,225 square miles) took place in the sanctuary, resulting in the sanctuary seafloor being 83% mapped as of August 2018 (Figure R.ED.2).

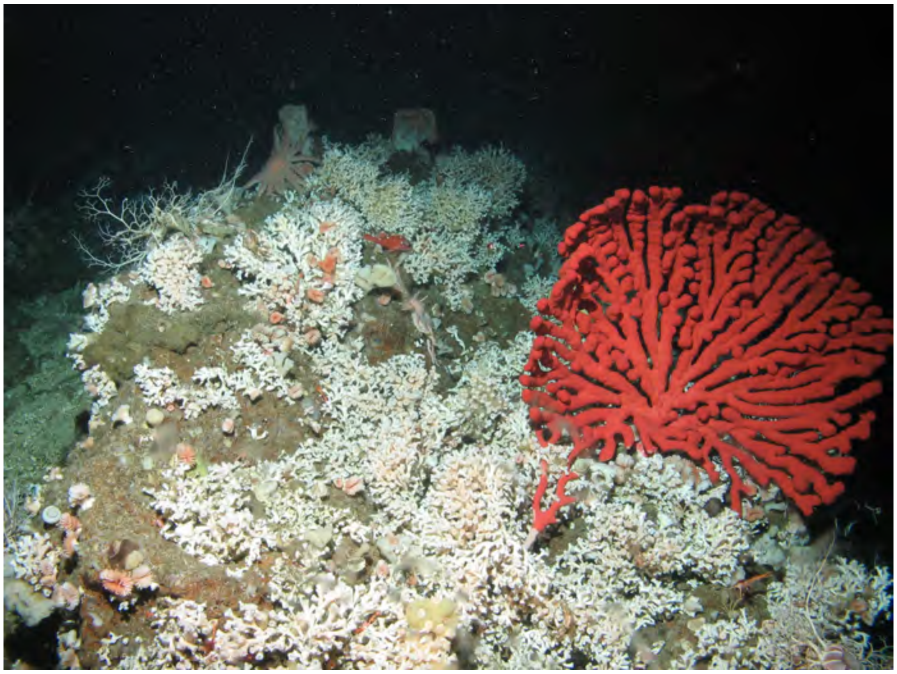


Figure R.CV.1. Deep-sea corals and sponges have been surveyed, characterized, and sampled over the course of several research cruises within the sanctuary. Photo: OET

Finally, ONMS believes it is important to play a role in operating NOAA-owned vessels and facilities in a climate-friendly manner. ONMS helped design the Leadership in Energy and Environmental Design (LEED)-Gold certified office building that serves as CINMS's main office on the campus of the University of California, Santa Barbara (UCSB) (Figure R.CV.2). ONMS is also replacing older engines for the research vessel *Shark Cat* with cleaner and more efficient models.

Figure R.CV.2. The Ocean Science Education Building on the campus of UCSB houses the sanctuary's main office, and is a Gold-level certified facility based on the globally recognized Leadership in Energy and Environmental Design rating system. Photo: Robert Schwemmer/NOAA

Conclusion

Given the sanctuary's remote offshore setting and unique mix of human activities, effectively responding to the wide range of issues and threats presented in the Driving Forces and Pressures section of this report requires a long-term commitment to marine conservation using a multidisciplinary, partnership-based approach. This involves the need for scientific research and monitoring studies, ongoing monitoring of conditions, enforcement of existing regulations, watchful attention to emerging threats, community-based initiatives, and the use of education and outreach to inspire others to care and help. Groups, such at the CINMS advisory council and its working groups, are critical for helping to identify, assess, and prioritize emerging issues, and for crafting sound management advice. The collection of actions summarized in this Response section are representative of this type of multi-faceted and partnership-based approach, but not necessarily adequate for addressing every threat. The dynamic and emerging nature of many issues requires that recurring assessment and adaptation are part of the sanctuary's management cycle. Going forward, this condition report will inform the next sanctuary management plan update process, expected to begin in 2019. That process will identify priority actions, whether new or continuing, to help address issues raised in this report.

CONCLUDING REMARKS

This 2016 Condition Report for Channel Islands National Marine Sanctuary is a comprehensive update to the 2009 Condition Report. We have made numerous improvements and changes to the report in order to enhance its utility to scientists, resource managers, stakeholders, and the general public. For example, in response to feedback on the 2009 report from our Advisory Council's Research Activities Panel, this report bases all status and trend ratings on the best available quantitative data through 2016, and provides expert panel confidence levels for most ratings. Another exciting enhancement is our effort to increase data availability and visualization using online portals. Going forward, we are excited to be pursuing partnerships to develop increased data availability and online visualization tools accessible from a central web site. Rather than waiting for the next condition report, we would like people to be able to go online to get the latest update on sanctuary trends, such as ocean upwelling intensity or kelp forest cover, with just a click of a computer mouse.

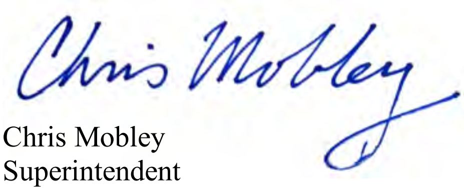
Much of the sanctuary appears healthy and stable, including eutrophic conditions, water quality that is safe for swimming and recreation, the general condition of shoreline and seafloor habitat, many fish species, overall native sanctuary biodiversity, and the condition of maritime archaeological resources. For context, the Santa Barbara/Ventura/Port Hueneme Port Complex still has the most valuable fisheries landings in the entire State of California — much of it harvested from the sanctuary. The sanctuary also continues to be a beautiful, world-class recreation and tourism destination.

Regardless, the report has also documented new threats to sanctuary resources and resulting impacts since 2009 that will require additional monitoring. These include the "blob" warm water event, increased frequency of harmful algal blooms, widespread sea star wasting disease, declines in some habitat-forming species, such as kelp and deep-sea corals, and an increase in invasive species. This new information will be invaluable as we update our sanctuary management plan and adjust our priorities for the next five years.

This report also highlights important information gaps that will help guide our research and monitoring work with partners in the future. For example, we would like more information on the status of beaches and soft-bottom habitats, more monitoring of deeper habitats, better metrics for tracking changes in biodiversity, stock assessments of harvested species, and a better understanding of the impacts of underwater noise and marine debris.

This report would not have been possible without the dedicated support and input of numerous contributors and reviewers. On behalf of the Office of National Marine Sanctuaries (ONMS) and myself, I want to express our sincerest gratitude for both past and ongoing contributions to both sanctuary monitoring and management. It is only through continued these collaborations and partnerships that we will successfully protect, conserve, and restore this precious ocean treasure for generations to come.

Finally, again on behalf of ONMS, and especially Channel Islands National Marine Sanctuary, I would like to express our deepest appreciation to members of the Chumash community for providing their perspectives on the value of the sanctuary in their own words. Their perspective spans thousands of years and challenges us to think about ocean conservation in a more holistic manner and over a much longer time frame.



Chris Mobley
Superintendent
Channel Islands National Marine Sanctuary

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APPENDIX A: Rating Scheme for System-wide Monitoring Questions

The purpose of this appendix is to clarify the questions and possible responses used to report the condition of sanctuary resources in “condition reports” for all national marine sanctuaries. The Office of National Marine Sanctuaries (ONMS) and subject matter experts used this guidance, as well as their own understanding of the condition of resources, to make judgments about the status and trends of sanctuary resources.

The questions derive from the National Marine Sanctuary System’s mission, and a system-wide monitoring framework (NMSP 2004) developed to ensure the timely flow of data and information to those responsible for managing and protecting resources in the ocean and coastal zone, and to those that use, depend on, and study sanctuary resources. The questions are being used to guide ONMS and its partners at each of the sanctuary system’s 14 units in the sanctuary system in the development of periodic sanctuary condition reports. Evaluations of status and trends were based on interpretation of quantitative and, when necessary, non-quantitative assessments and observations of scientists, managers, and users.

In 2012, ONMS led an effort to review and edit the set of questions and their possible responses that were developed for the first round of condition reports (drafted between 2007 and 2014) (NMSP 2004). The questions that follow are revised and improved versions of those original questions. Although all questions have been edited to some degree, both in their description and status ratings, the nature and intent of most questions have not changed. Five questions (i.e., Questions 1, 8, 10, 12, and 13), however, are either new or are significantly altered and therefore, are not directly comparable to the original questions. For these, a new baseline will need to be established.

- A new question that addresses the status and trend of driving forces that ultimately influence the pressures on sanctuary resources was added.
- Among the Water Quality questions, one was added on climate change. This was necessary to address the constantly increasing awareness and attention to the issue following the original design of the condition report process, which began in 2002. It also removed the need to combine climate change discussions with other questions.
- Two Habitat Quality questions were combined due to feedback received during the development of the first round of reports. A single question regarding the “integrity of major habitat types” has been created and combines prior questions that separately inquired about non-biogenic and biogenic habitats. Experience showed that species constituting biogenic habitat (e.g., kelp, corals, seagrass, etc.) were considered adequately within questions about living resources and need not be covered twice in the reports.
- Among the Living Resource Quality questions, one used in the first round of condition reports that asked about “the status of environmentally sustainable fishing” was removed entirely. This question was removed for a variety of reasons including it was the only question focused on a single, specific human activity and because fishing activity discussions were already included in the question regarding “human activities that may influence living resource quality.” In addition, living resource quality that would provide a basis for judgement for this question was typically

considered as a part of other living resource questions, and need not be covered twice. Another change to the Living Resource Quality questions pertains to the question about the "health of key species" that was previously addressed in a single question, but is now split into two. The first asks specifically about the status of "keystone and foundation" species, the second about "other focal species." In either case, the health of any species of interest can be considered in judgement of status and trends.

Ratings for a number of questions depend on judgments of the "ecological integrity" within a national marine sanctuary. This is because one of the foundational principles behind the establishment of sanctuaries is to protect ocean ecosystems. The term ecological integrity is used to imply "the presence of naturally occurring species, populations and communities, and ecological processes functioning at appropriate rates, scales, and levels of natural variation, as well as the environmental conditions that support these attributes" (modified from the National Park Service's Vital Signs Monitoring Program: http://science.nature.nps.gov/im/monitor/Glossary.cfm). Sanctuaries have ecological integrity when they have their native components intact, including abiotic components (i.e., the physical forces and chemical elements, such as water), biotic elements (such as habitats), biodiversity (i.e., the composition and abundance of species and communities), and ecological processes (e.g., competition, predation, symbioses) (modified from Parks Canada at http://www.pc.gc.ca/progs/np-pn/ie-ei.aspx). For purposes of this report, the level of integrity that is judged to exist is based on the extent to which humans have altered specific components of the system, and the effect of that change on the ability of an ecosystem to resist continued change and recover from it. The statements for many questions are intended to reflect this judgment. Reference is made in the rating system to "near-pristine" conditions, for which this report would imply a status as near to an unaltered ecosystem as can reasonably be presumed to exist, recognizing that there are virtually no ecosystems on Earth completely free from human influence.

Not all questions, however, use ecological integrity as a basis for judgment. One focuses on the impacts of water quality factors on human health. Two questions rate the status of keystone and key species compared with that expected in an unaltered ecosystem. One rates maritime archaeological resources based on their historical, archaeological, scientific, and educational value. Another considers the level and persistence of localized threats posed by degrading archaeological resources. Finally, four ask specifically about the levels of ongoing human activities (i.e., Pressures) that could affect resource condition.

During workshops in which status and trends are rated, subject matter experts discuss each question and available data, literature (e.g., published scientific studies, reports), and experience associated with the topic. They then discuss the statements provided as options for judgments about status; these statements have been customized for each question. Once a particular statement is agreed upon, a color code and status rating (e.g., good, fair, poor) is assigned. Experts can also decide that the most appropriate rating is "N/A" (i.e., the question does not apply) or "Undet." (i.e., resource status is undetermined due to a paucity of relevant information).

A subsequent discussion is then held about the trend. Conditions are determined to be improving, remaining the same, or worsening in comparison to the results found in the first round of condition reports. Symbols used to indicate trends are the same for all questions: "▲" — conditions appear to be improving; "▬" — conditions do not appear to be changing; "▼" — conditions appear to be worsening; and "?" — trend is undetermined.

Drivers/pressures

Question 1 (Drivers/Human Activities): What are the states of influential human drivers and how are they changing?

Driving forces are those characteristics of human societies that influence the nature and extent of pressures on resources. They are the underlying cause of change in coastal marine ecosystems, as they determine human use. Drivers are influenced by demographics (e.g., age structure, population, etc.), demand, economic circumstances, industrial development patterns, business trends, and societal values. They operate at global, regional, and local scales. Examples include increasing global demand for agricultural commodities, which increases the use of chemicals that degrade coastal water quality; difficult economic times that reduce fishing efforts for a period of time within certain regions; or local construction booms that alter recreational visitation trends. Other drivers could be the demands that govern trends, such as global greenhouse gas generation, regional shipping or offshore industrial development, local recreation and tourism, fishing, port improvement, manufacturing, and age-specific services (e.g., retirement). Each of these, in turn, influences certain pressures on natural and cultural resources.

Integrated into this question should be consideration of societal values, which include such matters as levels of conservation awareness, political leanings, opinion about environmental issues relative to other concerns, or changing opinions about the acceptability of specific behaviors (e.g., littering, fishing). Understanding these values gives one a better understanding of the likely future trends in drivers and pressures, as well as the nature of the societal tradeoffs in different uses of the ecosystem resources (e.g., the effects of multiple changing drivers on each other and the resources they affect). This can better inform policy and management responses, and education and outreach efforts that are designed to change societal values with the intention to change drivers and reduce pressures.

In rating the status and trends for drivers, experts should consider the following:

- the main driving forces behind each pressure affecting natural resources and the environment
- the best available indicators of each driving force
- the status and trend of each driving force
- societal values behind each driving force
- the best indicators of societal values
- the status and trend of societal values

Good	Few or no drivers occur that have the potential to influence pressures in ways that will negatively affect resource qualities.
Good/Fair	Some drivers exist that may influence pressures in ways expected to degrade some attributes of resource quality.
Fair	Selected drivers are influencing pressures in ways that cause measurable resource impacts.
Fair/Poor	Selected drivers are influencing pressures in ways that result in severe impacts that are either widespread or persistent.
Poor	Selected drivers are influencing pressures in ways that result in severe, persistent and widespread impacts.

Question 2 (Water/Human Activities): What are the levels of human activities that may adversely influence water quality and how are they changing?

Among the human activities in or near sanctuaries that affect water quality are those involving direct discharges and spills (e.g., vessels, onshore and offshore industrial facilities, public wastewater facilities), those that contribute contaminants to groundwater, stream, river, and water control discharges (e.g., agriculture, runoff from impermeable surfaces through storm drains, conversion of land use), and those releasing airborne chemicals that subsequently deposit via particulates at sea (e.g., vessels, land-based traffic, power plants, manufacturing facilities, refineries). In addition, dredging and trawling can cause resuspension of contaminants in sediments. Many of these activities can be controlled through management actions in order to limit their impact on protected resources.

Good	Few or no activities occur that are likely to negatively affect water quality.
Good/Fair	Some potentially harmful activities exist, but they have not been shown to degrade water quality.
Fair	Selected activities have caused measurable resource impacts, but effects are localized and nc widespread or persistent.
Fair/Poor	Selected activities have caused severe impacts that are either widespread or persistent.
Poor	Selected activities have caused severe, persistent, and widespread impacts.

Question 3 (Habitat/Human Activities): What are the levels of human activities that may adversely influence habitats and how are they changing?

Human activities that degrade habitat quality do so by affecting structural (physical), biological, oceanographic, acoustic, or chemical characteristics of the habitat. Structural impacts, such as removal or mechanical alteration of habitat, can result from various fishing methods (e.g., trawls, traps, dredges, longlines, and even hook-and-line in some habitats), dredging of channels and harbors, dumping dredge spoil, grounding of vessels, anchoring, laying pipelines and cables, installing offshore structures, discharging drill cuttings, dragging tow cables, and placing artificial reefs. Removal or alteration of critical biological components of habitats can occur due to several of the above activities, most notably trawling, groundings, and cable drags. Marine debris, particularly in large quantities (e.g., lost gill nets and other types of fishing gear), can degrade both biological and structural habitat components. Changes in water circulation often occur when channels are dredged, fill is added, coastlines are armored, or other construction takes place. Management actions, such as beach wrack removal or sand replenishment on high public-use beaches, may impact the integrity of the natural ecosystem. Alterations in circulations can lead to changes in food delivery, waste removal, water quality (e.g., salinity, clarity and sedimentation), recruitment patterns, and a host of other ecological processes. Chemical alterations most commonly occur following spills and can have both acute and chronic impacts. Many of these activities can be controlled through management actions in order to limit their impact on protected resources.

Good	Few or no activities occur that are likely to negatively affect habitat quality.
Good/Fair	Some potentially harmful activities exist, but they have not been shown to degrade habitat quality.
Fair	Selected activities have caused measurable resource impacts, but effects are localized and nc widespread or persistent.
Fair/Poor	Selected activities have caused severe impacts that are either widespread or persistent.
Poor	Selected activities have caused severe, persistent, and widespread impacts.

Question 4 (Living Resources/Human Activities): What are the levels of human activities that may adversely influence living resources and how are they changing?

Human activities that degrade the condition of living resources do so by causing a loss or reduction of one or more species, by disrupting critical life stages, by impairing various physiological processes, or by promoting the introduction of non-indigenous species or pathogens. (Note: Activities that impact habitat and water quality may also affect living resources. These activities are dealt with in Questions 2 and 3, and some may be repeated here as they also directly affect living resources).

For most sanctuaries, recreational or commercial fishing and collecting have direct effects on animal or plant populations, either through removal or injury of organisms. Related to this, lost fishing gear can cause extended periods of loss for some species through entanglement and "ghost fishing." In addition, some fishing techniques are size-selective, resulting in impacts to particular life stages. High levels of visitor use in some places also cause localized depletion, particularly in intertidal areas or on shallow coral reefs, where collecting and trampling can be chronic problems.

Mortality and injury to living resources has also been documented from cable drags (e.g., towed barge operations), dumping spoil or drill cuttings, vessel groundings, or repeated anchoring. Contamination caused by acute or chronic spills or increased sedimentation to nearshore ecosystems from road developments in watersheds (including runoff from coastal construction or highly built coastal areas), discharges by vessels, or municipal and industrial facilities can make habitats unsuitable for recruitment or other ecosystem services (e.g., as nurseries or spawning grounds). While coastal armoring and construction can increase the availability of surfaces suitable for hard bottom species, the activity may disrupt recruitment patterns for other species (e.g., intertidal soft bottom animals), and natural habitat may be lost.

Oil spills (and spill response actions), discharges, and contaminants released from sediments (e.g., by dredging and dumping) can all cause physiological impairment and tissue contamination. Such activities can affect all life stages by direct mortality, reducing fecundity, reducing disease resistance, loss as prey and disruption of predator-prey relationships, and increasing susceptibility to predation. Furthermore, bioaccumulation results in some contaminants moving upward through the food chain, disproportionately affecting certain species.

Activities that promote the introduction of non-indigenous species include bilge discharges and ballast water exchange, commercial shipping, and vessel transportation. Intentional or accidental releases of aquarium fish and plants can also lead to introductions of non-indigenous species.

Many of these activities are controlled through management actions in order to limit their impact on protected resources.

Good	Few or no activities occur that are likely to negatively affect living resource quality.
Good/Fair	Some potentially harmful activities exist, but they have not been shown to degrade living resource quality.
Fair	Selected activities have caused measurable living resource impacts, but effects are localized and not widespread or persistent.
Fair/Poor	Selected activities have caused severe impacts that are either widespread or persistent.
Poor	Selected activities have caused severe, persistent, and widespread impacts.

Question 5 (Maritime Archaeological Resources/Human Activities): What are the levels of human activities that may adversely affect maritime archaeological resources and how are they changing?

Some human maritime activities threaten the archaeological integrity of maritime archaeological resources. Archaeological integrity is compromised when elements are moved, removed, or otherwise damaged. Threats come from looting by divers, inadvertent damage by scuba diving visitors, improperly conducted archaeology that does not fully document site disturbance, anchoring, groundings, and commercial and recreational fishing activities, among others. Many of these activities can be controlled through management actions in order to limit their impact on archaeological resources.

Good	Few or no activities occur at maritime archaeological resources site that are likely to adversely affect their integrity.
Good/Fair	Some potentially relevant activities exist, but they have not been shown to degrade maritime archaeological resource integrity.
Fair	Selected activities have caused measurable impacts to maritime archaeological resources, but effects are localized and not widespread or persistent.
Fair/Poor	Selected activities have caused severe impacts that are either widespread or persistent.
Poor	Selected activities have caused severe, persistent, and widespread impacts.

Water Quality

Question 6 (Water/Eutrophic Condition): What is the eutrophic condition of sanctuary waters and how is it changing?

Eutrophication is the accelerated production of organic matter, particularly algae, in a water body. It is usually caused by an increase in the amount of nutrients (largely nitrogen and phosphorus) being discharged to the water body. As a result of accelerated algal production, a variety of interrelated impacts may occur, including nuisance and toxic algal blooms, depleted dissolved oxygen, and loss of submerged aquatic vegetation (Bricker et al. 1999). Indicators commonly used to detect eutrophication and associated problems include nutrient concentrations, chlorophyll content, rates of water column or benthic primary production, benthic algae cover, algae bloom frequency and intensity, oxygen levels, and light penetration.

Eutrophication of sanctuary waters can impact the condition of other sanctuary resources. Nutrient enrichment often leads to plankton and/or algae blooms. Blooms of benthic algae can affect benthic communities directly through space competition. Indirect effects of overgrowth, and other competitive interactions (e.g., accumulation of algal-sediment mats) often lead to shifts in dominance in the benthic assemblage, oxygen depletion, etc. Disease incidence and frequency can also be affected by algae competition and changes in the chemical environment along competitive boundaries. Blooms can also affect water column conditions, including light penetration and plankton availability, which can alter pelagic food webs. Harmful algal blooms (HABs), some of which are exacerbated by eutrophic conditions, often affect other living resources, as biotoxins are consumed or released into the water and air, or decomposition depletes oxygen concentrations.

Good	Eutrophication has not been documented, or does not appear to have the potential to negatively affect ecological integrity.
Good/Fair	Eutrophication is suspected and may degrade some attributes of ecological integrity, but has not yet caused measurable degradation.
Fair	Eutrophication has caused measurable, but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Eutrophication has caused severe degradation in some, but not all attributes of ecological integrity.
Poor	Eutrophication has caused severe degradation in most, if not all attributes of ecological integrity.

Question 7 (Water/Human Health): Do sanctuary waters pose risks to human health and how are they changing?

Human health concerns are generally aroused by evidence of contamination (usually bacterial or chemical) in bathing waters or seafood intended for consumption. They also arise when harmful algal blooms are reported or when cases of respiratory distress or other disorders attributable to harmful algal blooms increase dramatically. Any of these conditions should be considered in the course of judging the risk to humans posed by waters in a sanctuary.

Some sanctuaries may have access to specific information about beach closures and seafood contamination. In particular, beaches may be closed when criteria for water safety are exceeded. Shellfish harvesting and fishing may be prohibited when contaminant or biotoxin loads or infection rates exceed certain levels. Alternatively, seafood advisories may also be issued, recommending that people avoid or limit intake of particular types of seafood from certain areas (e.g., when ciguatera poisoning is reported). Any of these conditions, along with changing frequencies or intensities, can be important indicators of human health problems and can be characterized using the descriptions below.

Good	Water quality does not appear to have the potential to negatively affect human health.
Good/Fair	One or more water quality indicators suggest the potential for human health impacts, but human health impacts have not been reported.
Fair	Water quality problems have caused measurable human impacts, but effects are localized an not widespread or persistent.
Fair/Poor	Water quality problems have caused severe impacts that are either widespread or persistent.
Poor	Water quality problems have caused severe, persistent, and widespread human impacts.

Question 8 (Water/Climate Change): Have recent, accelerated changes in climate altered water conditions and how are they changing?

The purpose of this question is to capture shifts in water quality, and associated impacts on sanctuary resources, due to climate change. Though temporal changes in climate have always occurred on Earth, evidence is strong that changes over the last century have been accelerated by human activities. Indicators of climate change in sanctuary waters include water temperature, acidity, sea level, upwelling intensity and timing, storm intensity and frequency, changes in erosion and sedimentation patterns, and freshwater delivery (e.g., rainfall patterns). Climate-related changes in one or more of these indicators can impact the condition of habitats, living resources, and maritime archaeological resources in sanctuaries.

Increasing water temperature has been linked to changing growth rates, reduced disease resistance, and disruptions in symbiotic relationships (e.g., bleaching on coral reefs), and changes in water temperature exposure may affect a species' resistance or the capacity to adapt to disturbances. Acidification can affect the survival and growth of organisms throughout the food web, as well as the persistence of skeletal material after death (through changes in rates of dissolution and bioerosion). Recent findings also suggest acidification impacts at sensory and behavioral levels, which can alter vitality and species interactions. Sea level change alters habitats, as well as their use and persistence. Variations in the timing and intensity of upwelling is known to change water quality through factors such as oxygen content and nutrient flow, further disrupting food webs, and the natural functioning of ecosystems. Changing patterns and intensities of storms alter community resistance and resilience within ecosystems that have, over long periods of time, adapted to such disturbances. Altered rates and volumes of freshwater delivery to coastal ecosystems affects salinity and turbidity regimes and can disrupt reproduction, recruitment, growth, disease incidence, phenology, and other important processes.

Good	Climate-related changes in water conditions have not been documented or do not appear to have the potential to negatively affect ecological integrity.
Good/Fair	Climate-related changes are suspected and may degrade some attributes of ecological integrity, but have not yet caused measurable degradation.
Fair	Climate-related changes have caused measurable, but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Climate-related changes have caused severe degradation in some, but not all attributes of ecological integrity.
Poor	Climate-related changes have caused severe degradation in most, if not all attributes of ecological integrity.

Question 9 (Water/Other Stressors): Are other stressors, individually or in combination, affecting water quality, and how are they changing?

The purpose of this question is to capture shifts in water quality due to anthropogenic stressors not addressed in other questions. For example, localized changes in circulation or sedimentation resulting from coastal construction or dredge spoil disposal can affect light penetration, salinity regimes, oxygen levels, productivity, waste transport, and other aspects of water quality that in turn influence the condition of habitats and living resources. Human inputs, generally in the form of contaminants from point or nonpoint sources, including fertilizers, pesticides, hydrocarbons, heavy metals, and sewage, are common causes of environmental degradation. When present in the water column, any of these contaminants can affect marine life by direct contact or ingestion, or through bioaccumulation via the food chain.

[Note: Over time, accumulation in sediments can sequester and concentrate contaminants; their effects may manifest only when the sediments are re-suspended during storm or other energetic events. In such cases, reports of status should be made under Question 11 — Habitat contaminants.]

Good	Other stressors on water quality have not been documented, or do not appear to have the potential to negatively affect ecological integrity.
Good/Fair	Selected stressors are suspected and may degrade some attributes of ecological integrity, but have not yet caused measurable degradation.
Fair	Selected stressors have caused measurable, but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Selected stressors have caused severe degradation in some, but not all attributes of ecologica integrity.
Poor	Selected stressors have caused severe degradation in most, if not all attributes of ecological integrity.

Habitat

Question 10 (Habitat/Integrity): What is the integrity of major habitat types and how are they changing?

Ocean habitats can be categorized in many different ways, including water column characteristics, benthic assemblages, substrate types, and structural character. There are intertidal and subtidal habitats. The water column itself is one habitat type (FGDC 2012). There are habitats composed of substrates formed by rocks or sand that originate from purely physical processes. There are also certain animals and plants that create, in life or after their death, substrates that attract or support other organisms (e.g., corals, kelp, beach wrack, drift algae); these are commonly called biogenic habitats.

Regardless of the habitat type, change and loss of habitat is of paramount concern when it comes to protecting marine and terrestrial ecosystems. Of greatest concern to sanctuaries are changes to habitats caused, either directly or indirectly, by human activities. Human activities like coastal development alter the distribution of habitat types along the shoreline. Changes in water conditions in estuaries, bays, and nearshore waters can negatively affect biogenic habitat formed by submerged aquatic vegetation. Intertidal habitats can be affected for long periods by oil spills or by chronic pollutant exposure. Marine debris, such trash and lost fishing gear, can degrade the quality of many different marine habitats including, beaches, subtidal benthic habitats, and the water column. Sandy seafloor and hard bottom habitats, even rocky areas several hundred meters deep, can be disturbed or destroyed by certain types of fishing gear, including bottom trawls, shellfish dredges, bottom longlines, and fish traps. Groundings, anchors, and irresponsible diving practices damage submerged reefs. Cables and pipelines disturb corridors across numerous habitat types and can be destructive if they become mobile.

Integrity of biogenic habitats depends on the condition of particular living organisms. Coral, sponges, and kelp are well known examples of biogenic habitat-forming organisms. The diverse assemblages residing within these habitats depend on and interact with each other in tightly linked food webs. They may also depend on each other for the recycling of wastes, hygiene, and the maintenance of water quality. Other communities that are dependent on biogenic habitat include intertidal communities structured by mussels, barnacles, and algae and subtidal hard bottom communities structured by bivalves, corals, or coralline algae. In numerous open ocean areas, drift algal mats provide food and cover for juvenile fish, turtles, and other organisms. The integrity of these communities depends largely on the condition of species that provide structure for them.

This question is intended to address acute or chronic changes in both the extent of habitat available to organisms and the quality of that habitat, whether non-living or biogenic. It asks about the quality of habitats compared to those that would be expected in near-pristine conditions (see definition above).

Good	Habitats are in near-pristine condition.
Good/Fair	Selected habitat loss or alteration is suspected and may degrade some attributes of ecological integrity, but has not yet caused measurable degradation.
Fair	Selected habitat loss or alteration has caused measurable, but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Selected habitat loss or alteration has caused severe degradation in some, but not all attributes of ecological integrity.
Poor	Selected habitat loss or alteration has caused severe degradation in most, if not all attributes of ecological integrity.

Question 11 (Habitat/Contaminants): What are contaminant concentrations in sanctuary habitats and how are they changing?

Habitat contaminants result from the introduction of unnatural levels of chemicals or other harmful material into the environment. Contaminants may be introduced through discrete entry locations, called point sources (e.g., rivers, pipes, or ships) and those with diffuse origins, called nonpoint sources (e.g., groundwater and urban runoff). Chemical contaminants themselves can be very specific, as in a spill from a containment facility or vessel grounding, or a complex mix, as with urban runoff. Familiar chemical contaminants include pesticides, hydrocarbons, heavy metals, and nutrients. Contaminants may also arrive in the form of materials that alter turbidity or smother plants or animals, therefore affecting metabolism and production.

This question is focused on risks posed primarily by contaminants within benthic formations, such as soft sediments, hard bottoms, or structure-forming organisms (see notes below). Not only are contaminants within benthic formations consumed or absorbed by benthic fauna, but resuspension due to benthic disturbance makes the contaminants available to water column organisms; in both cases, contaminants can be passed upwards through the food chain. While the contaminants of most common concern to sanctuaries are generally pesticides, hydrocarbons, and nutrients, the specific concerns of individual sanctuaries may differ substantially.

Notes: 1) Contaminants in the water column addressed in the water quality section of this report should be cited, but details need not be repeated here; 2) Many consider noise a pollutant, but in the interest of focusing here on more traditional forms of habitat degradation caused by contaminants, the impacts of acoustic pollution should be addressed within the living resource section, most likely as it impacts key species.

Good	Contaminants have not been documented, or do not appear to have the potential to negativel affect ecological integrity.
Good/Fair	Selected contaminants are suspected and may degrade some attributes of ecological integrity but have not yet caused measurable degradation.
Fair	Selected contaminants have caused measurable, but not severe degradation in some attribute of ecological integrity.
Fair/Poor	Selected contaminants have caused severe degradation in some, but not all attributes of ecological integrity.
Poor	Selected contaminants have caused severe degradation in most, if not all attributes of ecological integrity.

Living Resources

Question 12 (Living Resources/Keystone & Foundation Species): What is the status of keystone and foundation species and how is it changing?

Certain species are defined as "keystone" within ecosystems, meaning they are species on which the persistence of a large number of other species in the ecosystem depends (Paine 1966). They are the pillars of community stability (among other things, they strongly affect both resistance and resilience) and their contribution to ecosystem function is disproportionate to their numerical abundance or biomass; their impact is therefore important at the community or ecosystem level. Keystone species are often called "ecosystem engineers" and can include habitat creators (e.g., corals, kelp), predators that control food web structure (e.g., Humboldt squid, sea otters), herbivores that regulate benthic recruitment (e.g., certain sea urchins), and those involved in critical symbiotic relationships (e.g., cleaning or co-habitating species).

"Foundation" species are single species that define much of the structure of a community by creating locally stable conditions for other species and by modulating and stabilizing fundamental ecosystem processes (Dayton 1972). These are typically dominant biomass producers in an ecosystem and strongly influence the abundance and biomass of many other species. Examples include krill and other zooplankton, kelp, and forage fish, such as rockfish, anchovy, sardine, and coral. Foundation species exhibit similar control over ecosystems as keystone species, but their high abundance distinguishes them.

Changes in either keystone or foundation species may transform ecosystem structure through disappearances of or dramatic increases in the abundance of dependent species. Not only do the abundances of keystone and foundation species affect ecosystem integrity, but measures of condition can also be important to determining the likelihood that these species will persist and continue to provide vital ecosystem functions. Measures of condition may include growth rates, fecundity, recruitment, age-specific survival, contaminant loads, pathologies (e.g., disease incidence, tumors, and deformities), the presence and abundance of critical symbionts, or parasite loads.

Good	The status of keystone and foundation species appears to reflect near-pristine conditions and may promote ecological integrity (i.e., full community development and function).
Good/Fair	The status of keystone or foundation species may preclude full community development and function, but has not yet led to measurable degradation.
Fair	The status of keystone or foundation species suggests measurable, but not severe degradatio in some attributes of ecological integrity.
Fair/Poor	The status of keystone and foundation species suggests severe degradation in some, but not all attributes of ecological integrity.
Poor	The status of keystone and foundation species suggests severe degradation in most, if not all attributes of ecological integrity.

Question 13 (Living Resources/Other Focal Key Species): What is the status of other key species and how is it changing?

This question targets other species of particular interest from the perspective of sanctuary management. These “key species” may not be abundant or provide high value to ecosystem function, but their presence and health is important for the provision of other services, whether conservation, economic, or strategic. Examples include species targeted for special protection (e.g., threatened or endangered species), species for which specific regulations exist to minimize perturbations from human disturbance (e.g., touching corals, riding manta rays or whale sharks, disturbing white sharks, disturbing nesting birds), or indicator species (e.g., common murres as indicators of oil pollution). This category could also include so-called “flagship” species, which include charismatic or iconic species associated with specific locations, ecosystems, or are in need of specific management actions, are highly popular and attract visitors or business, have marketing appeal, or represent rallying points for conservation action (e.g., humpback and blue whales, Dungeness crab).

Status of these other key species can be assessed through measures of abundance, relative abundance, or condition, as described for keystone species in Question 12. In contrast to keystone and foundation species, however, the impact of changes in the abundance or condition of key species is more likely to be observed at the population or individual level, and less likely to result in ecosystem or community effects.

Good	Selected key species appear to reflect near-pristine conditions.
Good/Fair	Reduced abundances in selected key species are suspected, but have not yet been measured.
Fair	Selected key species are at reduced levels, but recovery is possible.
Fair/Poor	Selected key species are at substantially reduced levels, and prospects for recovery are uncertain.
Poor	Selected key species are at severely reduced levels, and recovery is unlikely.

Question 14 (Living Resources/Non-Indigenous Species): What is the status of non-indigenous species and how is it changing?

This question allows sanctuaries to report on the threat posed and impacts caused by non-indigenous species. Also called alien, exotic, non-native, or introduced species, these are animals or plants living outside their native distributional range, having arrived there by human activity, either deliberate or accidental. Activities that commonly facilitate invasions include vessel ballast water exchange, restaurant waste disposal, and trade in exotic species for aquaria. In some cases, climate change has resulted in water temperature fluctuations that have allowed range extensions for certain species.

Non-indigenous species that have damaging effects on ecosystems are called “invasive” species. Some can be extremely destructive, and because of this potential, non-indigenous species are usually considered problematic and warrant rapid response after invasion. For those that become established, however, their impacts can sometimes be assessed by quantifying changes in affected native species. In some cases, the presence of a species alone constitutes a significant threat (e.g., certain invasive algae and invertebrates). In other cases, impacts have been measured, and may or may not significantly affect ecosystem integrity.

Evaluating the potential impacts of non-indigenous species may require consideration of how climate change may enhance the recruitment, establishment, and/or severity of impacts of non-indigenous species. Altered temperature or salinity conditions, for example, may facilitate the range expansion, establishment, and survival of non-indigenous species while stressing native species, thus reducing ecosystem resistance. This will also make management response decisions difficult, as changing conditions will make new areas even more hospitable for non-indigenous species targeted for removal.

Good	Non-indigenous species are not suspected to be present or do not appear to affect ecological integrity (i.e., full community development and function).
Good/Fair	Non-indigenous species are present and may preclude full community development and function, but have not yet caused measurable degradation.
Fair	Non-indigenous species have caused measurable, but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Non-indigenous species have caused severe degradation in some, but not all attributes of ecological integrity.
Poor	Non-indigenous species have caused severe degradation in most, if not all attributes of ecological integrity.

Question 15 (Living Resources/Biodiversity): What is the status of biodiversity and how is it changing?

Broadly defined, biodiversity refers to variety of life on Earth, and includes the diversity of ecosystems, species, and genes, and the ecological processes that support them (United Nations Convention on Biological Diversity). This question is intended as an overall assessment of biodiversity compared to that expected in a near-pristine system (i.e., one as near to an unaltered ecosystem as we can reasonably expect, given that there are virtually no ecosystems completely free from human influence). It may include consideration of measures of biodiversity (i.e., usually aspects of species richness and evenness) and the status of functional interactions between species (e.g., trophic relationships and symbioses). Intact ecosystems require that all parts not only exist, but that they function together, resulting in natural symbioses, competition, predator-prey relationships, and redundancies (e.g., multiple species capable of performing the same ecological role). Intact structural elements, processes, and natural spatial and temporal variability are essential characteristics of community integrity and provide a natural adaptive capacity through resistance and resilience.

The response to this question will depend largely on changes in biodiversity that have occurred as a result of human activities that cause depletion, extirpation or extinction, illness, contamination, disturbance, and changes in environmental quality. Examples include collection of organisms, excessive visitation (e.g., trampling), industrial activities, coastal development, pollution, activities creating noise in the marine environment, and those that promote the spread of non-indigenous species.

Loss of species or changing relative abundances can be mediated through selective mortality or changing fecundity, either of which can influence ecosystem shifts. Human activities of particular interest in this regard are commercial and recreational harvesting. Both can be highly selective and disruptive activities, with a limited number of targeted species, and often result in the removal of high proportions of the populations, as well as large amounts of untargeted species (i.e., bycatch). Extraction removes biomass from the ecosystem, reducing its availability to other consumers. When too much extraction occurs, ecosystem stability can be compromised through long-term disruptions to food web structure, as well as changes in species relationships and related functions and services (e.g. cleaning symbioses); this has been defined as “ecologically unsustainable” extraction (Zabel et al. 2003).

Good	Biodiversity appears to reflect near-pristine conditions and promotes ecological integrity (i.e., full community development and function).
Good/Fair	Selected biodiversity loss or change is suspected and may preclude full community development and function, but has not yet caused measurable degradation.
Fair	Selected biodiversity loss or change has caused measurable, but not severe degradation in some attributes of ecological integrity.
Fair/Poor	Selected biodiversity loss or change has caused severe degradation in some, but not all attributes of ecological integrity.
Poor	Selected biodiversity loss or change has caused severe degradation in most, if not all attributes of ecological integrity.

Maritime Archaeological Resources

Question 16 (Maritime Archaeological Resources/Integrity): What is the archaeological integrity of known maritime archaeological resources and how is it changing?

Archaeological resources are material evidence of past human activities and include vessels, aircraft, structures, habitation sites, and objects created or modified by humans. The condition of archaeological resources in a marine sanctuary significantly affect their value for science and education, as well as the resource's eligibility for listing in the National Register of Historic Places. The integrity of an archaeological resource refers to its ability to help scientists answer questions about the past through archaeological research. Historical significance of an archaeological resource depends upon its integrity and/or its representativeness of past events that made a significant contribution to the broad patterns of history, its association with important persons, or its embodiment of distinctive type or architecture. Thus, while archaeological integrity is generally linked to condition, historical significance may rely on other factors as well.

Assessments of archaeological resources include evaluation of the apparent levels of integrity, which result from deterioration caused by human and natural forces (unlike questions about water, habitat, and living resources, the non-renewable nature of archaeological resources makes any reduction in integrity, even if caused by natural forces, permanent). The archaeological, scientific and educational values of archaeological resources are substantially determined and affected by resource integrity and historical significance.

Good	Known archaeological resources appear to reflect little or no unexpected disturbance.
Good/Fair	Selected archaeological resources exhibit indications of disturbance, but there appears to have been little or no reduction in historical, archaeological, scientific, or educational value.
Fair	The diminished condition of selected archaeological resources has reduced, to some extent, their historical, archaeological, scientific, or educational value, and may affect the eligibility of some sites for listing in the National Register of Historic Places.
Fair/Poor	The diminished condition of selected archaeological resources has substantially reduced their historical, archaeological, scientific, or educational value, and is likely to affect their eligibility for listing in the National Register of Historic Places.
Poor	The degraded condition of known archaeological resources in general makes them ineffective in terms of historical, archaeological, scientific, or educational value, and precludes their listing in the National Register of Historic Places.

Question 17 (Maritime Archaeological Resources/Threat to Environment): Do known maritime archaeological resources pose an environmental hazard and how is this threat changing?

Deliberate or accidental sinking of a ship, aircraft, or other manufactured goods, sometimes including lost or discarded munitions, potentially introduces hazardous materials into the marine environment. Many historic shipwrecks, particularly those sunk in the early to mid-20th century, still have the potential to retain oil and fuel in tanks and bunkers. As shipwrecks age and deteriorate, the potential increases for release of these materials into the environment.

Typically, the relatively small size of lost crafts and other man-made goods makes them more localized threats and unlikely to exhibit effects at the ecosystem scale; therefore, the ratings below reflect the different levels of impact within these areas of influence, and the likely persistence of those impacts.

Good	Known maritime archaeological resources pose few or no environmental threats.
Good/Fair	Selected maritime archaeological resources may pose isolated or limited environmental threats, but substantial or persistent impacts are not expected.
Fair	Selected maritime archaeological resources cause or are likely to cause measurable, but not severe, impacts to certain sanctuary resources or areas, but recovery is possible.
Fair/Poor	Selected maritime archaeological resources pose substantial threats to certain sanctuary resources or areas, and prospects for recovery are uncertain.
Poor	Selected maritime archaeological resources pose serious threats to sanctuary resources, and recovery is unlikely.

APPENDIX B: Consultation with Experts and Document Review

The process for preparing condition reports involves a combination of accepted techniques for collecting and interpreting information gathered from subject matter experts. The approach varies somewhat from sanctuary to sanctuary, in order to accommodate different styles for work with partners. The Channel Islands National Marine Sanctuary approach was closely related to the Delphi Method, a technique designed to organize group communication among a panel of geographically dispersed experts by using questionnaires, ultimately facilitating the formation of a group judgment. This method can be applied when it is necessary for decision makers to combine the testimony of a group of experts, whether in the form of facts or informed opinion, or both, into a single useful statement.

The Delphi Method relies on repeated interactions with experts who respond to questions with a limited number of choices to arrive at the best supported answers. Feedback to the experts allows them to refine their views, gradually moving the group toward the most agreeable judgment. For condition reports, the Office of National Marine Sanctuaries (ONMS) uses standardized questions related to the status and trends of sanctuary resources, with accompanying descriptions and five possible choices that describe resource condition (Appendix A).

In order to address the standardized state of the ecosystem questions (Questions 2–17), ONMS selected and consulted outside experts familiar with water quality, habitat, and living resources in the sanctuary. A two-day workshop was held May 31–June 1, 2016, where experts participated in facilitated discussions about the questions related to Pressures (Questions 2–4), water quality (Questions 6–9), habitat (Questions 10 and 11), and living resources (Questions 12–15). Experts represented various affiliations; a list of experts who provided input is available in the Acknowledgement section of this report. A separate meeting between ONMS scientific staff and the ONMS West Coast Regional Maritime Heritage Coordinator was held to discuss questions related to maritime archaeological resources (Questions 5, 16, and 17). The Drivers question (Question 1) was determined and reviewed by ONMS socioeconomists who used indicators to make a preliminary status and trend rating and draft an accompanying summary statement. This material was then reviewed by CINMS staff.

At the workshop, experts were introduced to the questions and provided with relevant time series datasets ONMS had collected from experts prior to the meeting (Appendix G). Attendees were then asked to review the datasets, identify data gaps, or misrepresentations and any additional datasets. Once all datasets were reviewed, experts were asked to provide status and trend recommendations and supporting arguments. In order to ensure consistency with Delphic methods, a critical role of the facilitator was to minimize dominance of the discussion by a single individual or opinion (which often leads to "follow the leader" tendencies in group meetings) and to encourage the expression of honest differences of opinion. As discussions progressed, the group converged in their opinion of the rating that most accurately describes the current resource condition. After an appropriate amount of time, the facilitator asked whether the group could agree on a rating for the question, as defined by specific language linked to each rating (see Appendix A). If an agreement was reached, the result was recorded and the group moved on to consider the trend in the same manner. If agreement was not reached, the facilitator recorded the vote of individuals for each rating category and that information helped to inform the confidence scoring process.

Experts assigned a level of confidence for each status and trend rating by: 1) characterizing the sources of information they used to make judgments; and 2) their agreement with the selected status and trend ratings. The evidence and agreement ratings were then combined to determine the overall confidence ratings, as described in the table below.

Step 1: Rate Evidence
Consider three categories of evidence typically used to make status or trend ratings: (1.) data,(2.) published information and(3.) personal experience.

Evidence Scores		
Limited	**Medium**	**Robust**
Limited data or published information, and little or no substantive personal experience.	Data available, some peer reviewed published information, or direct personal experience.	Considerable data, extensive record of publication, or extensive personal experience.

Step 2: Rate Agreement
Rate agreement among those participating in determining the status and trend rating, or if possible, within the broader scientific community. Levels of agreement can be characterized as *"low," "medium"* or *"high."*

Step 3: Rate Confidence
Using the matrix below, combine ratings for both evidence and agreement to identify a level of confidence. Levels of confidence can be characterized as *"very low," "low," "medium," "high" or "very high."*

Agreement →			
	"Medium" High agreement Limited evidence	*"High"* High agreement Medium evidence	*"Very High"* High agreement Robust evidence
	"Low" Medium Agreement Limited evidence	*"Medium"* Medium agreement Medium evidence	*"High"* Medium agreement Robust evidence
	"Very Low" Low agreement Limited evidence	*"Low"* Low agreement Medium evidence	*"Medium"* Low agreement Robust evidence

Evidence (type, amount, quality, consistency) →

An initial draft of the report, written by ONMS, summarized the new information, expert opinions, and level of confidence expressed by the experts. Comments, data, and citations received from the experts were included, as appropriate, in text supporting the ratings and compiled in three appendices. This initial draft was made available to contributing experts and data providers, which allowed them to review the content and determine if the report accurately reflected their input, identify information gaps, provide comments, or suggest revisions to the ratings and text.

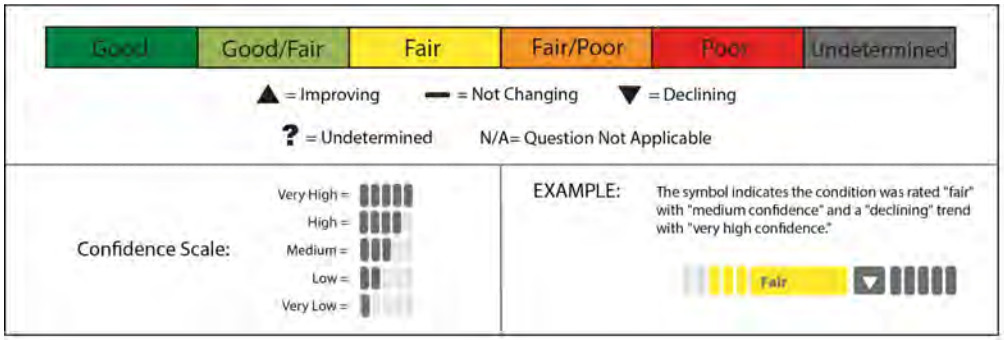
Following the expert review, the document was then sent to representatives of partner agencies, including BOEM, NPS, NMFS HQ, NMFS Regional Office, NMFS NWFSC, NMFS SWFSC, and the Channel Islands National Marine Sanctuary Advisory Council. These representatives were asked to review the technical merits of resource ratings and accompanying text, as well as to point out any omissions or factual errors. Upon receiving reviewer comments, ONMS revised the text and ratings, as appropriate.

In January 2018, a draft final report was sent to three regional science experts for a required External Peer Review. In December 2004, External Peer Review became a requirement when the White House Office of Management and Budget (OMB) issued a Final Information Quality Bulletin for Peer Review (OMB Bulletin) that established peer review standards to enhance the quality and credibility of the federal government's scientific information. Along with other information, these standards apply to "Influential Scientific Information," which is information that can reasonably be determined to have a "clear and substantial impact on important public policies or private sector decisions." Condition reports are considered Influential Scientific Information. For this reason, these reports are subject to the review requirements of both the Information Quality Act and the OMB Bulletin guidelines; therefore, every condition report is reviewed by a minimum of three individuals who are considered to be experts in their field, were not involved in the development of the report, and are not ONMS employees. Comments and recommendations of the peer reviewers were considered and incorporated, as appropriate, into the final text of this report. Furthermore, OMB Bulletin guidelines require that reviewer comments, names, and affiliations be posted on the agency website, http://www.cio.noaa.gov/. Reviewer comments, however, are not attributed to specific individuals. Comments by the External Peer Reviewers are posted at the same time as the formatted final document.

In all steps of the review process, experts were asked to review the technical merits of resource ratings and accompanying text, as well as to point out any omissions or factual errors; however, the interpretation, ratings, and text in the condition report were the responsibility of and received final approval by ONMS. To emphasize this important point, authorship of the report is attributed to ONMS subject matter experts are not authors, though their efforts and affiliations are acknowledged in the report.

Channel Islands National Marine Sanctuary

Confidence Ratings from May 31–June 1, 2016 Expert Workshop



Question	2016 Rating	Evidence *(limited, medium, or robust)*	Agreement *(low, medium, or high)*	Confidence *(very low, low, medium, high, or very high)*	Symbols *(combined rating and confidence)*	Notes
Drivers/Pressures						
Q2: What are the levels of human activities that may adversely influence water quality and how are they changing?	**Status: Good/Fair**	Medium	Medium	Medium		Activities exist that have potential to have measurable impacts to water quality (some widespread and persistent and some very localized and infrequent), but very limited data on significant impacts to water quality.
	Trend: Undetermined	Limited	High	Medium		Some activities increasing, some activities decreasing. No clear overall trend; need more data.
Q3: What are the levels of human activities that may	**Status: Fair**	Limited	High	Medium		Limited data on levels and distribution of various human activities.

adversely influence habitats and how are they changing?	**Trend: Undetermined**	Limited	High	Medium		Limited data on the various activities with potential to negatively impact habitat. Increasing levels of fishing take and gear impacts a concern. Information needed on boating activity, marine debris abundance.
Q4: What are the levels of human activities that may adversely influence living resource quality and how are they changing?	**Status: Fair**	Medium	Medium	Medium		Medium evidence because some data and publications available, but data needed on activity levels and impacts for many activities of concern. Medium agreement for status — 15 experts selected Fair and three selected Fair/Poor. High confidence in overall trend of Worsening due to increasing levels of some activities that negatively impact living resources.
	Trend: Worsening	Medium	High	High		
Water Quality						
Q6: What is the eutrophic condition of sanctuary waters and how is it changing?	**Status: Good**	Robust	High	Very High		Few/minor inputs of nutrients from island, mainland input does not reach/significantly influence CINMS.
	Trend: Not changing	Robust	High	Very High		
Q7: Do sanctuary waters pose risks to human health and how are they changing?	**Status: Good/Fair**	Limited	High	Medium		Good evidence for increased incidence of HABs, some evidence for high biotoxin levels in seafood (certain shellfish), limited reporting of human health impacts.
	Trend: Not changing	Limited	High	Medium		Though HABs/DA have increased in part due to high nutrient availability, no change in reporting human impacts.

Q8: Have recent, accelerated changes in climate altered water conditions and how are they changing?	**Status: Fair**	Medium	Medium	Medium		Compelling data available on the blob (and increased variability) and impacts to organisms but less information on the connection to climate change.
	Trend: Worsening	Medium	Medium	Medium		Blob caused the decline in conditions that led to impacts to living resources, but was the blob caused by climate change? Will the system recover or the decline continue?
Q9: Are other stressors, individually or in combination, affecting water quality, and how are they changing?	**Status: Undetermined**	Limited	High	Medium		Very limited information on some stressors of concern.
	Trend: Undetermined	Limited	High	Medium		Very limited information on some stressors of concern.
Habitat						
Q10: What is the integrity of major habitat types and how are they changing?	**Status: Fair**	Medium	High	High		No known change in relative abundance of physical benthic habitat. Some measurable loss in many components of biogenic habitat (principally in the east). Some impacts to benthic habitat from fixed gear or other human activity.
	Trend: Worsening	Medium	High	High		Many components have short or long-term declining trend. Some components with severe decline (limited in spatial scale), a few with stable or increasing trend, declines principally in the east.

Q11: What are contaminant concentrations in sanctuary habitats and how are they changing?	**Status: Good/Fair**	Medium	High	High		Data on presence of some contaminants in sediments, mussels, bird shells, but no information on impacts.
	Trend: Not changing	Medium	High	High		Egg shell and mussels showed some decrease; sediment infauna and microplastics suggest there may be some increases, but more information needed.
Living Resources						
Q12: What is the status of keystone and foundation species and how is it changing?	**Status: Fair**	Robust	Medium	High		Robust evidence because peer-reviewed publications and long-term monitoring data available for many keystone and foundation species. Sea stars, fished species, forage at reduced abundances from historic levels and declines observed during the 2009–2016 time period; however these may be within normal variability for some species. Medium agreement because 12 experts selected Fair and four selected Fair/Poor.
	Trend: Worsening	Robust	Medium	High		
Q13: What is the status of other focal species and how is it changing?	**Status: Fair**	Robust	High	Very High		Robust evidence because peer-reviewed publications and long-term monitoring data available for many focal species. Very High agreement on Fair status rating because harvested species and some seabirds and marine mammals are reduced compared to historic levels. Overall trend was Undetermined due to mixed trends across all focal species; some
	Trend: Undetermined	Robust	High	Very High		

						declining, others stable or increasing.
Q14: What is the status of non-indigenous species and how is it changing?	**Status: Fair**	Medium	Medium	Medium		High agreement of a worsening trend based on Robust evidence that *Sargassum horneri* is increasing in abundance and spreading to new sites. Less evidence on ecological impacts of *S. horneri*; evidence rated Medium by five experts and Limited by four experts. 'Medium' agreement because 14 experts selected Fair, two selected Fair/Poor, and one selected Good/Fair.
	Trend: Worsening	Robust	High	Very High		
Q15: What is the status of biodiversity and how is it changing?	**Status: Fair**	Medium	Medium	Medium		Medium evidence because robust data of some population declines/losses, but limited evidence of ecological impacts from these changes. Agreement Medium: 14 experts selected Fair and five selected Good/Fair. High agreement on overall trend of Undetermined due to shallow habitats, deep habitats, and pelagic habitats having different trends.
	Trend: Undetermined	Medium	High	High		

APPENDIX C:
Driving Forces and Pressures Tables and Graphs

Table App.C.1.1. Summary of the tables and figures that were considered by the Office of National Marine Sanctuaries socioeconomists when determining the status and trend rating for Question 1: *What are the states of influential human drivers and how are they changing?*

Driver	Source	Table/Figure #	Summary
Population	Woods & Poole, 2016	Table C.1.2	Population is expected to continue to increase throughout the sanctuary region.
Population	Woods & Poole, 2016	Figure C.1.1	Population is expected to continue to increase throughout the sanctuary region.
Real Per Capita Income	Woods & Poole, 2016	Table C.1.3	Per capita income is expceted to increase through 2030 at a rate higher than California and the US.
Real Per Capita Income	Woods & Poole, 2016	Figure C.1.2	Per capita income is expceted to increase through 2030 at a rate higher than California and the US.
Population & Real Per Captia Income Growth Rates	Woods & Poole, 2016	Table C.1.4	Population growth rates in the 3-county study area are lower than the state or the country both historically and for future projections. The real per capita income growth rates was higher in the 3-county area historically, but are similar to the state and the country for 2015-2030.
GDP per Capita in China	Trading Economics, 2017	Table C1.5	GDP per capita has been increasing annually and is forecasted to continue to increase through 2020. China is a large source of demand for sanctuary fishery resources.
TEU Shipping and Forecasts	Mercator Transport Group, 2005	Table C.1.6	From 2010-2020 the TEU's are growing at a 5.5% growth rates and from 2020-2030 growth rates are forecasted to be 4.7%
Average Reatail Gasoline Prices	US EIA, 2017	Figure C.1.3	Retail gasoline prices have been decreaseing from 2012-2016 and are expected to remain stable through 2018.
Renewable Energy Supply	US EIA, 2017	Table C.1.7	Most renewable energies have seen positive growth rates since 2009. Wind and solar energy have experienced the largest growth rates from 1009 to 2018.
Channel Islands Park Visitation	NPS, 2017	Table C.1.8	The number of visitors on boat has declined from 2000-2016 and the number of visitors ashore has more than doubled since 2000.
Channel Islands Park Visitation	NPS, 2017	Figure C.1.4	The number of visitors on boat has declined from 2000-2016 and the number of visitors ashore has more than doubled since 2000.

Table App.C.1.2. Population in the U.S., California, and Three-county Study Area from 1990 to 2030 (in 1,000s). Data source: Woods and Poole 2016

	U.S.	California	3-County Area
1990	249,623	29,960	9,919
2000	282,162	33,988	10,695
2010	309,347	37,334	11,076
2015	321,421	39,145	11,466
2020	336,383	41,135	11,852
2025	352,315	43,237	12,247
2030	368,644	45,376	12,630

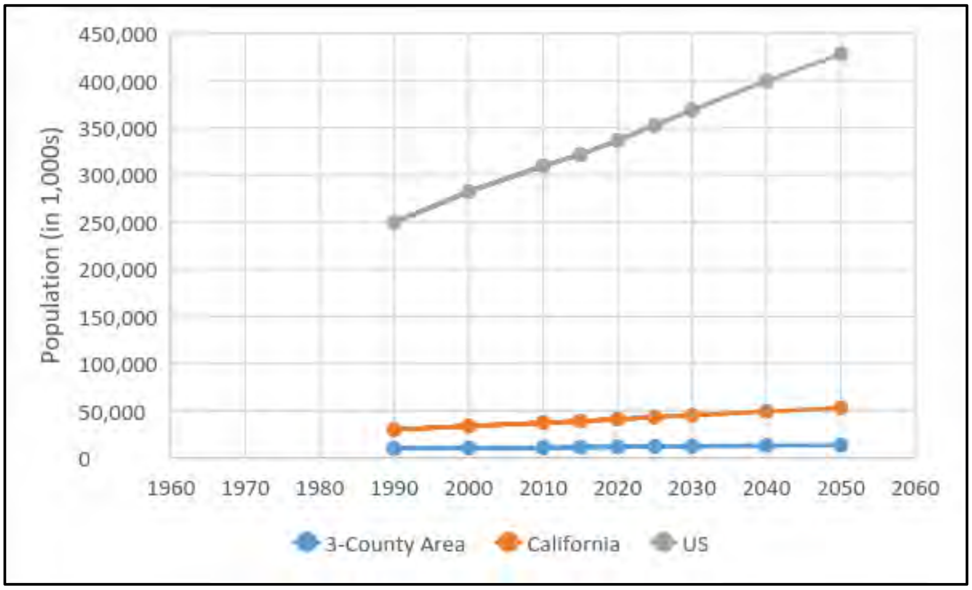


Figure App.C.1.1. Population in the U.S., California, and Three-county Study Area from 1990 to 2030 (in 1,000s). Data source: Woods and Poole 2016

Table App.C.1.3. Real Per Capita Income (2017 $) for the U.S., California, and the Three-county Study Area. Data source: Woods and Poole 2016

	U.S.	California	3-County Area
1990	$ 33,282	$36,121	$35,572
2000	$ 42,152	$45,533	$40,730
2010	$ 45,344	$48,765	$48,952
2015	$ 50,267	$56,149	$56,005
2020	$ 54,220	$60,143	$60,305
2025	$ 58,311	$64,360	$64,965
2030	$ 62,186	$68,358	$69,493

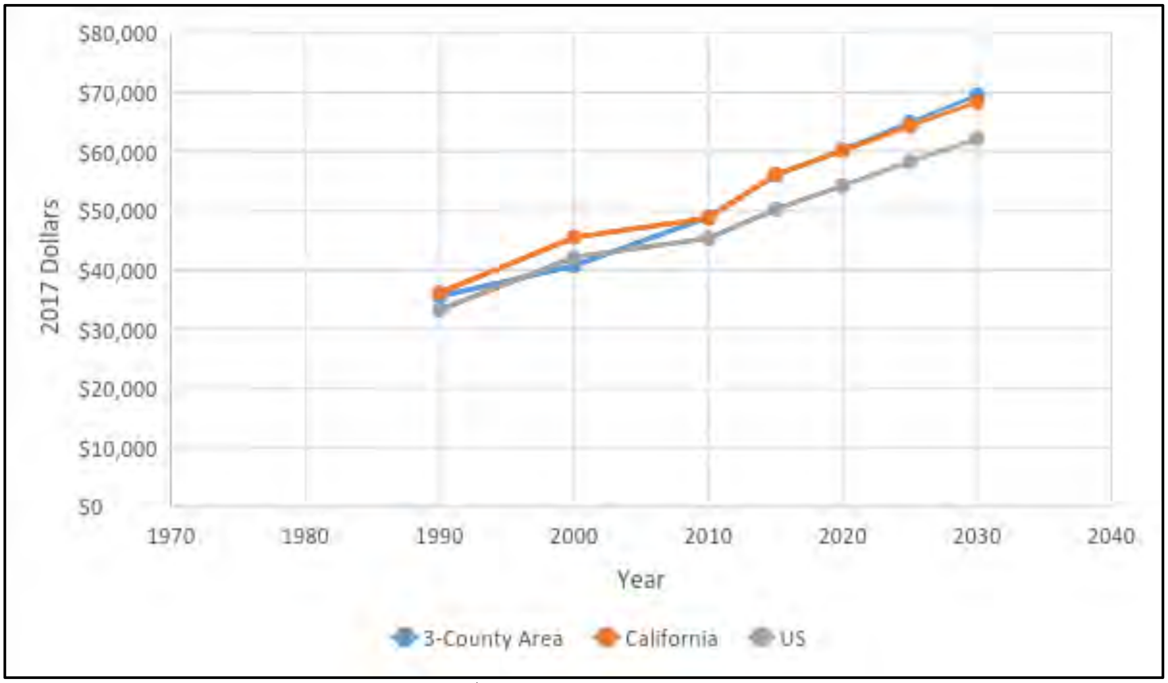


Figure App.C.1.2. Real Per Capita Income (2017$) for the U.S., California, and the Three-county Study Area. Data source: Woods and Poole 2016

Table App.C.1.4. Population and Real Per Capita Income Average Annual Growth Rates for the U.S., California, and the Three-county Study Area from 2000 to 2030. Data source: Woods and Poole 2016

Measure/Years	U.S.	California	3-County Area
Population			
Historical			
2000 to 2015	0.9%	1.0%	0.5%
Forecasted			
2015 to 2030	1.0%	1.1%	0.7%
Real Per Capita Income (2017$)*			
Historical			
2000 to 2015	1.3%	1.6%	2.5%
Forecasted			
2015 to 2030	1.6%	1.5%	1.6%

*Real Per Capita Income is converted to 2017 dollars using the Consumer Price Index.

Table App.C.1.5. Gross Domestic Product Per Capita for China from 2008 to 2020 (2008 $).
Data source: Trading Economics 2017

Year	GDP Per Capita*
Historical	
2008	$7,948
2009	$8,652
2010	$9,526
2011	$10,384
2012	$11,146
2013	$11,951
2014	$12,759
2015	$13,570
2016	$14,401
Forecasted	
2017	$14,520
2018	$15,300
2020	$18,450

*GDP Per Capita is converted to Purchasing Power Parity or the amount of equivalent purchasing power in U.S. 2008 dollars.

Table App.C.1.6. Twenty Foot Equivalent (TEU) Shipping and Forecasts.
Data source: Mercator Transport Group 2005

Years	TEUs
Baseline 2005	13,983
2010	12,814
2015	16,959
2020	21,827
2030	34,563
Growth Rates	
2010 to 2020	5.50%
2020 to 2030	4.70%

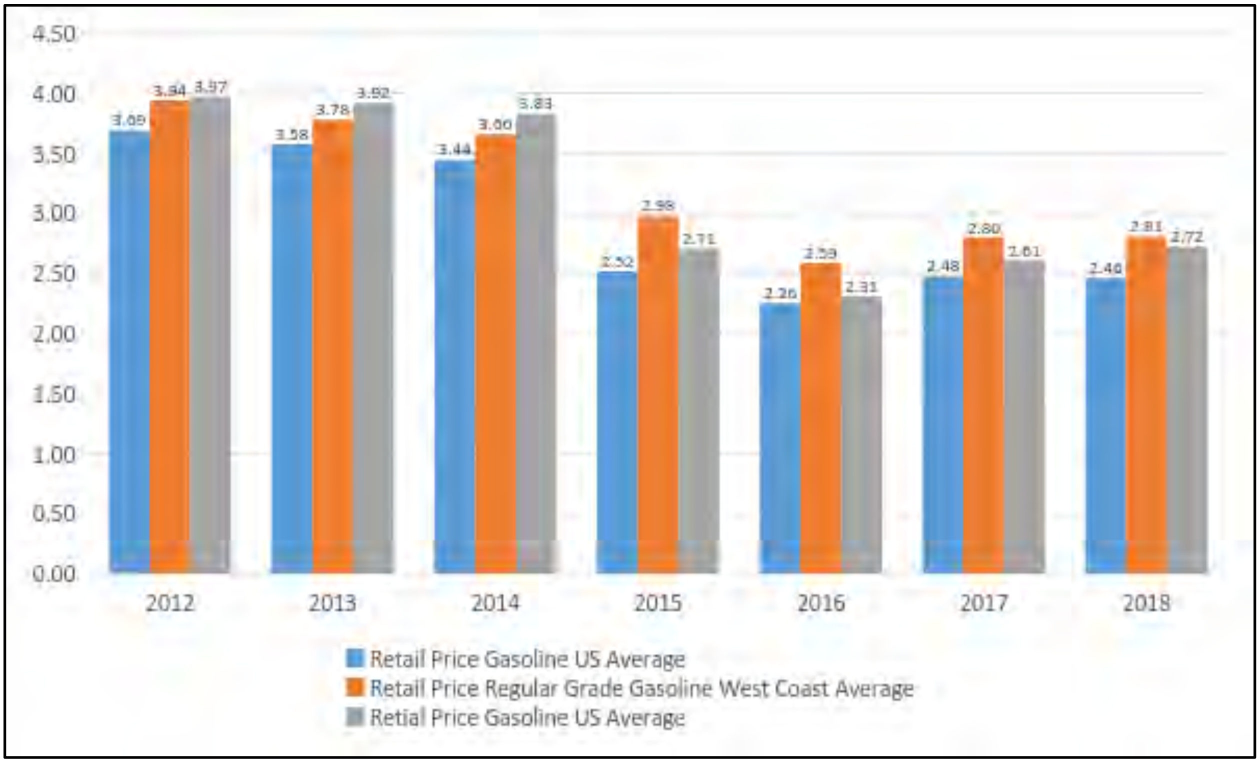


Figure App.C.1.3. Average Retail gas prices for the U.S. and West Coast from 2012 to 2018. Figure: U.S. Energy Information Administration 2017a

Table App.C.1.7. Renewable energy supply in U.S. from 2009 to 2018. Table: U.S. Energy Information Administration 2017b

U.S. Renewable Energy Supply (Quadrillion Btu)											
Energy Source	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**Growth Rate 2009-2018**
Hydropower	2.67	2.54	3.10	2.63	2.56	2.47	2.32	2.48	2.78	2.50	-6.3%
Wood biomass	1.93	1.98	2.01	2.01	2.17	2.24	2.07	1.96	1.96	1.95	1.2%
Liquid biofuels	0.97	1.14	1.27	1.22	1.27	1.34	1.38	1.46	1.50	1.53	57.7%
Wind power	0.72	0.92	1.17	1.34	1.60	1.73	1.78	2.11	2.30	2.41	234.5%
Other biomass	0.45	0.47	0.46	0.47	0.50	0.52	0.52	0.52	0.52	0.52	15.9%
Geothermal	0.20	0.21	0.21	0.21	0.21	0.21	0.21	0.23	0.23	0.24	18.0%
Solar	0.08	0.09	0.11	0.16	0.23	0.34	0.43	0.59	0.79	0.92	1087.8%
Total	7.02	7.35	8.34	8.03	8.54	8.71	8.85	9.35	10.08	10.08	43.5%

Table App.C.1.8. Visitation estimates for Channel Islands National Park, Visitors Ashore and Boats from 2000 to 2016. Data source: National Park Service (NPS 2017)

Year	Visitors on Boat	Visitors Ashore
2000	168,387	41,486
2001	152,556	43,817
2002	253,298	55,237
2003	191,332	62,249
2004	165,199	81,501
2005	153,029	64,640
2006	123,219	59,400
2007	105,247	58,794
2008	64,755	67,990
2009	74,348	70,306
2010	14,443	58,522
2011	15,305	50,953
2012	14,750	68,816
2013	17,232	77,359
2014	59,277	81,103
2015	43,904	85,168
2016	44,330	86,693

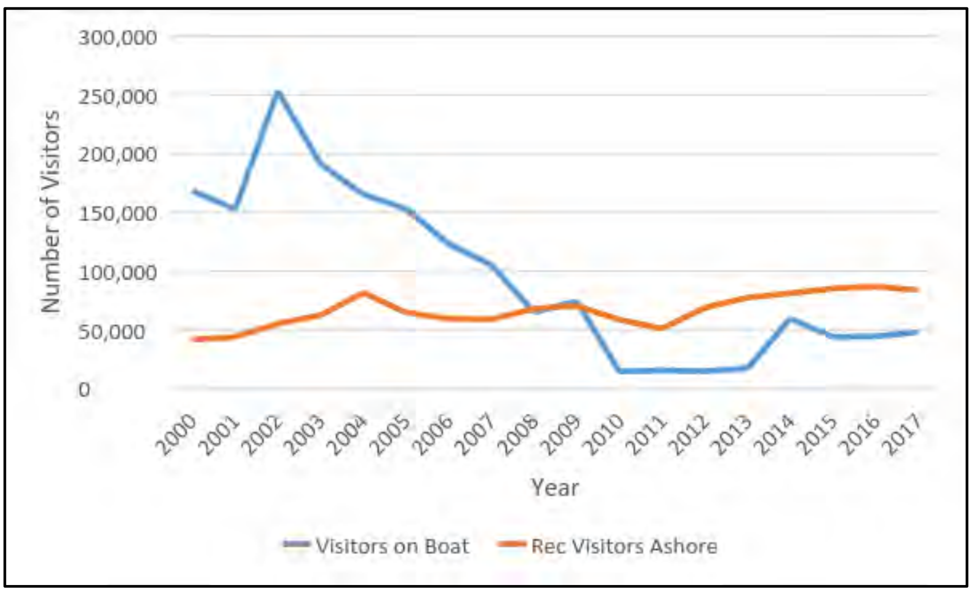


Figure App.C.1.4. Visitors ashore and by boat in Channel Islands National Park from 2000 to 2016. Data source: National Park Service (NPS 2017)

2. What are the levels of human activities that may adversely influence water quality and how are they changing?

Table App.C.2.1. Data presented to water quality experts at the May 31, 2016 workshop to update status and trend assessments for Channel Islands National Marine Sanctuary (CINMS).

**Denotes graphs that were unavailable for expert review during the workshop; however a representative from the monitoring program was present at the workshop and discussed the data.

Oil Spills From Offshore Platforms	Source	Figure #	Data Summary
Volumes of naturally seeped oil (bbl), and small spills at offshore platforms and tankers.	BSEE BOEM	App.C.2.1–C.2.2, Tables App.C.2.2–C.2.3, see Appendix C:C4.15	Status: Spills from platforms are few and less volume than natural seeps, but have more dramatic impacts on water quality when they occur. Trend: Spill frequency and volume has generally decreased, apart from the 2015 Refugio Oil Spill.
Refugio Oil Spill			
Simulated oil trajectories	B. Emery and L. Washburn, UCSB	App.C.2.3–C.2.5	Status: Effects of this and other spills will be revisited in later condition reports. Refugio spill-related information was not available for assessment at the time of the expert workshop. Trend: Data limited; however ecosystem appears to be in recovery.
Ocean Noise			
Sound spectrum (Hz) — ships	McKenna et al. 2012, 2013, 2015; Redfern et al. 2017; NOAA	App.C.2.6–C2.8, see Appendix C: C4.12–C4.13	Status: Ship noise decreased after the economic recession and air quality control rules. They have since increased, but levels are still lower than prior to the recession. Other sources of noise should also be quantified. Trend: Ocean noise continues to increase with increases in human activities.

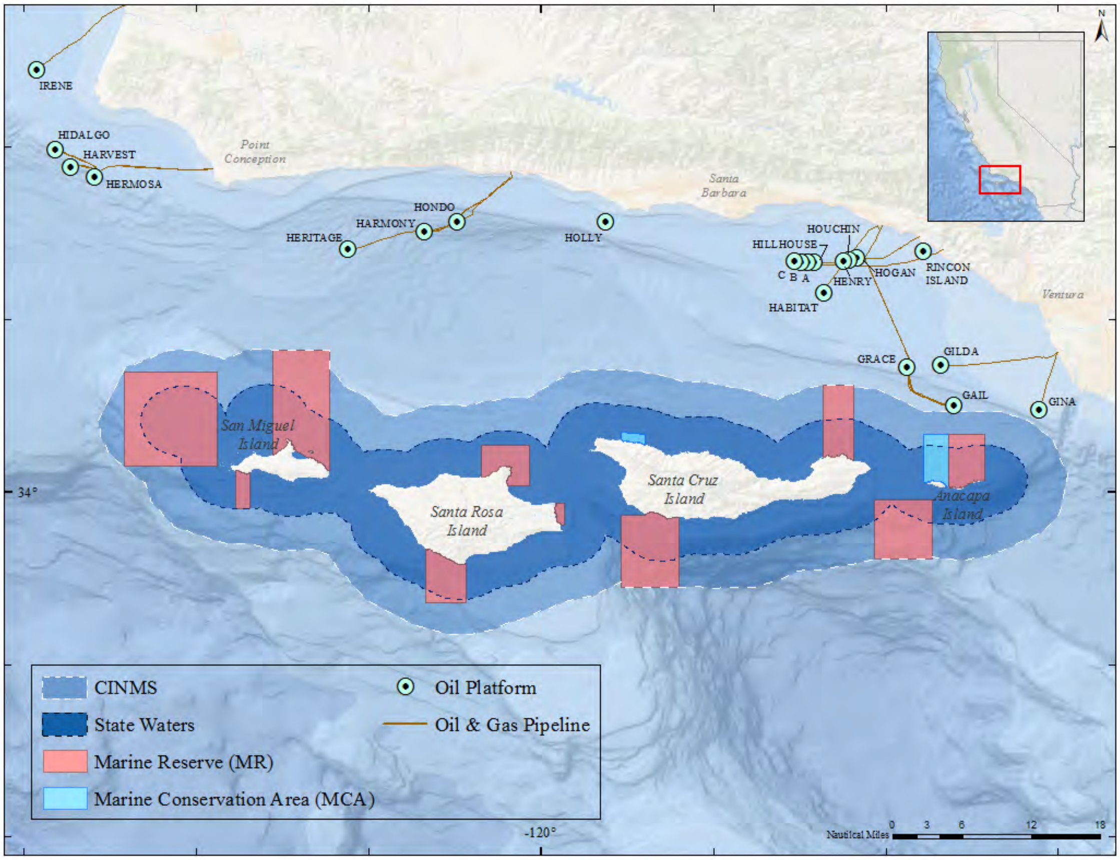


Figure App.C.2.1. Map of offshore oil platforms within the Santa Barbara Channel, from west to east: Hondo, Harmony, Heritage, Holly, C, B, A, Hillhouse, Habitat, Henry, Houchin, Hogan, Rincon Island, Grace, Gilda, Gail, and Gina. Data source: State of California GeoPortal; Map: M. Cajandig/NOAA

Oil and gas industry[1] in Pacific OCS Region		
Year	Annual volume (bbl) oil spilled	Cumulative volume (bbl) since 1982
1982	6	6
1983	14	20
1984	41	61
1985	18	79
1986	18	96
1987	19	115
1988	6	121
1989	12	133
1990	104	237
1991	66	303
1992	1	304
1993	1	304
1994	83	388
1995	2	390
1996	156	546
1997	166	712
1998	1	713
1999	11	724
2000	1	725
2001	2	727
2002	10	737
2003	1	738
2004	1	739
2005	3	742
2006	2	744
2007	2	746
2008	28	775
2009	1	776
2010	1	776
2011	<1	776
2012	36	812
2013	<1	812
2014	<1	813
2015	<1	813

Coal Oil Point natural oil and gas seep		
Year	Annual volume (150 bbl/day) oil released[2]	Cumulative volume (bbl) since 1982
1982	54,750	54,750
1983	54,750	109,500
1984	54,750	164,250
1985	54,750	219,000
1986	54,750	273,750
1987	54,750	328,500
1988	54,750	383,250
1989	54,750	438,000
1990	54,750	492,750
1991	54,750	547,500
1992	54,750	602,250
1993	54,750	657,000
1994	54,750	711,750
1995	54,750	766,500
1996	54,750	821,250
1997	54,750	876,000
1998	54,750	930,750
1999	54,750	985,500
2000	54,750	1,040,250
2001	54,750	1,095,000
2002	54,750	1,149,750
2003	54,750	1,204,500
2004	54,750	1,259,250
2005	54,750	1,314,000
2006	54,750	1,368,750
2007	54,750	1,423,500
2008	54,750	1,478,250
2009	54,750	1,533,000
2010	54,750	1,587,750
2011	54,750	1,642,500
2012	54,750	1,697,250
2013	54,750	1,752,000
2014	54,750	1,806,750
2015	54,750	1,861,500

Table App.C.2.2. Reported values for volume of oil (bbl) spilled (left panel) and seeped (right panel) annually from 1982 to 2015 across the Pacific Outer Continental Shelf (OCS) region (offshore Washington, Oregon and California). Cumulative oil spilled from industry is 0.04 percent of natural seepage from Coal Oil Point, or, the sum volume of 34 years of industry spills is equivalent to about five days of natural seepage. Data source: Left panel: Data from the Bureau of Safety and Environmental Enforcement. Volumes are rounded to the nearest barrel (bbl). Oil spill volumes do not include offshore accidents resulting from activities managed by the State of California. Right panel: Daily estimate of 150 to 170 bbl per day from Hornafius et al. 1999; Table: BOEM 2016

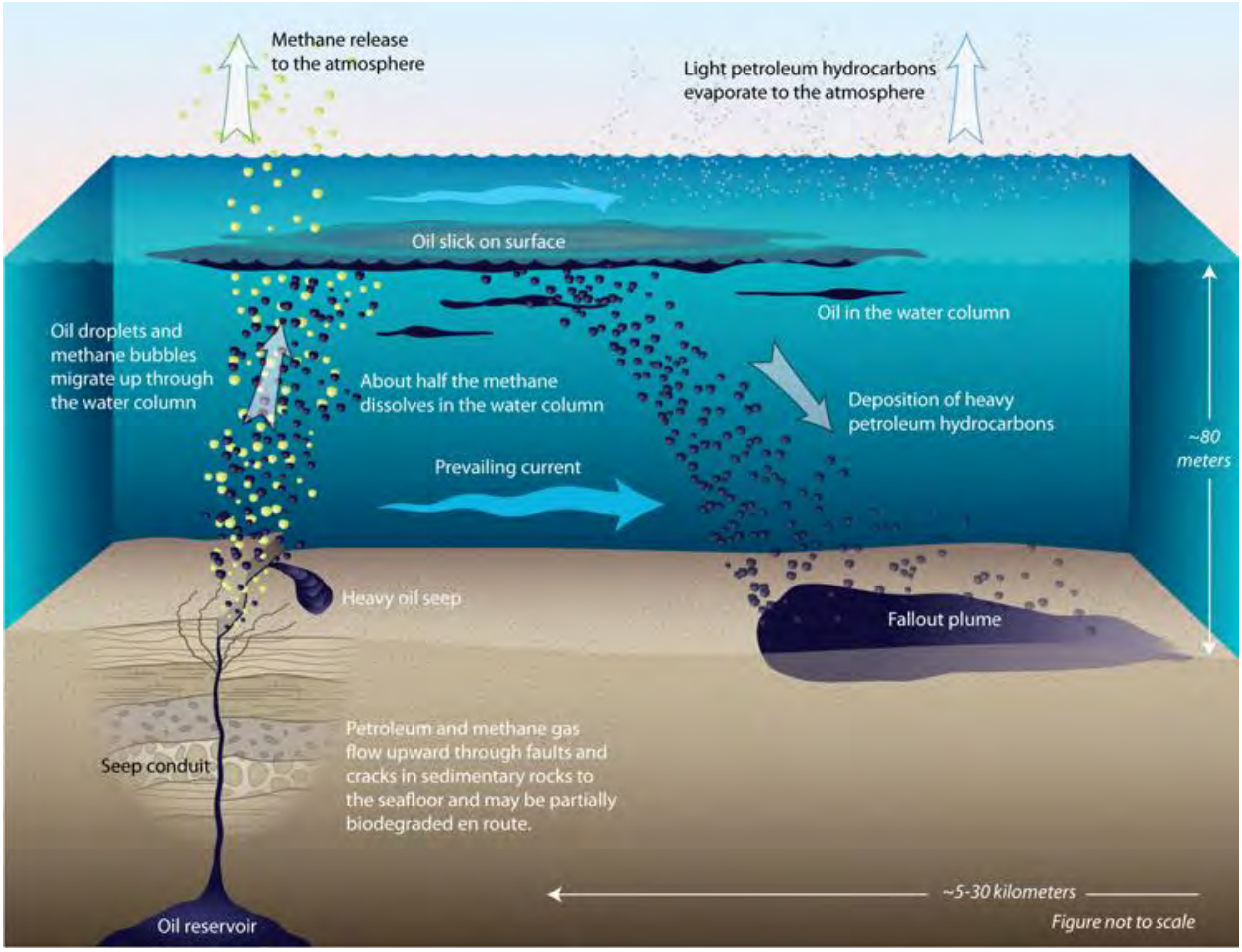


Figure App.C.2.2. About one-half of the oil in the ocean comes from natural oil seeps. In southern California, there are over 2,000 oil and natural gas seeps, the most active being south of Coal Oil Point. This illustration shows the route traveled by oil leaving the subseafloor reservoir as it travels through the water column to the surface and ultimately sinks and falls out in a plume shape onto the seafloor where it remains in the sediment. Figure: J. Cook/Woods Hole Oceanographic Institution 2009 (http://www.whoi.edu/main/topic/natural-oil-seeps)

Class	Chemical	No. of Samples	No. of Detects (%)	Median Concentration[a]	95th Percentile Concentration[b]
Phenol	Phenol	405	269 (66%)	9.7	313
Phenol	2,4-Dimethylphenol	136	70 (51%)	25.1	2341
PAH	High-MW PAHs[c]	449	13 (3%)	0.10	3.2
PAH	Naphthalene	146	78 (53%)	10.5	97
Metal	Arsenic	425	28 (7%)	0.975	14.5
Metal	Cadmium	425	29 (7%)	0.091	1.13
Metal	Chromium	421	114 (27%)	0.68	13.6
Metal	Copper	429	106 (25%)	1.25	21.4
Metal	Lead	425	44 (10%)	0.463	7.6
Metal	Mercury	4210	24 (6%)	0.0058	0.0687
Metal	Nickel	419	72 (17%)	2.47	49.2
Metal	Selenium	180	6 (3%)	0.51	4.5
Metal	Silver	412	43 (10%)	0.25	6.7
Metal	Zinc	419	165 (39%)	5.9	168
BTEX	Benzene	233	193 (83%)	93.5	1,346
BTEX	Ethylbenzene	198	152 (77%)	23	271
BTEX	Toluene	199	150 (75%)	127	1,586
	Cyanide	388	27 (7%)	1.3	6.4
	Ammonia (w/o Harmony)	187	136 (73%)	9,405	85,486
	Ammonia (Harmony)	47	47 (100%)	85,831	335,277
	Undissociated Sulfide	99	82 (83%)	653	5,684

[a] The median concentration is that concentration that half of the samples exceed and the other half are below.

[b] The 95th percentile concentration is the concentration below which 95% of all the measured concentrations fall.

[c] PAHs with high molecular weights.

Table App.C.2.3.** Concentrations (ug/L) of chemical constituents in produced water samples from platforms on the Pacific Outer Continental Shelf (OCS). Data source: MRS 2005; Table: BSEE and BOEM 2016

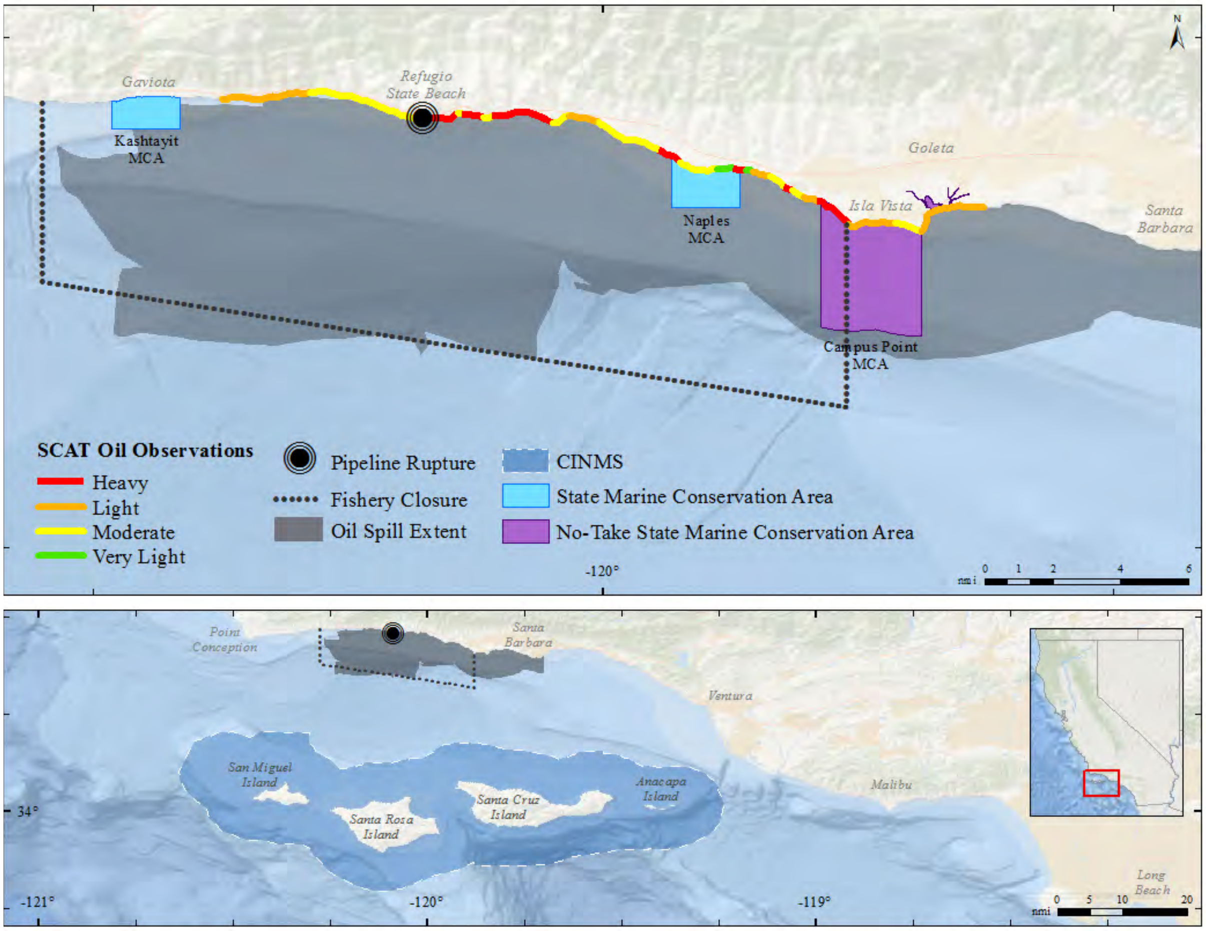


Figure App.C.2.3. Diagonal black lines cover the area where oil sheen was observed after the 2015 Refugio Oil Spill. The dark black line indicates the short-term fishery closures. See Figures C2.4 and C13.5 for the modeled oil transport, which predicts crude oil reaching sanctuary waters, Santa Rosa, and Santa Cruz islands north-facing beaches days after the spill.
Data source: Shoreline Cleanup and Assessment Technique (SCAT) Shoreline Oiling Map: http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources/shoreline-cleanup-and-assessment-technique-scat.html. Map: M. Cajandig/NOAA

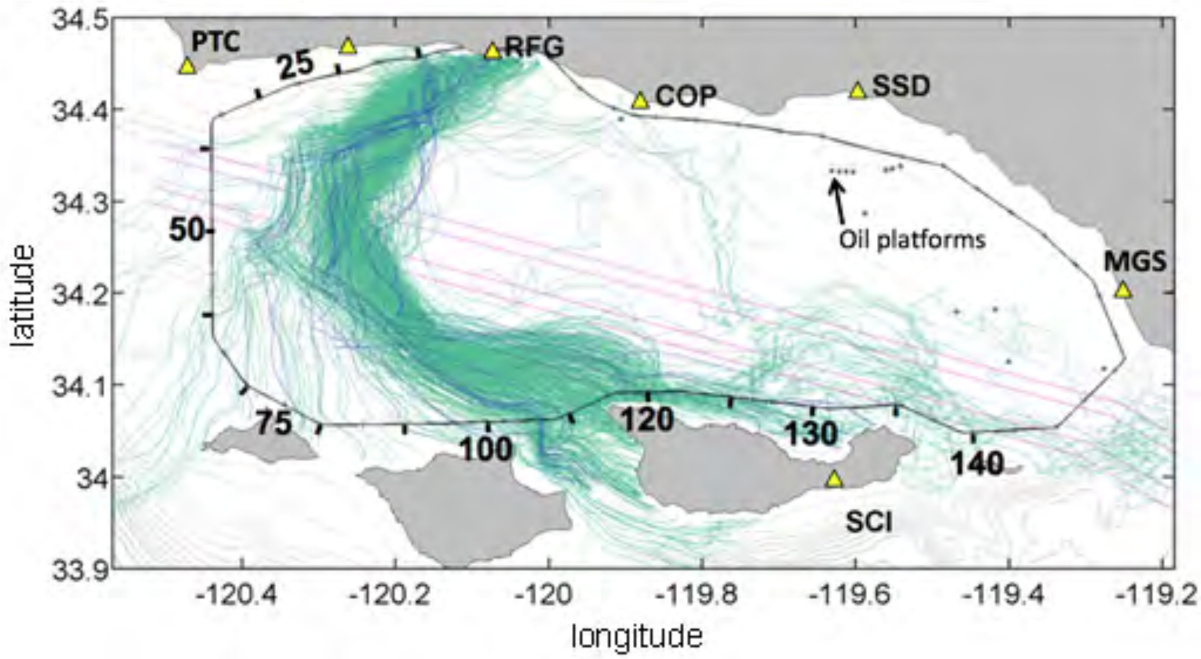


Figure App.C.2.4. Modeled oil trajectories based on high frequency (HF) radar and averaged sea surface current vectors during the month of May 2015 (green and blue lines). Yellow triangles represent SCCOOS HF Radar stations, and oil platforms are shown as small gray dots. The HF station at Gaviota was installed immediately after the spill to avoid local data gaps during this critical monitoring time period. It was only active for one and a half months. PTC = Point Conception; RFG = Refugio State Beach; COP = Coal Oil Point; SSD = Summerland Sanitary District; MGS = Mandalay Generating Station; SCI = Santa Cruz Island. Pink lines indicate commercial shipping lanes. The black line encircles the region of interest. Figure: B. Emery and L. Washburn/UCSB

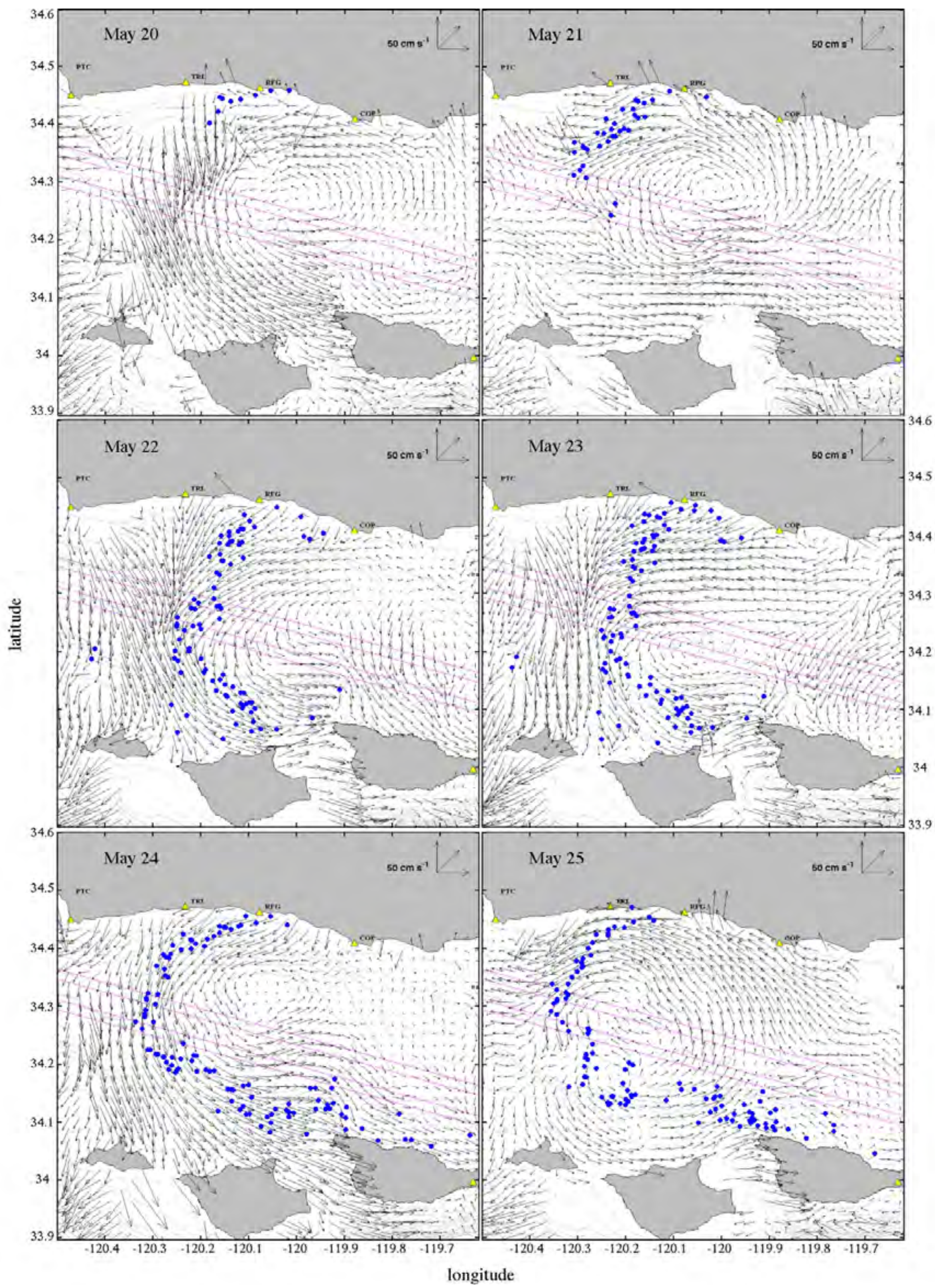


Figure App.C.2.5. Daily snapshots of oil transport simulations (blue dots) based on near-real time sea surface current direction and speeds (black arrows) from May 20 to 25, 2015, the days just after the Refugio oil spill. Yellow triangles represent SCCOOS high frequency radar (HFR) observation stations. PTC = Point Conception; RFG = Refugio State Beach; COP = Coal Oil Point. Not pictured is a HFR station at Gaviota, which was temporarily installed for one and half months following the spill (currently no longer active, see http://washburnlab.msi.ucsb.edu/mtu1) to address local data gaps. Not labeled is the yellow triangle/HFR station on Santa Cruz Island. Pink lines indicated commercial shipping lanes. The full oil transport model simulation can be viewed online: http://sccoos.org/about/news/2015-refugio-state-beach-oil-spill/. Source: SCCOOS: [http://sccoos.org/about/news/2015-refugio-state-beach-oil-spill/;](http://sccoos.org/about/news/2015-refugio-state-beach-oil-spill/) Figure: B. Emery and L. Washburn/UCSB

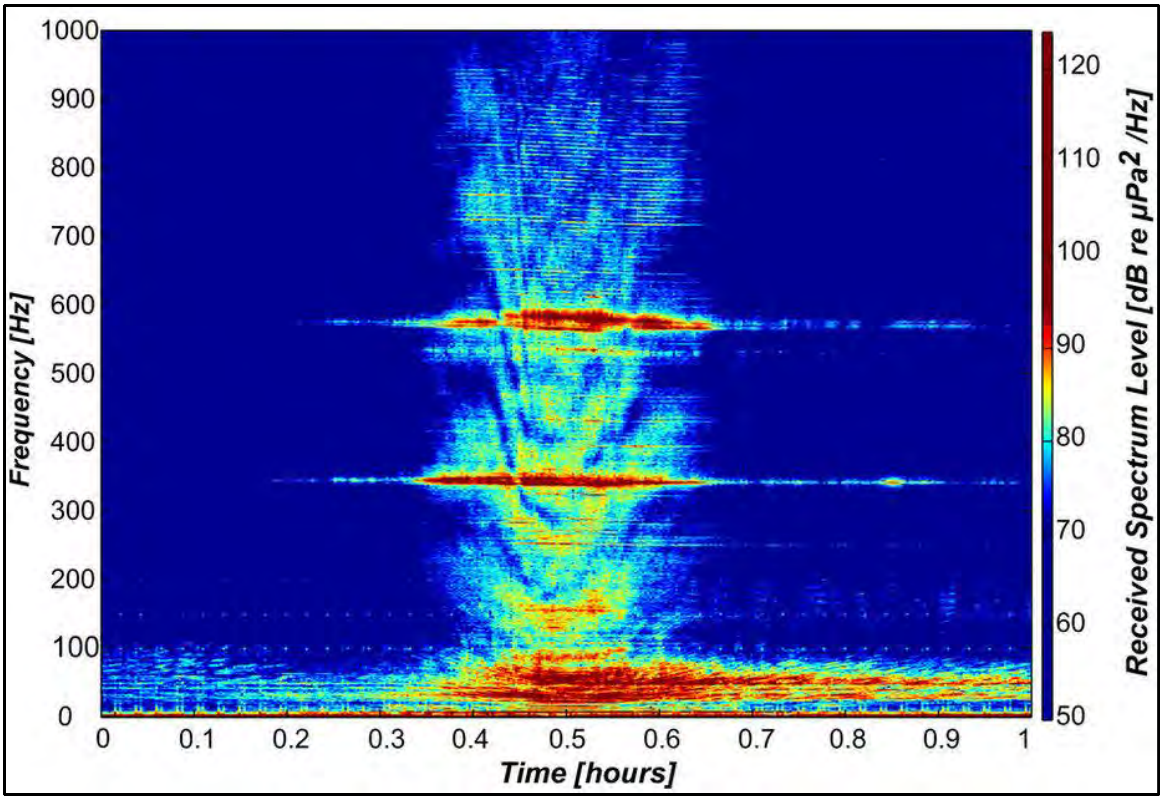


Figure App.C.2.6.** Spectrogram of received sound spectrum levels during a one-hour passage of a container ship through the Santa Barbara Channel. The spectrogram is centered on the closest point of approach (CPA) of the ship to the high-frequency acoustic recording package (HARP), a distance of 3 kilometers. The intense tones present at approximately 350 and 580 Hz are representative of the tones present in 10 percent of the container ships in the McKenna et al. 2013 study. Figure: McKenna et al. 2013

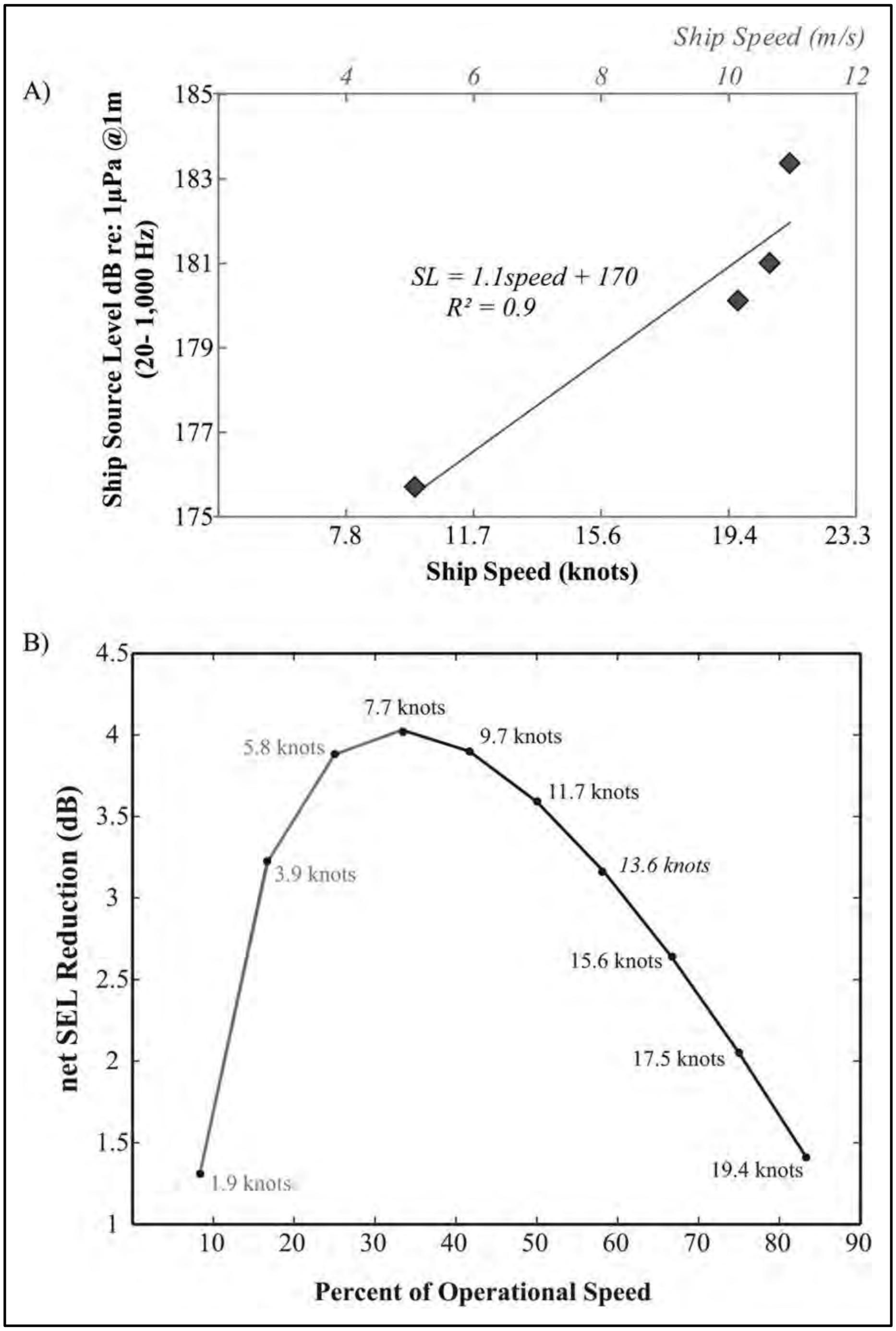


Figure App.C.2.7.** Relationship between container ship underwater noise levels and ship design, operational, and oceanographic conditions. (A) Relationship between broad-band SL and speed for a 294 meter container ship that transited the Santa Barbara Channel region on four separate days (10/17/2008, 11/21/2008, 04/10/2009, and 05/14/2009). Equation for the linear relationship and goodness of fit value (R2) are shown. (B) The net reduction in sound exposure level (SEL) for the container ship in (A) for different speeds. The derived curve is based on the relationship between source level (SL) and speed (A) and known operation speed of 12 meters per second (23.3 knots). The gray part of the curve indicates that these speeds are likely not possible for a container ship. Figure: McKenna et al. 2013

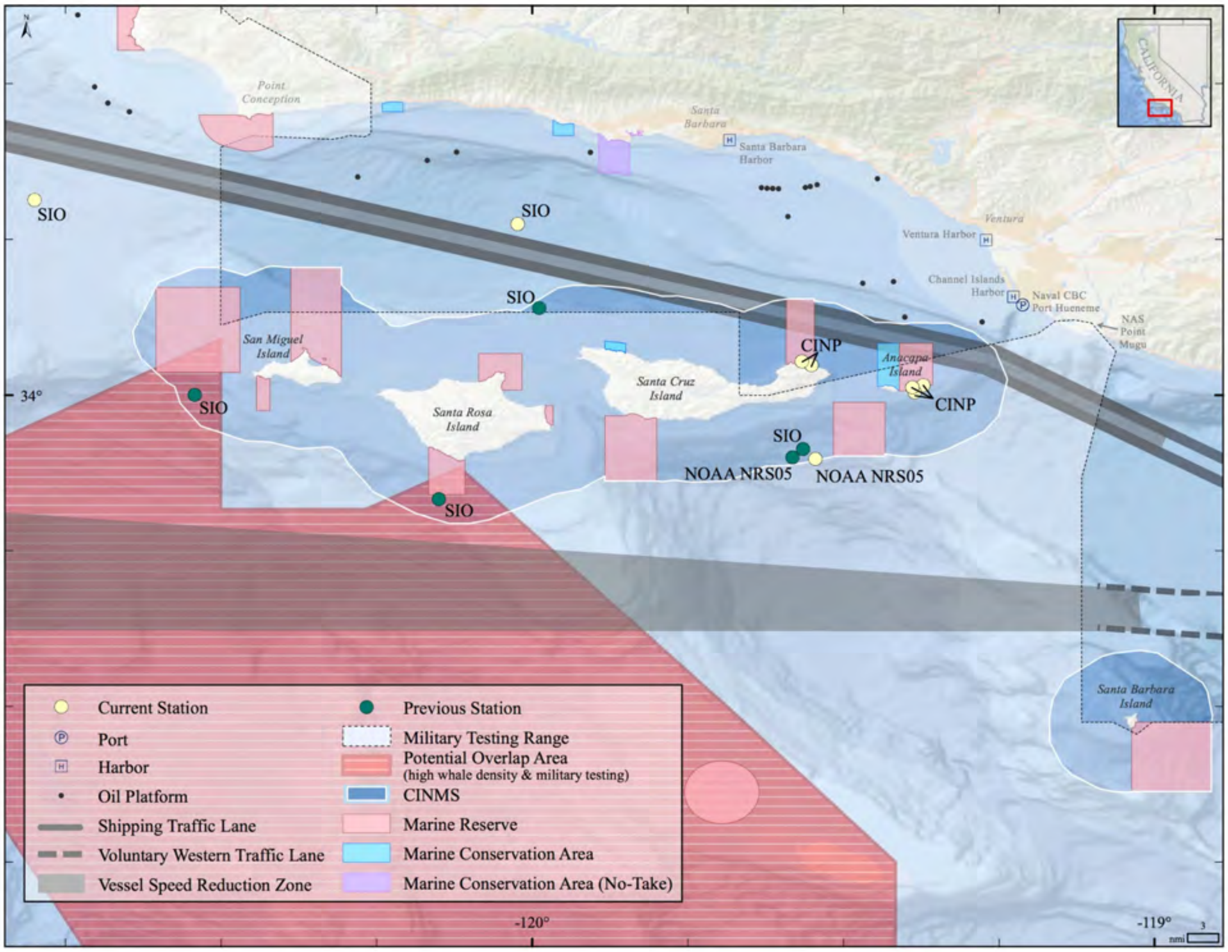


Figure App.C.2.8. Previous (green dots) and current (yellow dots) passive acoustic monitoring stations in and around CINMS are shown along with several sources of anthropogenic noise: ports and harbors, oil platforms, shipping lanes, and military testing zones. SIO = Scripps Institution of Oceanography; NOAA NRS = Noise Reference Station. Map: M. Cajandig/NOAA
Note: This is variant of a similar figure shown during the expert workshop.

3. What are the levels of human activity that may adversely influence habitats and how are they changing?

Table App.C.3.1. Data presented to the habitat experts at the workshop on June 1, 2016 to update status and trends assessments for Channel Islands National Marine Sanctuary (CINMS).

Indicator	Source	Figure #	Data Summary
Marine Debris — abundance	SeaDoc; Ocean Defenders; P. Etnoyer, NOS NCCOS; MARE	Table App.C.3.1–App.C.3.2	Status: Marine debris is present and persists despite cleanup efforts. Trend: Assumed to be increasing in abundance, but no time series data available.
Beach Debris	SB Adventure Co.	Table App.C.3.2	Status: Anecdotal evidence points to continual accumulation of beach trash. Trend: No scientific data available.
Vessel Groundings	CINMS and Vessel Assist	App.C.3.1	Status: Recent vessel groundings result in principally localized impacts. Trends: Recently there has been an increased number of grounding events
Fishing Activity — levels and spatial distribution	CDFW; P. Etnoyer, NOS NCCOS	App.C.3.2	Status: Fishing remains prevalent in sanctuary waters; however, shifting gear types change potential impacts. Trend: Declining net and trawl usage; increasing longline and traps usage.
Bottom Contact Gear — distance disturbed	CDFW; P. Etnoyer, NOS NCCOS	App.C.3.3–C.3.5	Status: Trawling effort has declined to minimal to no-effort levels,; however trap usage has become prevalent in CINMS. Trend: No trend data available.
Offshore Oil and Gas Activity	NMFS	App.C.3.6	Status: Oil and gas activity is currently far below the long- term mean. Trend: Oil and gas activity has been relatively stable over the past several years.
Annual Visitation to Frenchy's Cove, Anacapa Island	NPS	App.C.3.7	Status: Recent data for Frenchy's Cove is not available since 2014 at the time of the workshop; but at that time visitation to Frenchy's Cove was at its lowest point since 1993. Trend: Decreasing as of 2014; however, visitation is thought to have increased since then.

Table App.C.3.1. Between 2009 and 2013, SeaDoc's California Lost Fishing Gear Recovery Project collected more than 33,890 pounds of gear over 58 days from the seafloor within Channel Islands National Marine Sanctuary and nearby regions. Areas within the sanctuary are presented in bold: **AI = Anacapa Island, SBI = Santa Barbara Island, SCI = Santa Cruz Island, SRI = Santa Rosa Island, CINMS = Channel Islands National Marine Sanctuary (location not specified)**. Areas outside of the sanctuary are left unbolded: VCo = Ventura coast. SBCo = Santa Barbara coast, Oxn = Oxnard, SCleml = San Clemente Island, Mal = Malibu, Cat = Catalina Island. Data source: SeaDoc California Lost Fishing Gear Recovery Project Summaries

Cruise Location	Dates	Total days	Lobster traps	Trap frames	Nets	Other commercial gear	Misc.	# items removed	Weight (lbs)	Pounds/day	Notes
AI	5/12/2009–5/14/2009	3	70	16	0	2	5	92	5110	1700	
SBI, SCI	6/8/2009–6/10/2009	3	30	2	2	0	1	35	2200	730	
SBI, SCI	11/29/2009–12/1/2009	3	1	0	5	0	2	8	1620	540	
AI, SRI, SCI	4/20/2010–4/23/2010	2	28	10	0	2	2	42	760	380	
CINMS & SBCo	4/27/2011–5/6/2011	9	22	23	1	0	7	53	3250	361	
SRI, Mal, Oxn, VCo	10/24/2011–10/28/2011	5	5	0	9	0	0	14	1850	370	
CINMS & SBCo	3/31/2012–4/12/2012	9	93	58	4	2	20	177	6600	733	
SBI, SCI, AI, VCo, Catalina	5/14/2012–5/26/2012	9	33	0	3	1	6	13	3000	333	18 traps, 1 net, 1 misc. in CINMS
SCI, VCo, LACo, SCleml, Cat	9/10/2012–9/21/2012	9	0	0	10	0	0	10	7400	822	4/10 nets in CINMS
CINMS & SBCo	4/3/2013–4/13/2013	6	39	11	0	14	3	67	2100	350	3853' of line
TOTAL		**58**	**321**	**120**	**34**	**21**	**46**	**511**	**33890**		

Table App.C.3.2. Two other cleanup efforts, Ocean Defenders Alliance Operation Deep Sweep and a partnership between Channel Keeper, SB Adventure Co, Island Packers, and various other groups, conducted debris cleanups within Channel Islands National Marine Sanctuary. In three trips, Ocean Defenders collected various lost fishing gear from the seafloor at Frenchy's Cove, Anacapa Island. In a one day beach cleanup on February 26, 2015 at Yellowbanks, Santa Cruz Island, volunteers in the partnership effort collected over 1,300 p of trash and derelict fishing gear. Data source: Ocean Defenders Alliance Operation Deep Sweep pounds SB Adventure Co.

Group	Location	Squid net	Lobster traps	Polypro-pylene line	Misc trash and other fishing gear	Weight	Pounds/ day	Notes
Ocean Defenders Alliance	Frenchy's Cove, AI	900 lbs	5	400'		900+		3 trips
Channel Keeper, SB Adventure Co., Island Packers & others	Yellowbanks, SCI				1300	1300	1300	Beach debris; 1 day; Feb 2015

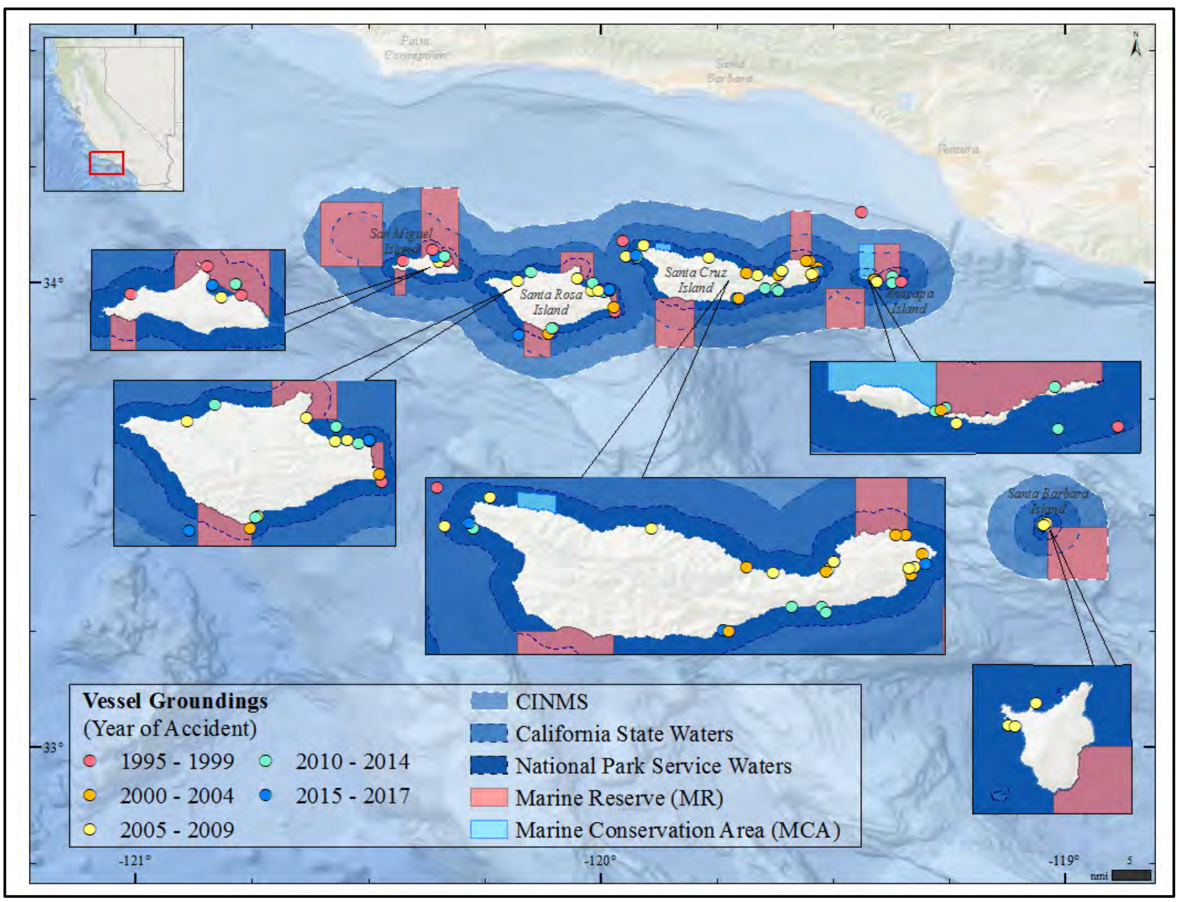


Figure App.C.3.1. Reported vessel grounding locations from 1999 to 2016 are shown in the map above. Not all groundings in the CINMS database are included as coordinates are unavailable for some grounding events. Data source: Vessel Assist; Map: M. Cajandig/NOAA

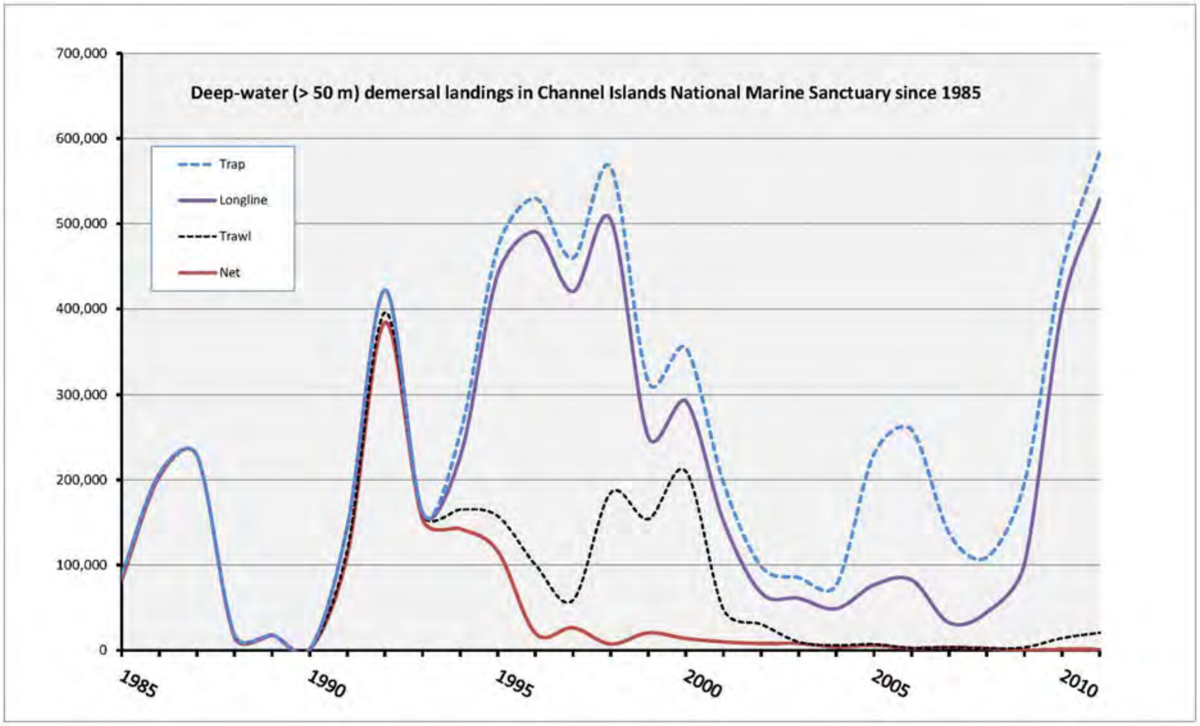


Figure App.C.3.2. Landings (in pounds) and the relative contribution of gear types has changed over time due to changing regulations, economics, and consumer demand. Since 2002, there is zero to minimal set net and trawl landings, and reduced landings for bottom longlines and traps until 2008, followed by a dramatic increase in bottom longline and trap landings to peak levels. Data source: CDFW; Figure: P. Etnoyer/NOAA

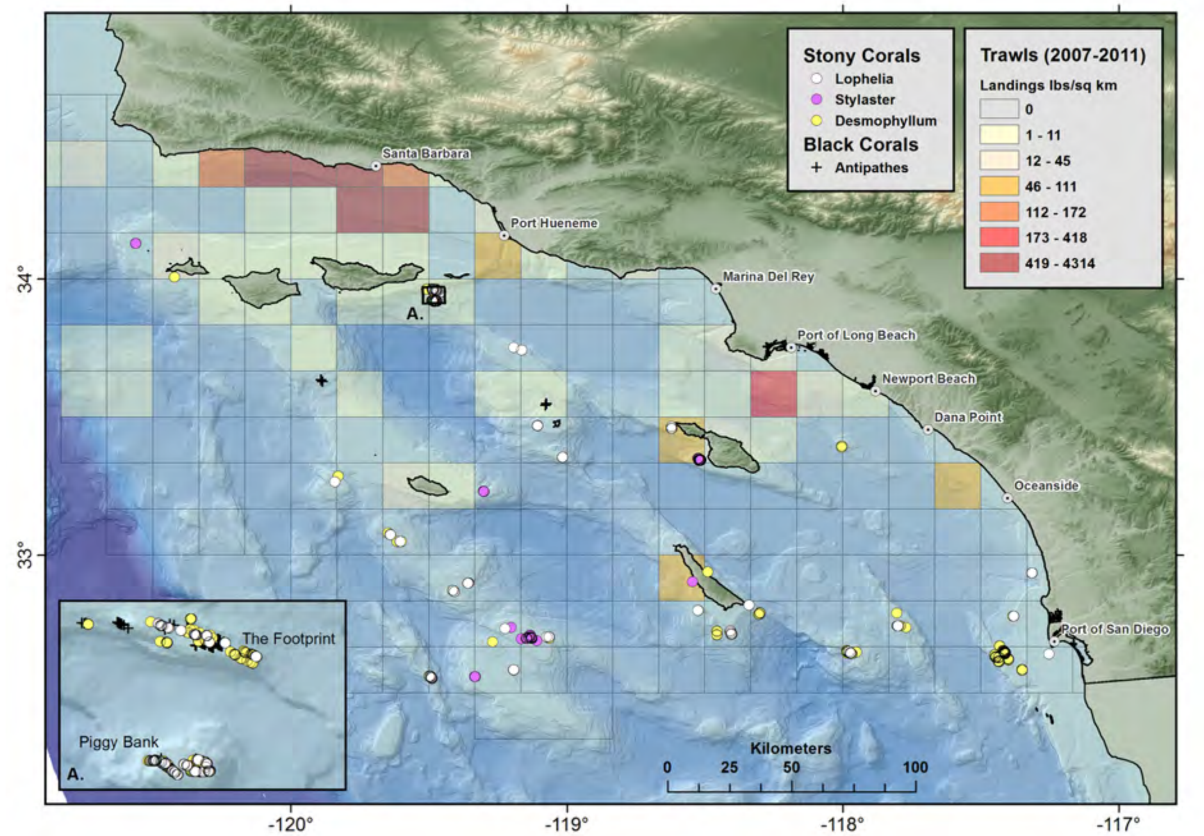


Figure App.C.3.3. Trawling landings across the Southern California Bight, as illustrated by CDFW 10 square kilometer blocks and shown along with known locations of stony deep-water corals. Trawling is known to disturb bottom habitats and deep-sea corals. Even though trawling effort has decreased in recent years, the impacts of this gear type can be long lived.
Data source: CDFW, Perry et al 2010; Map: P. Etnoyer/NOAA, Etnoyer et al. 2015

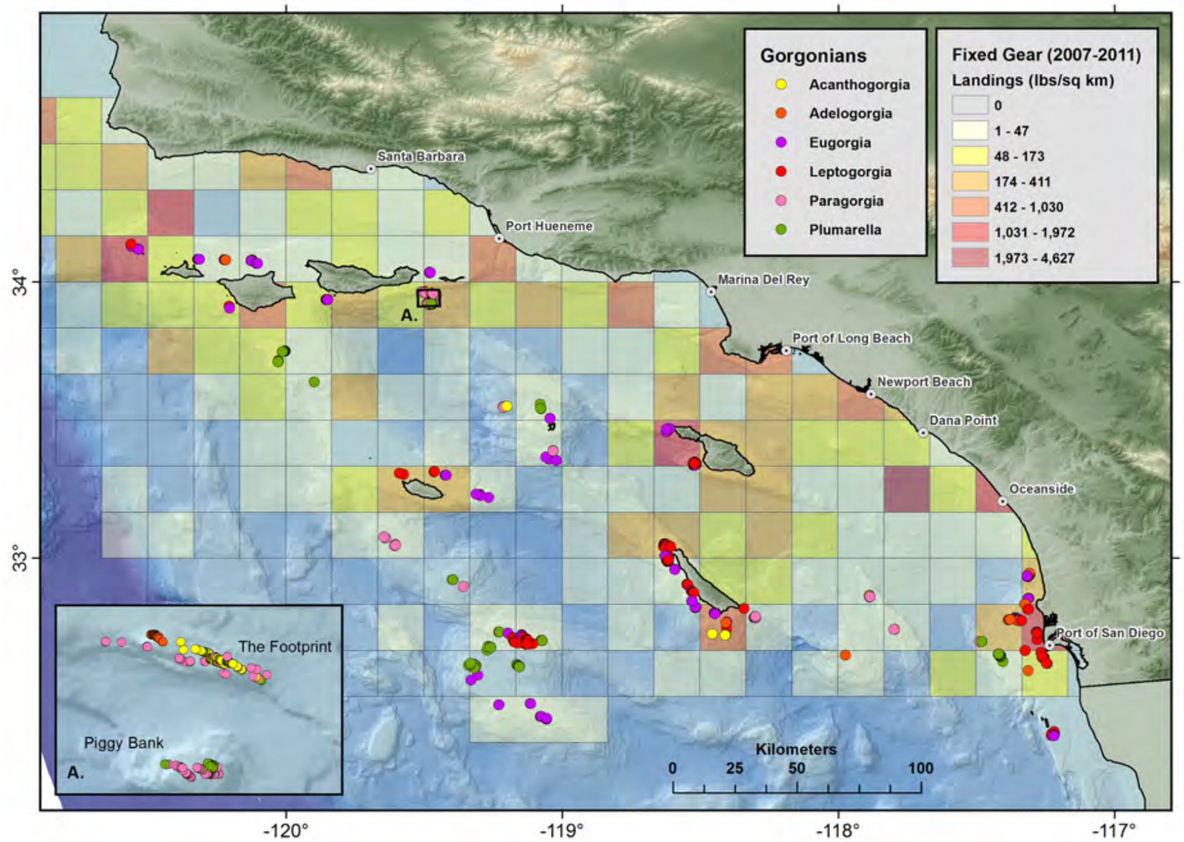


Figure App.C.3.4. Historical landings of fixed gear that could impact benthic habitats are shown along with the locations of deep-sea gorgonians in the map above. Fixed gear usage is moderate around the Channel Islands and likely impacts gorgonians in CINMS habitats. Data is from 2007 to 2011. Data source: CDFW, Perry et al 2010; Map: P. Etnoyer/NOAA, Etnoyer et al. 2015

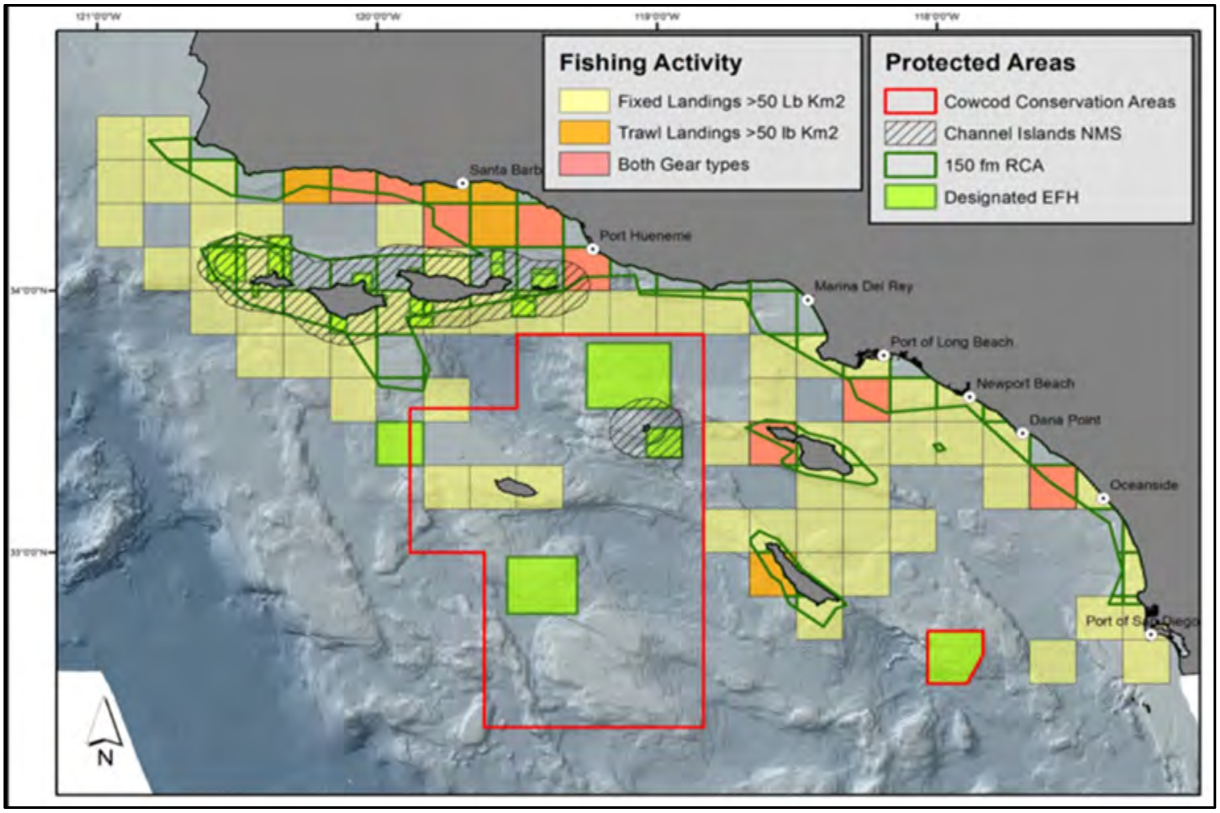


Figure App.C.3.5. Overlay of trawl and fixed gear fishing activity from 2007 to 2011 and protected areas is shown in the map above. Much of the landings is off the Santa Barbara mainland coast; however, fixed gear usage regularly occurs in sanctuary waters. Data source: CDFW; Map: P. Etnoyer/NOAA

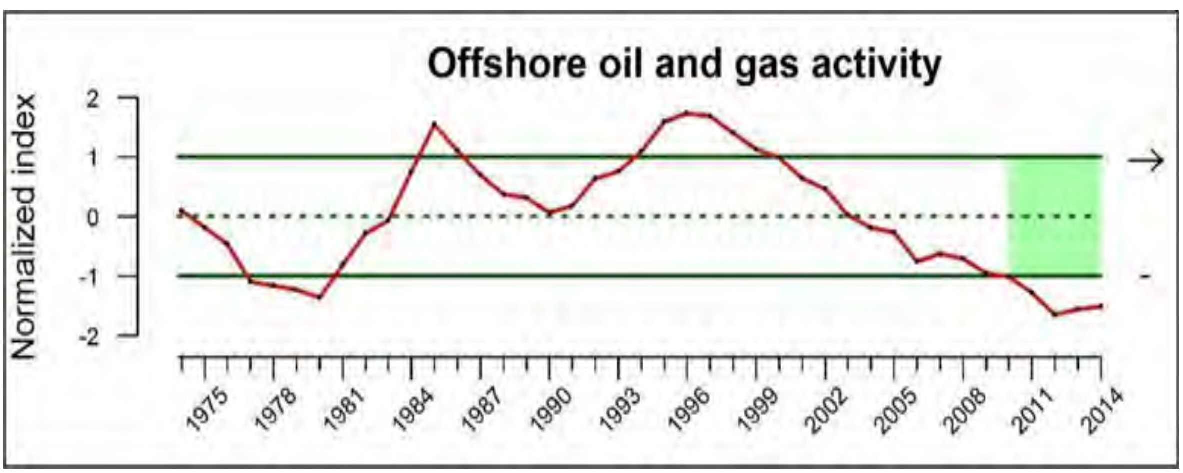


Figure App.C.3.6. The status and trends of offshore oil and gas activity in southern California was measured using a normalized index of oil and gas production from offshore wells in state and federal waters in California. Activity has been stable over the last five years and is well below the long-term average (dashed green line). A rather steady decrease in oil and gas production has occurred since the mid-1990s. Data source: California State Department of Conservation's Division of Oil, Gas, and Geothermal Resources; Figure: K. Andrews/NOAA

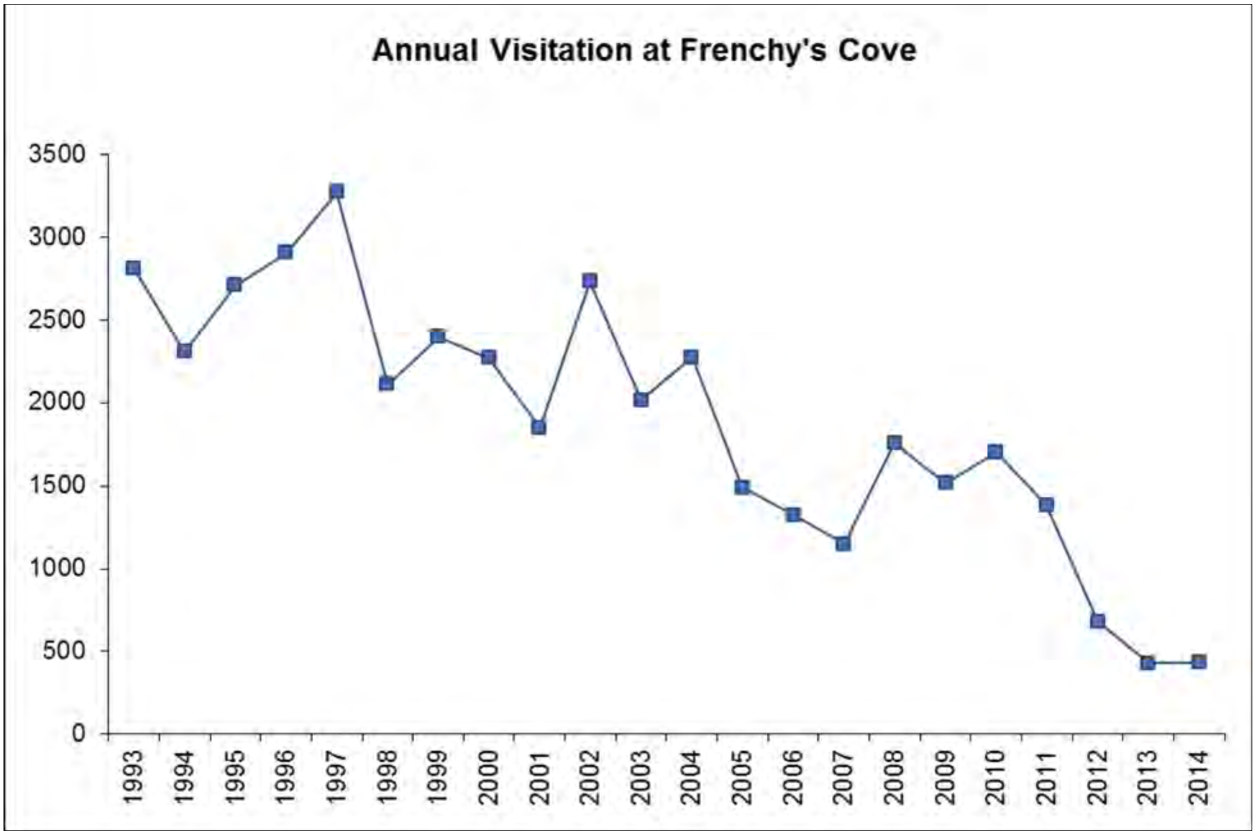


Figure App.C.3.7. Annual number of visitors brought to Frenchy's Cove, Anacapa Island, according to the Island Packers Company is shown in the time series above. No records are available for the number of private boaters that went ashore at any of the Channel Islands in the park. Figure: Channel Islands National Park

4. What are the levels of human activities that may adversely influence living resource quality and how are they changing?

Table App.C.4.1. Data presented to the living resources experts at the workshop on June 1, 2016 to update status and trends assessments for Channel Islands National Marine Sanctuary (CINMS).
**Denotes graphs that were received after the expert workshops and were not available for experts to view during the status and trend workshop.

Indicator	Source	Figure #	Habitat	Data Summary
Spatial distribution fishing pressure	Pondella et al. 2015	App.C.4.1	Kelp forest (rocky reef)	Status: Fishing pressure highest at Anacapa, south side of Santa Cruz Island, and west side of San Miguel Island.
Recreational fishing (CPFV) activity and landings	Chen et al. 2015b	App.C.4.2	Sandy bottom, kelp forest, deep seafloor, pelagic	Trend: Activity levels and landings in 2011 and 2012 have returned to the levels seen in the early 2000s.
Commercial fishing landings	Leeworthy et al. 2014a	App.C.4.4	Sandy bottom, kelp forest, deep seafloor, pelagic	Trend: Decreasing landings: market squid, sardine, and anchovy; stable landings: sea urchin, spiny lobster, and prawn and shrimp; increasing landings: crabs.
Halibut landings and vessels	CDFW	App.C.4.5**	Sandy bottom, deep seafloor	Trend: No clear trend in landings of halibut or number of vessels landing halibut.
Commercial crab landings and participation levels	CDFW	App.C.4.6	Sandy bottom, deep seafloor	Trend: Commercial landings of rock crabs increasing since 2010; number of fisherman landing crab increasing since 2008.
Spatial distribution recreational activity	Chen et al. 2015c	App.C.4.7	Rock intertidal, sandy beach	Status: Islands experience a low level of recreational use compared to mainland.
Visitation at Frenchy's Cove	CINP	App.C.4.8	Rocky intertidal	Status: Low levels compared to mainland. Trend: Decreasing over available time series.
Rate of human-caused disturbance to seabirds	Robinette et al. 2015	App.C.4.9	Pelagic	Status: Low rate at Santa Cruz Island compared to mainland (may have missed disturbance from other activities like kayaking along coast and in sea caves).
Whale entanglement reports	NMFS WCRO PRD	App.C.4.10	Pelagic	Status: More reports of whale entanglement. Trend: Increasing from 2009 to 2015.
Whale entanglement risk	Saez et al. 2013	App.C.4.11	Pelagic	Status: July to December is a period of elevated risk of entanglement for multiple whale species in gear from set net and trap fisheries.
Amount and location of shipping traffic	MSWGSS 2016; Moore et al. 2018	App.C.4.12	Pelagic	Status: Location of highest shipping activity changes significantly among years 2008, 2010, 2013, and 2015.
Amount of ambient low frequency noise	J. Hildebrand, SIO UCSD, unpubl. data	App.C.4.13**	Pelagic	Status: Recent levels lower than the highest levels observed from 2007 to 2008 Trend: Decreased from 2008 to 2010, increased from 2010 to 2013, and stable from 2013 to 2015.
Marine debris abundance	Ribic et al. 2012	App.C.4.14	Beach	Status: abundance of marine debris on mainland beaches lower than earlier (1999-2001). Trend: stable 2003-07, no recent data available.
Marine debris abundance and	Gilfillan et al. 2009	App.C.4.15, App.C4.16	Pelagic	Status: Micro-debris in more than 50 percent of samples, no relationship between particle

location				density and distance from shore. Trend: Stable from 1984 to 2007, no recent data available.
Oil and gas production	NMFS NWFSC	App.C.4.17	Pelagic	Status: Lower level of activity than in 1980s and 1990s. Trend: Steady decline since mid-1990s, stable in last five years.
Research permit activity	CDFW	App.C.4.18	Rocky intertidal, kelp forest, deep seafloor, pelagic	Status: Most permits issued research in kelp forest, rocky intertidal, and pelagic habitats. Trend: Decline in number of research permits issued by CDFW from 2010 to 2016.

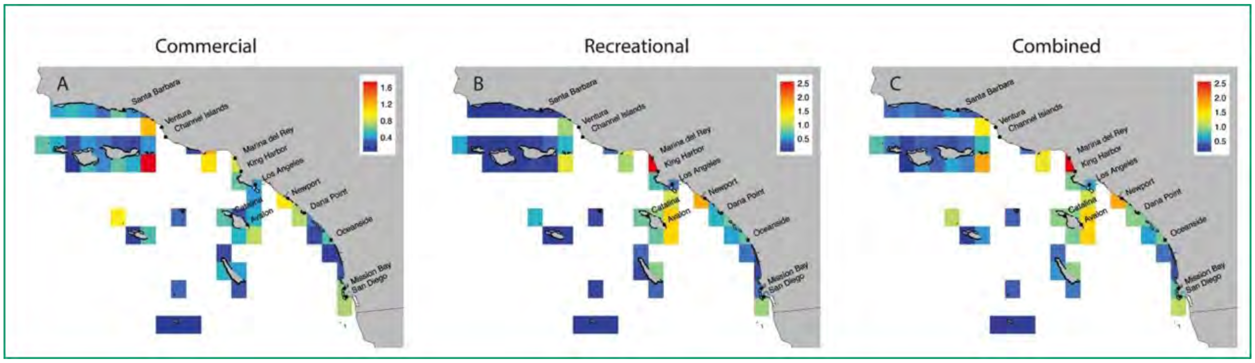


Figure App.C.4.1. Spatial distribution of the fishing pressure index on shallow rocky reef for (A) commercial, (B) recreational Commercial Passenger Fishing Vessels (CPFVs), and (C) the combined fisheries for years 1980 to 2009. The fishing pressure index was calculated as tons per year harvest rates per amount of reef area in each block (MT/yr/km^2). The colors indicate areas with high (red) versus low (blue) fishing harvest rates per square kilometer reef area. Only data for CDFW fishing blocks that contain shallow (< 30 meters depth) rocky reefs are shown. Figure: Pondella et al. 2016

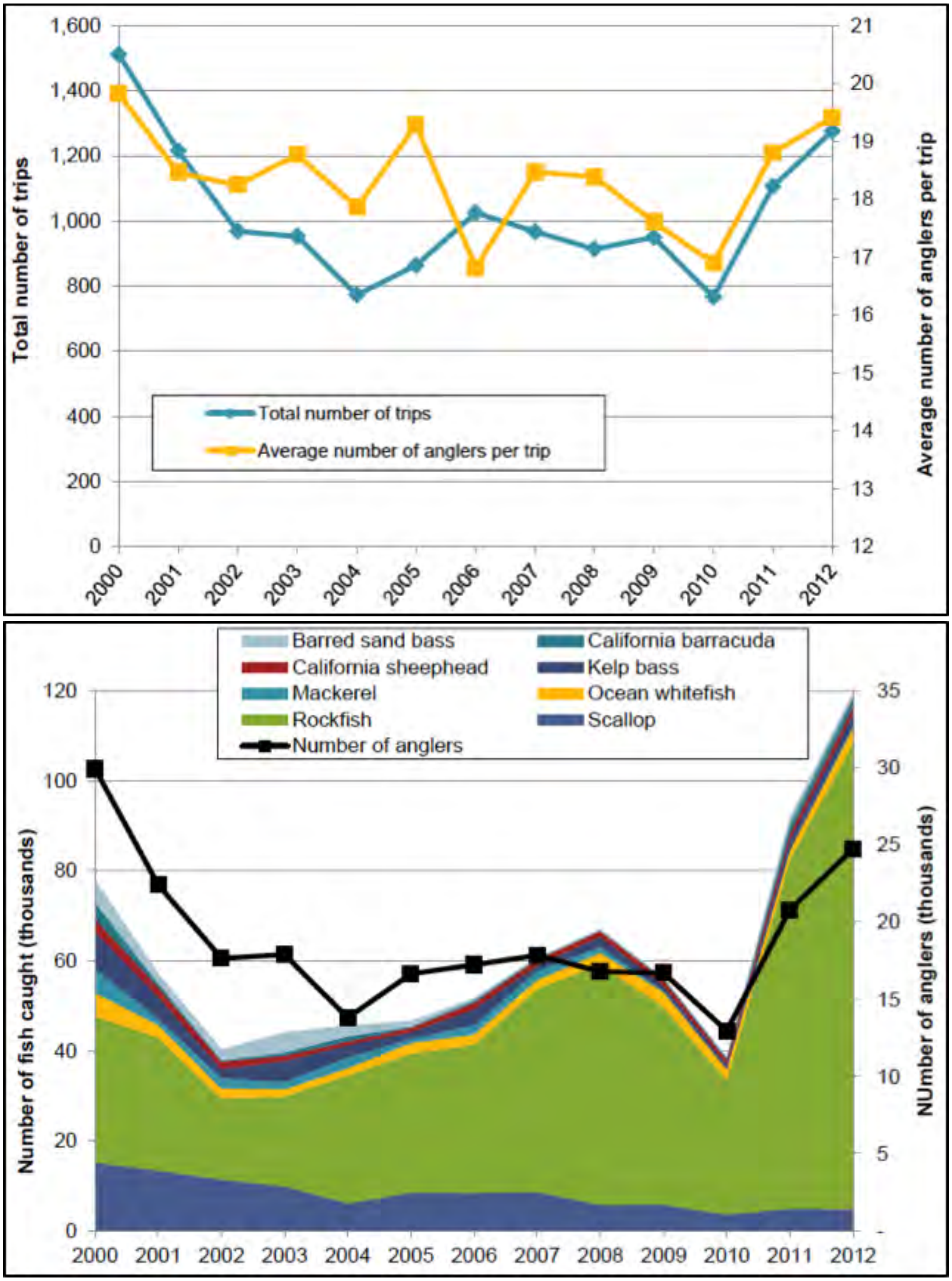


Figure App.C.4.2. Fishing activity levels and landings for Commercial Passenger Fishing Vessels (CPFVs) operating out of ports in Santa Barbara and Ventura from 2000 to 2012. Activity levels and landings in 2011 and 2012 returned to levels seen in the early 2000s. Figure: Chen et al. 2015b

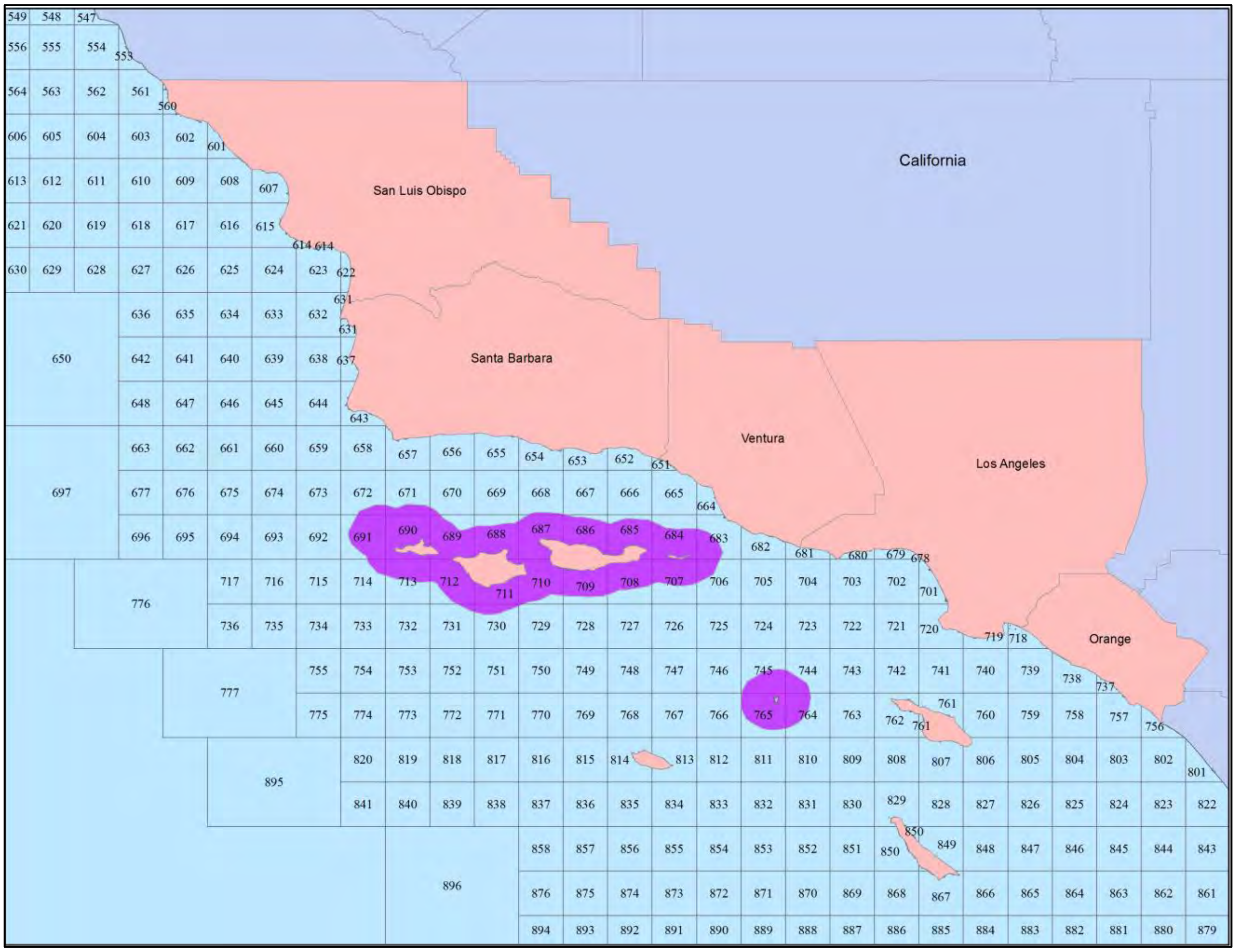


Figure App.C.4.3. The overlay of the Channel Islands National Marine Sanctuary boundary (magenta) on reporting blocks used in the California Fishery Information System (CFIS) from the California Department of Fish and Wildlife (CDFW). Each block has a three digit database code. Twenty-two blocks overlap substantially with Channel Islands National Marine Sanctuary and were included in analysis of commercial fishery landings and activity levels by Leeworthy et al. 2014a. Figure: Leeworthy et al. 2014a

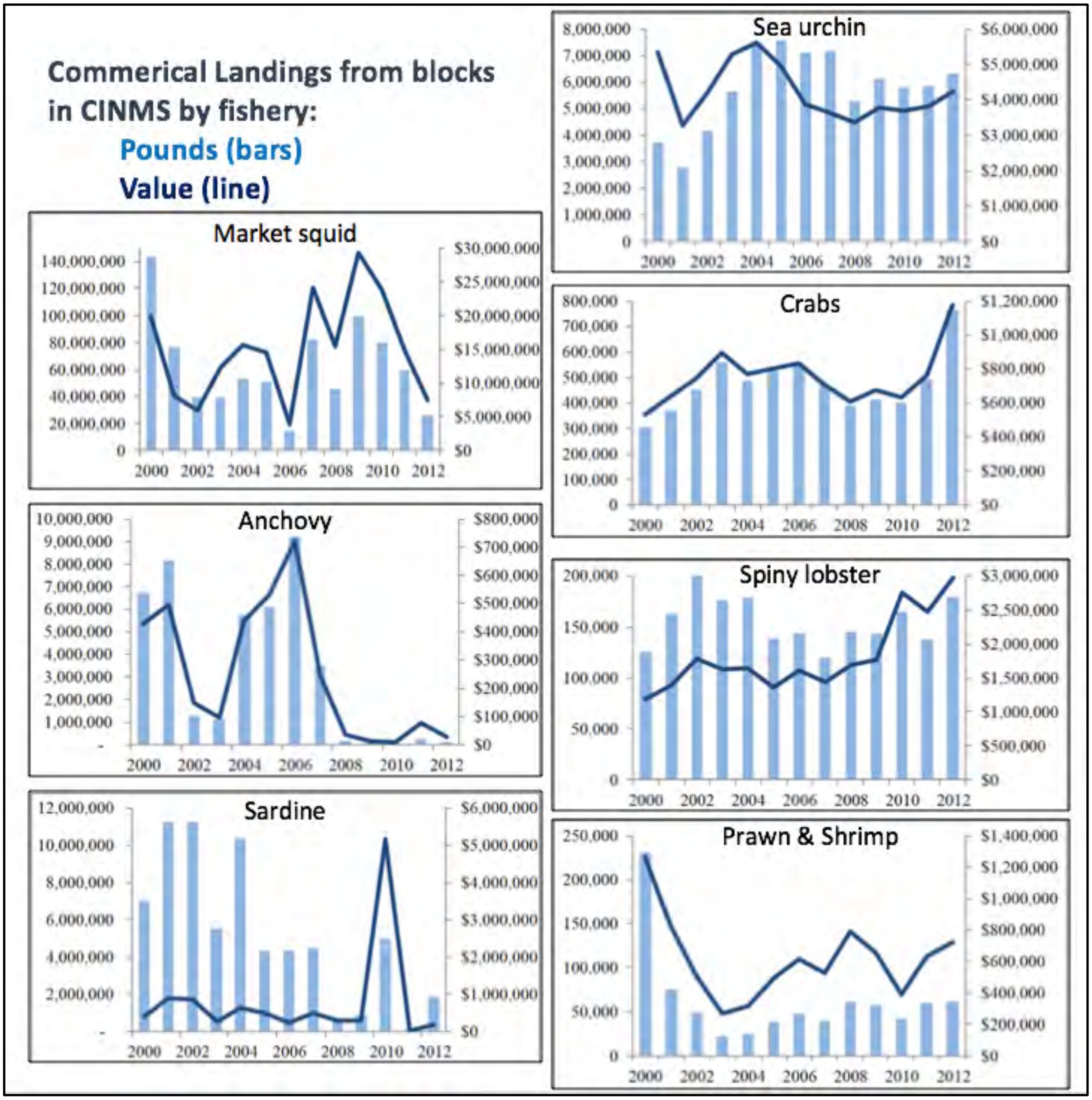
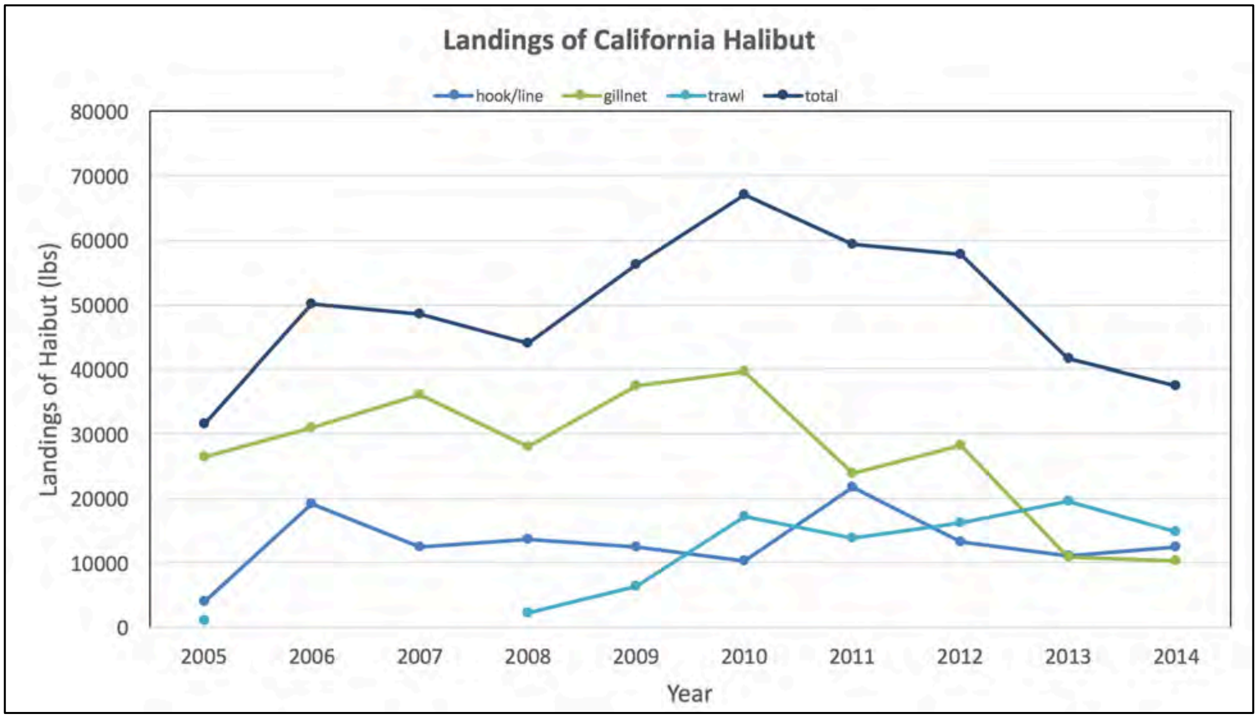


Figure App.C.4.4. Trends over time in commercial fishing activity in Channel Islands National Marine Sanctuary (CINMS) based on landings pounds (blue bars) and value (dark blue line) for seven fisheries from 2000 to 2012. Landings were combined for twenty-two blocks that overlap substantially with the sanctuary (see Figure App.C4.3. for map). Landings for market squid, sardine, and anchovy declined recently while landings of crabs increased. Landings of sea urchin, spiny lobster, and prawn and shrimp were relatively stable. Figure: Leeworthy et al. 2014a



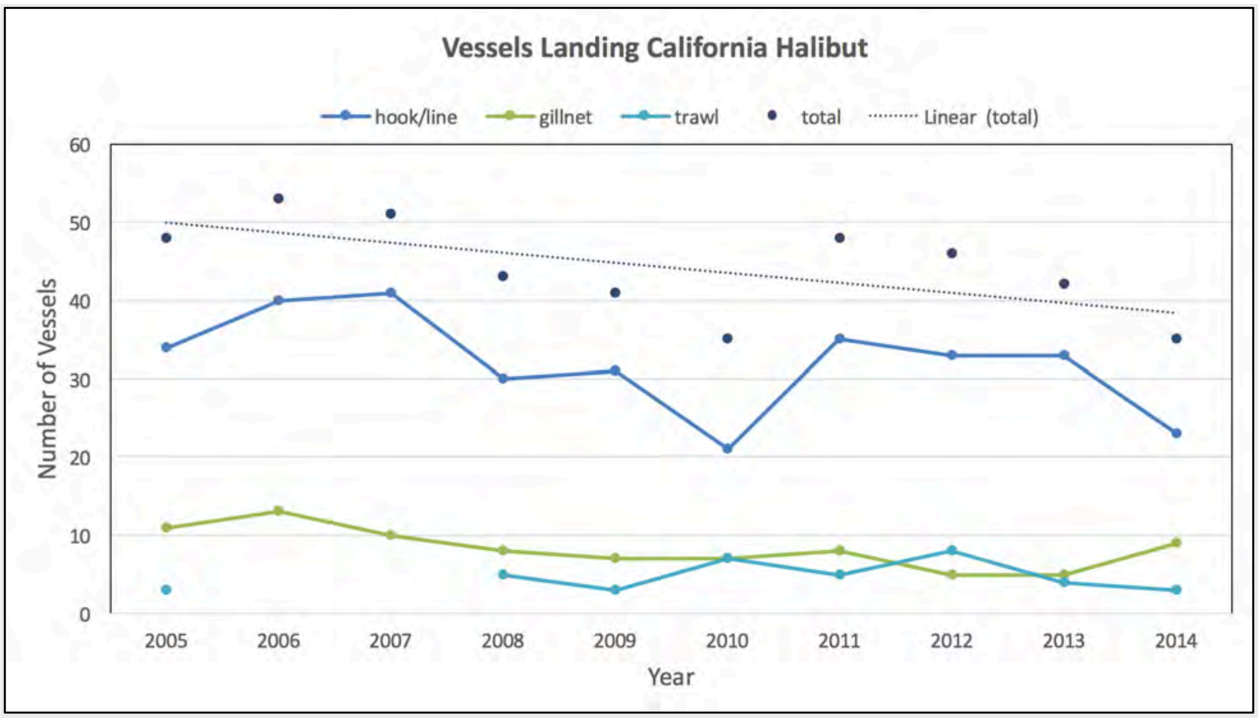
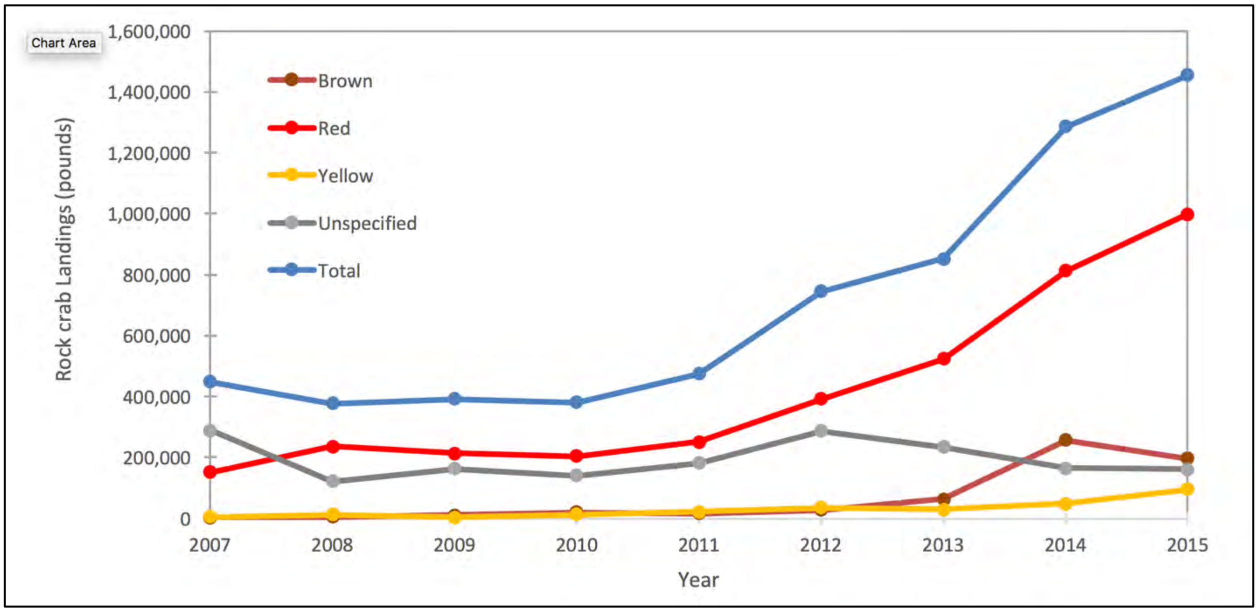


Figure App.C.4.5. Landings of California halibut (P*aralichthys californicus)* (top) and the number of vessels fishing for halibut (bottom) in blocks around Channel Islands National Marine Sanctuary by hook/line (blue), gillnet (green), and trawl (teal) fishing gear. Landings data from the Santa Barbara port complex (Santa Barbara, Ventura, Oxnard, and Port Hueneme) and reflect take from the Fish and Game blocks 683–691, 706-714, 744, 745, 764, and 765 (see Figure App.C4.3 for map of blocks). Data source: CDFW; Figure: NOAA



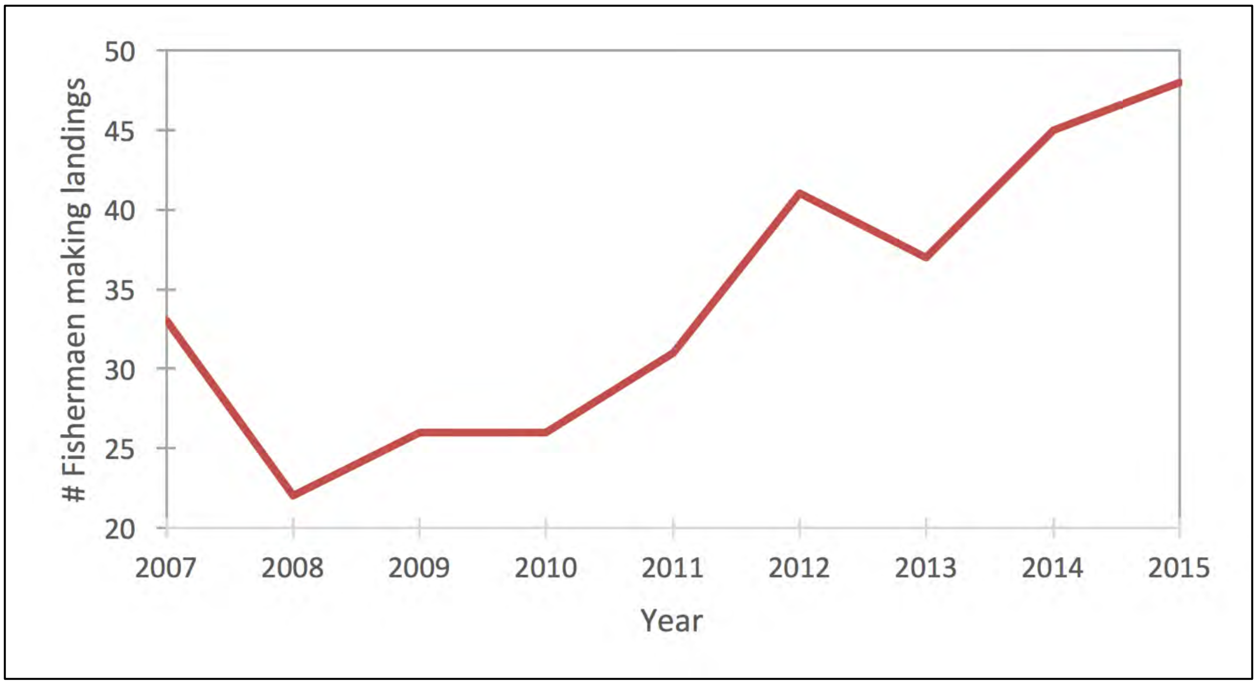


Figure App.C.4.6. Commercial fishing activity for rock crabs has increased recently in blocks around Channel Islands National Marine Sanctuary. Landings of rock crabs have increased since 2010 (top) and the number of fisherman landing crab has increased since 2008 (bottom). Commercial rock crab data from blocks 683–691, 706–714, 744–745, and 764–765 (see Figure App.C4.3 for map of blocks). Data source: CDFW; Figure: NOAA

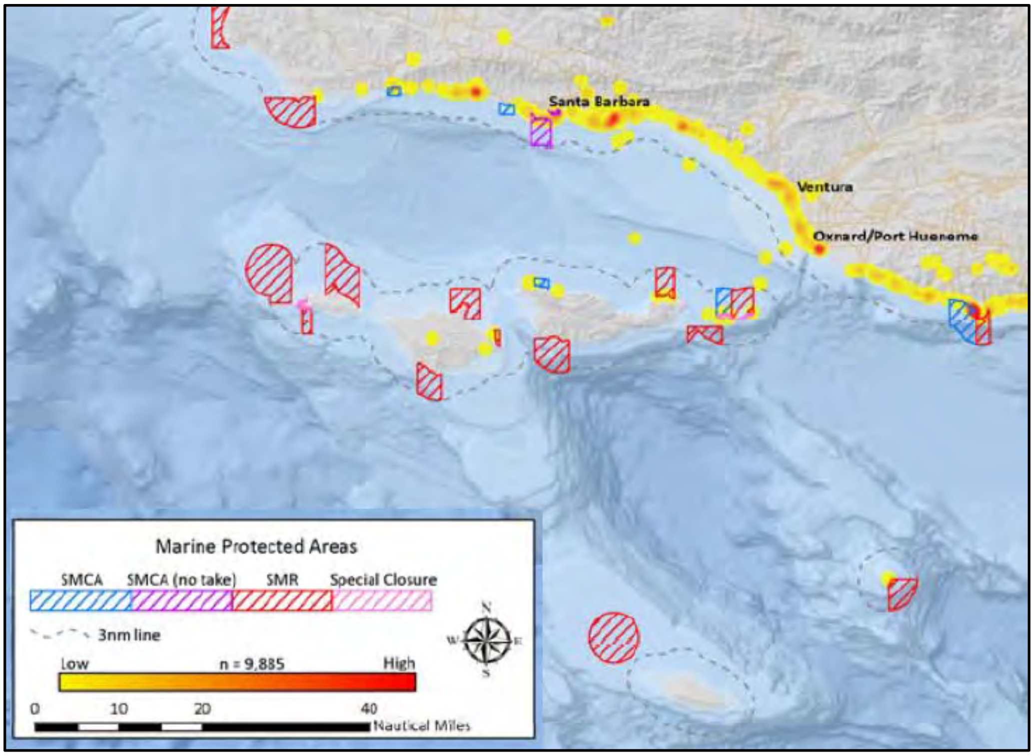


Figure App.C.4.7. Spatial patterns in coastal recreational activity levels in southern California (all activity types combined). Based on a standing internet panel designed to be demographically representative and surveyed 4,492 individuals in select south coast region counties. Activities at Channel Islands National Marine Sanctuary (CINMS) included: beach-going (SRI), scenic enjoyment (SRI, SCI, Anacapa, SBI), photography (SRI, SCI, Anacapa), birdwatching (SRI, SCI, SBI), and hiking (SRI, SCI). Figure: Chen et al. 2015c

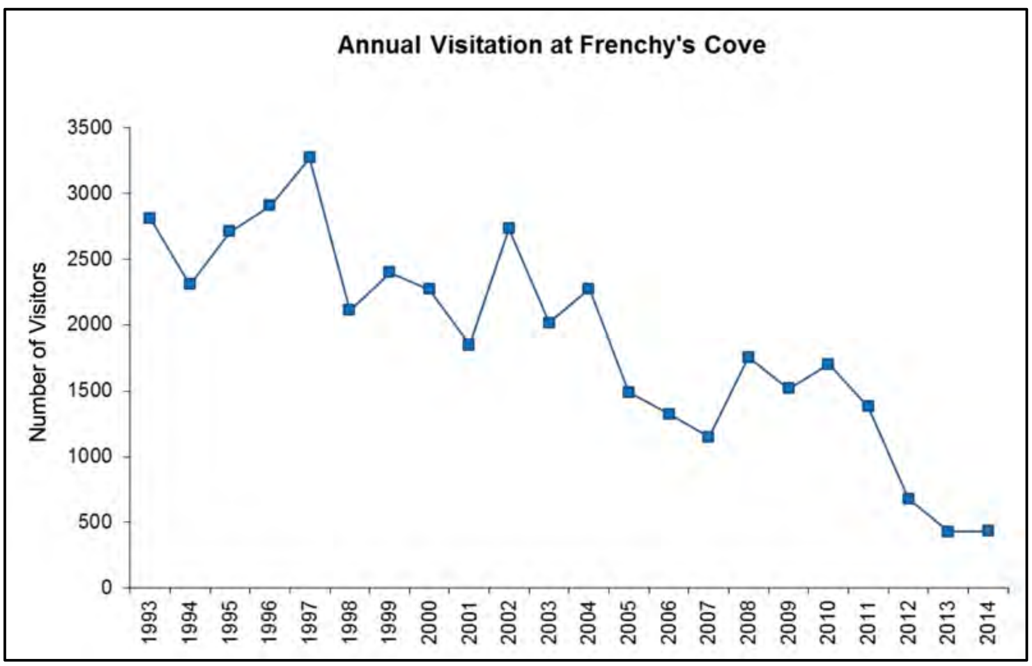


Figure App.C.4.8. Annual number of visitors brought to Frenchy's Cove, Anacapa Island, by the Island Packers Company. At south Frenchy's Cove and adjacent reefs, Island Packers Company conducts classroom programs for school groups typically during winter and spring months. No records are available for the number of private boaters that went ashore at any of the Channel Islands in the park. Figure: Channel Islands National Park

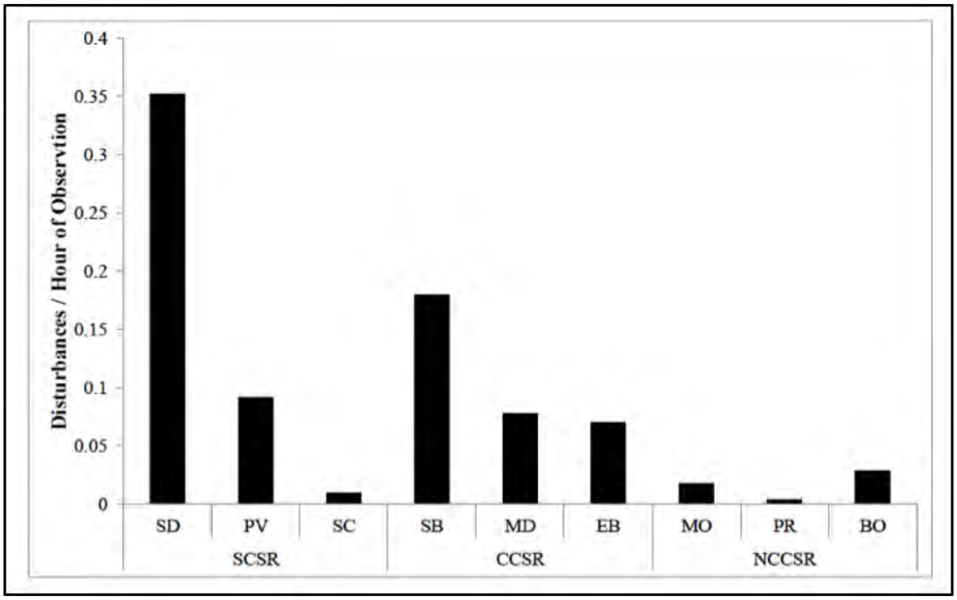


Figure App.C.4.9. Rates of human-caused disturbance to seabird breeding and roosting sites were low on Santa Cruz Island (SC) compared to other sites across the south coast (SCSR), central coast (CCSR), and north central coast (NCCSR) study regions. Activities noted as causing disturbance at SC in 2012 to 2013 were human power boats, recreational fishing boats, recreational power boats, commercial fishing boats, airplanes, and helicopters. SD = San Diego, PV = Palos Verdes Peninsula, SB = Shell Beach, MD = Montaña de Oro, EB = Estero Bluffs, MO = Montara, PR = Point Reyes, BO = Bodega. Figure: Robinette et al. 2015

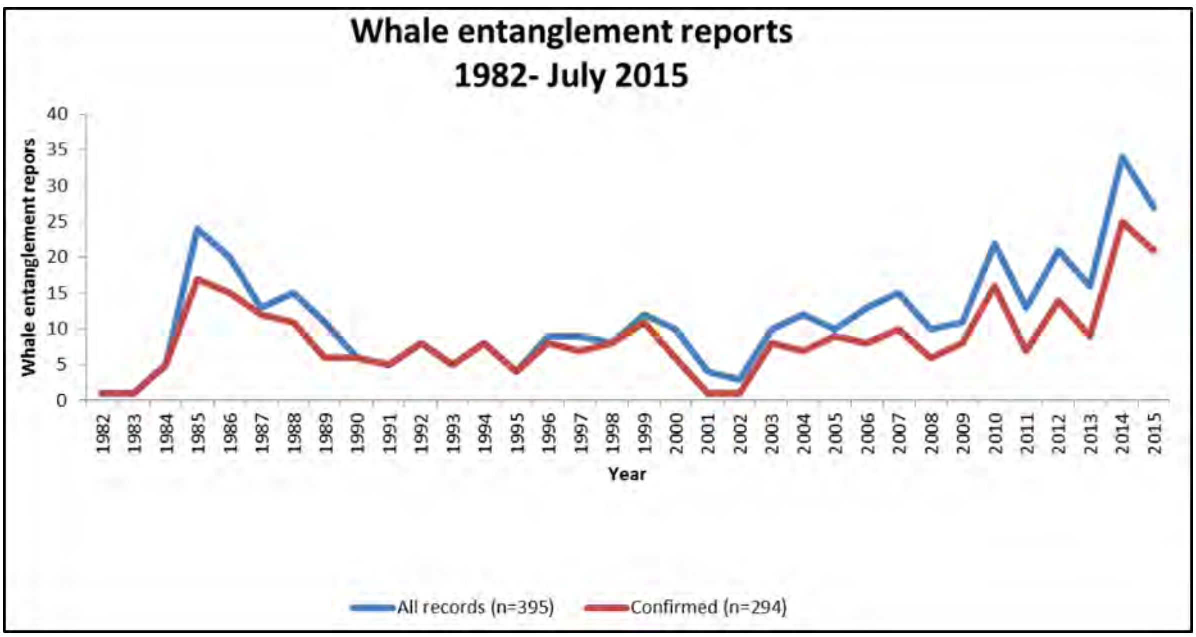


Figure App.C.4.10. Annual number of large whale entanglements reported (blue) and confirmed (red) along the U.S. West Coast. Reports of entanglements have increased in recent years. Factors contributing to this trend likely include an increasing overlap of whale activities (e.g., migrating, feeding) with human activities that have the potential to entangle whales (e.g., fishing, buoy installation) and an increase in on-the-water observers likely to report entangled individuals (e.g., whale watching, recreational boating). Confirmed entanglements from 2000 to 2015 of gray and humpback whales include 11 from Santa Barbara and two from Ventura counties. Figure: D. Lawson/NMFS WCRO PRD

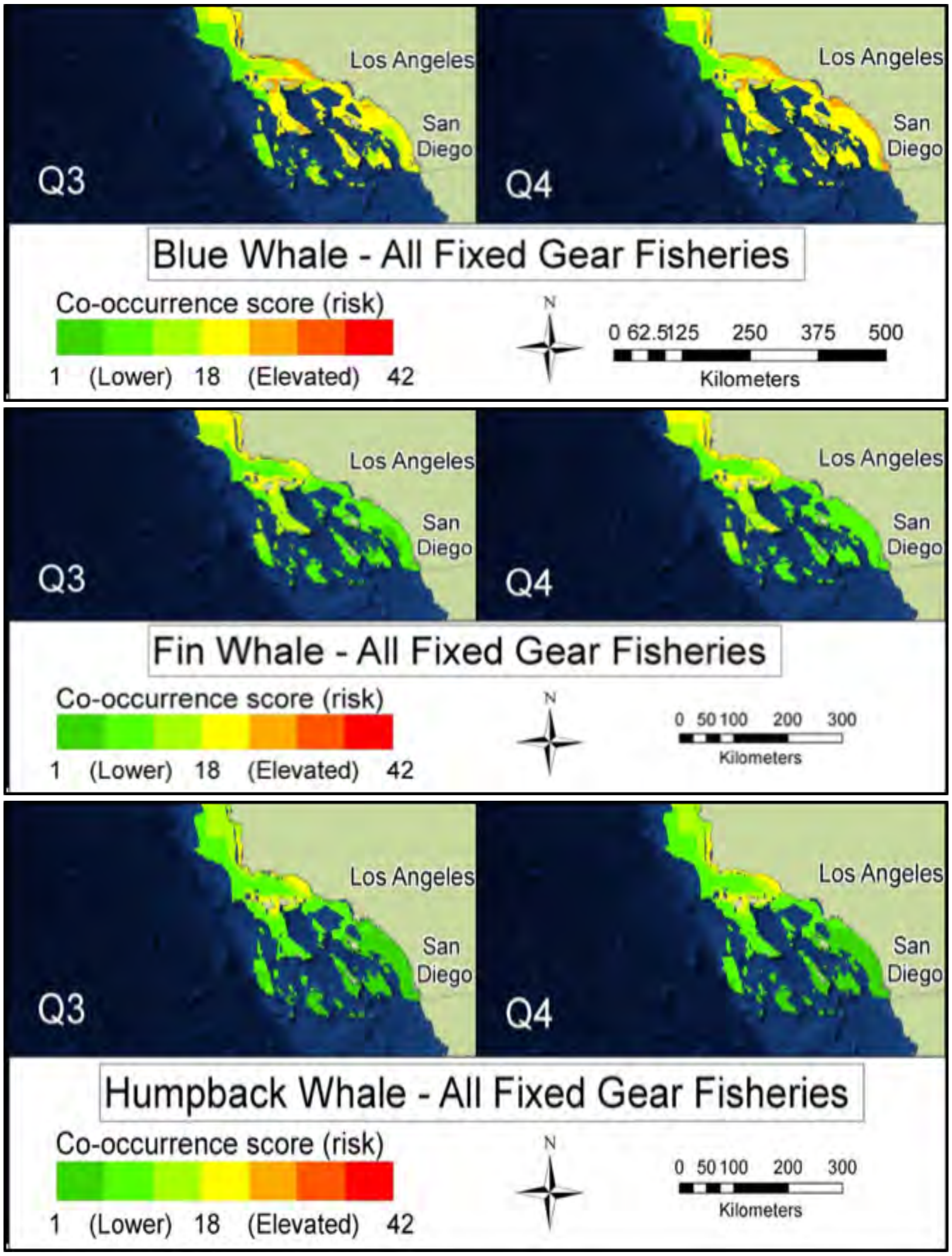


Figure App.C.4.11. Co-occurrence score (risk) based on multi-year average whale density and fishing effort for 11 fisheries is shown for quarters three (Q3) and four (Q4) for blue (top), fin (middle), and humpback (bottom) whales. In Santa Barbara from July to December, there is an elevated risk area for multiple whale species with the California halibut/white seabass set gillnet, hagfish trap, rock crab trap, sablefish, spiny lobster trap, and spot prawn trap fisheries. Figure: Saez et al. 2013

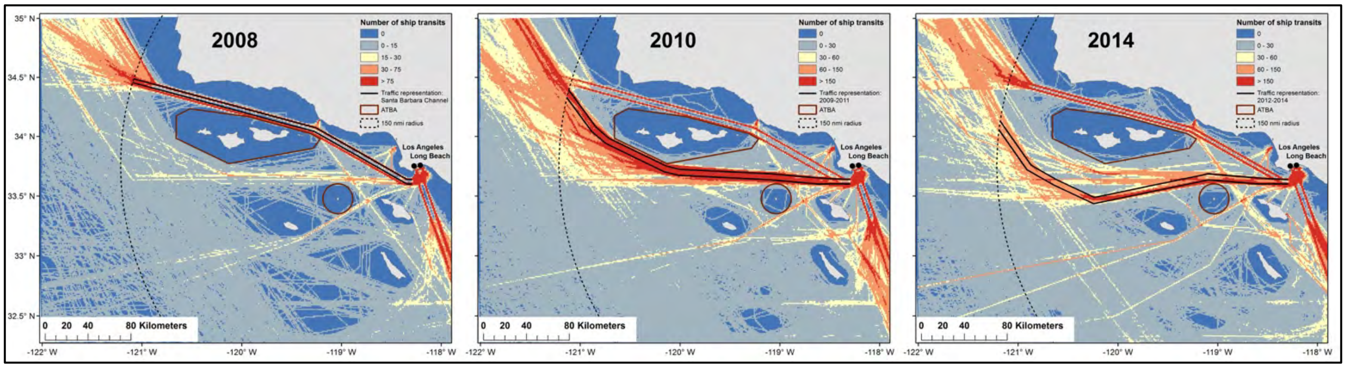


Figure App.C.4.12. Traffic patterns of large commercial vessels (cargo and tanker vessels) in the Santa Barbara Channel region for 2008, 2010, and 2014. The number of commercial ship transits is shown, using Automatic Identification System (AIS) data transmitted from ships. Vessels transiting to and from the Ports of Los Angeles/Long Beach that pass by the northern Channel Islands use either the Santa Barbara Channel Traffic Separation Scheme around the north side of the islands, or take routes south of the islands. Data source: USCG AIS data, processed by NMFS; Figure: MSWGSS 2016
Note: This is variant of a similar figure shown during the expert workshop.

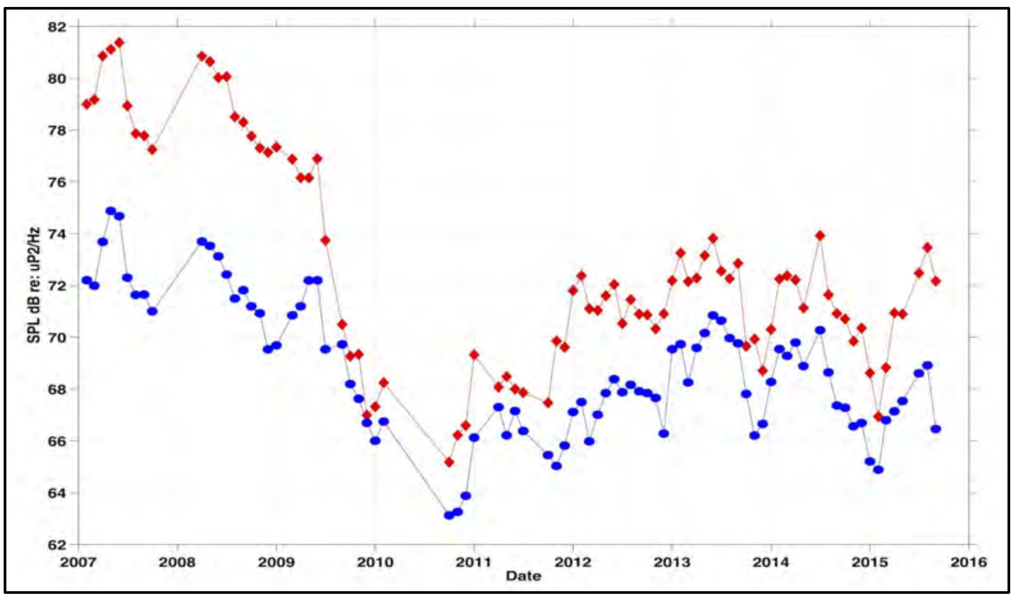


Figure App.C.4.13. Ambient noise levels in the Santa Barbara Channel represented as monthly averages for 40 Hz (red) and 90 Hz (blue) bands. The decline in ambient noise levels observed between 2007 and 2010 reflects decreased regional shipping activity during that time. While ambient noise has increased since 2010, it has not returned to the higher levels observed in 2007 to 2008. Data sources: McKenna et al. 2012, J. Hildebrand/ UCSD unpub. data; Figure: J. Hildebrand/SIO UCSD
***Note: Data from 2011 to 2015 were not available for experts to view during the status and trend discussion; however, representative from this monitoring program discussed the data during the meeting.*

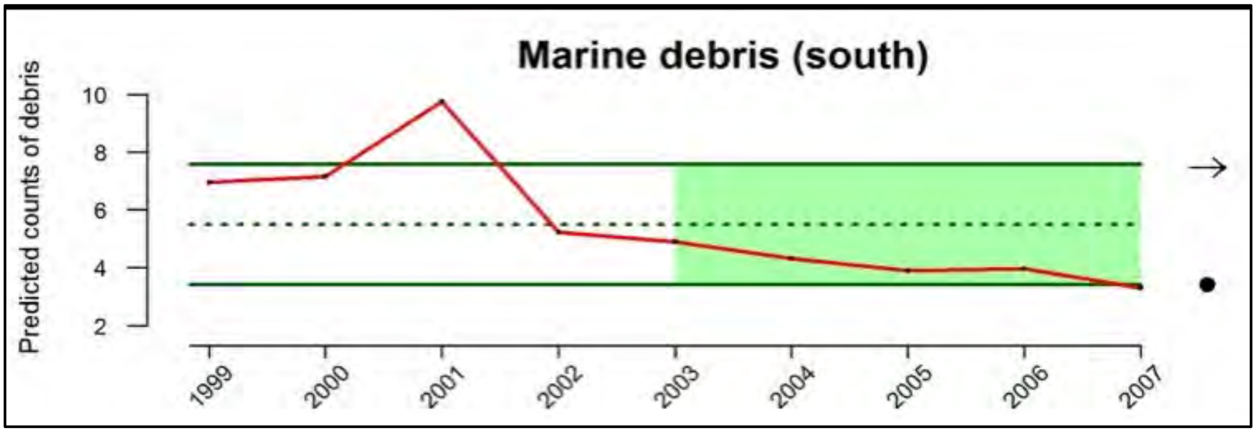


Figure App.C.4.14. Marine debris estimates modeled along the mainland southern California coast based on debris measured by the National Marine Debris Monitoring Program. Marine debris was relatively constant across the last five years of this time series (1999-2007) and within historic levels. Data source: Ribic et al. 2012; Figure: K. Andrews/NOAA

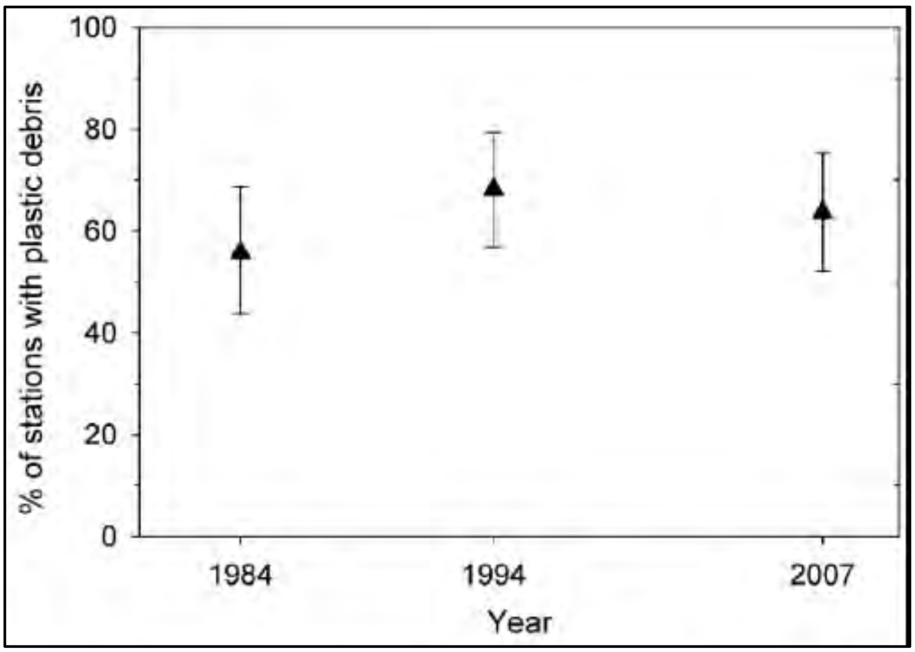


Figure App.C.4.15. Variation over time in percentage of stations from winter CalCOFI cruises with plastic micro-debris. Micro-debris was present in more than 50 percent of samples at each time period. Figure: Gilfillan et al. 2009

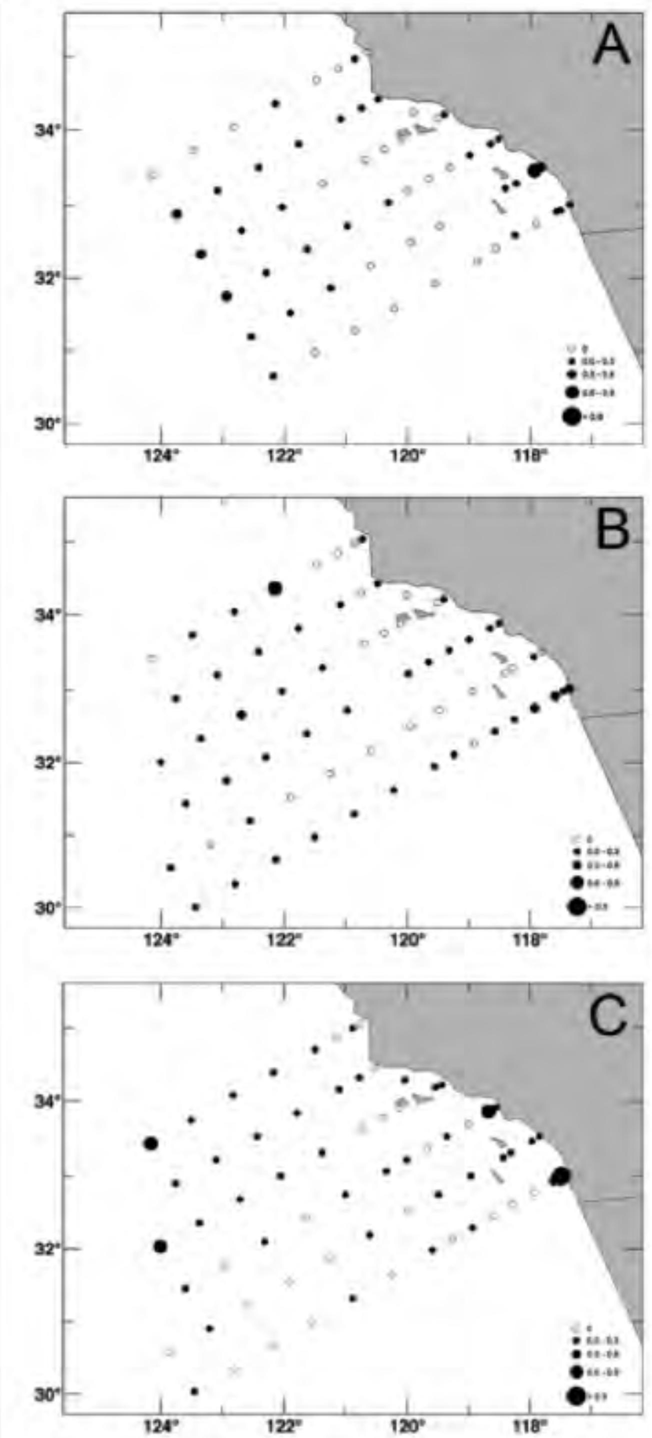


Figure 2. Spatial distribution of plastic micro-debris particles in the winter CalCOFI Manta net samples from cruises (A) 8401, (B) 9401, and (C) 0701. Open circles indicate no plastic debris detected and filled circle diameters are proportional to particle concentrations (No./m³).

Figure App.C.4.16. Spatial distribution, concentration, and characteristics of plastic micro-debris in net samples from the CalCOFI region from winter cruises in (A) 1984, (B) 1994, and (C) 2007. Open circles indicate no plastic debris detected and filled circle diameter are proportional to particle concentrations (number per cubic meter). There was no relationship between the numerical concentration of particles and distance from shore, the presumed source of the majority of debris. Figure: Gilfillan et al. 2009

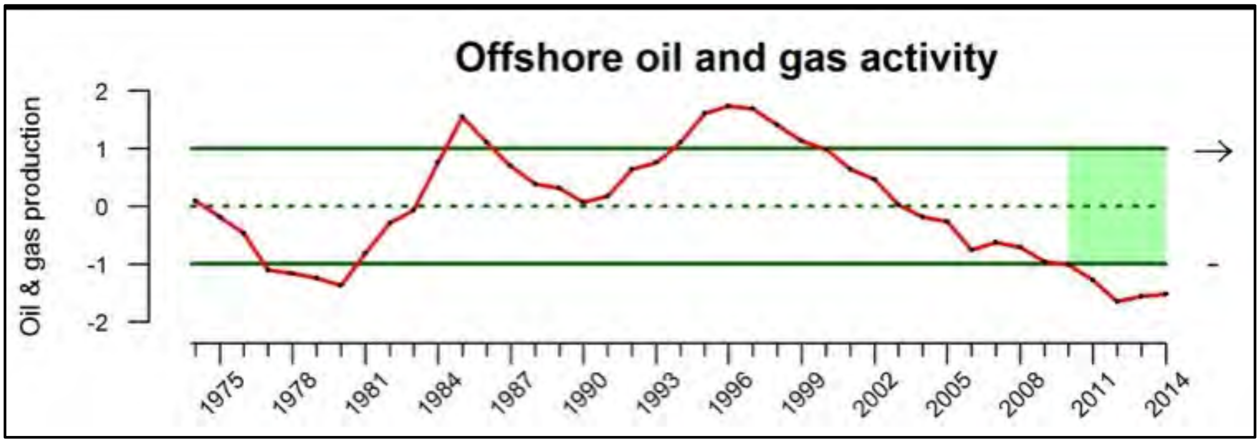
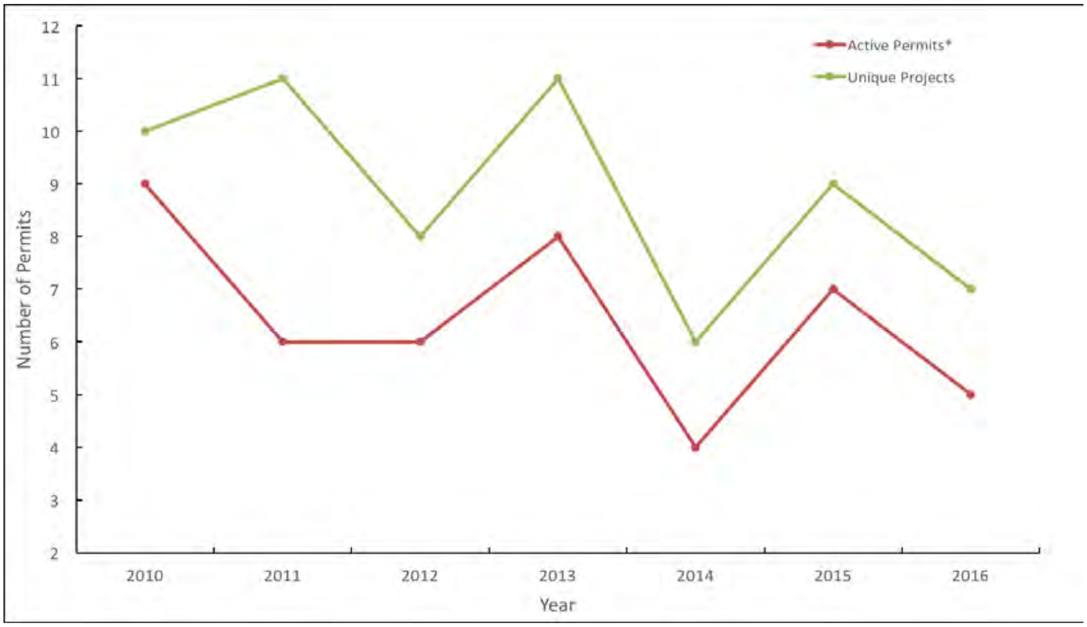


Figure App.C.4.17. The status and trends of offshore oil and gas activity in southern California was measured using a normalized index of oil and gas production from offshore wells in state and federal waters in California. Activity has been stable over the last five years, but the short-term average was well below the long-term average (dashed green line). A rather steady decrease in oil and gas production has occurred since the mid-1990s. Data source: Annual reports of the California State Department of Conservation's Division of Oil, Gas, and Geothermal Resources; Figure: K. Andrews/NOAA



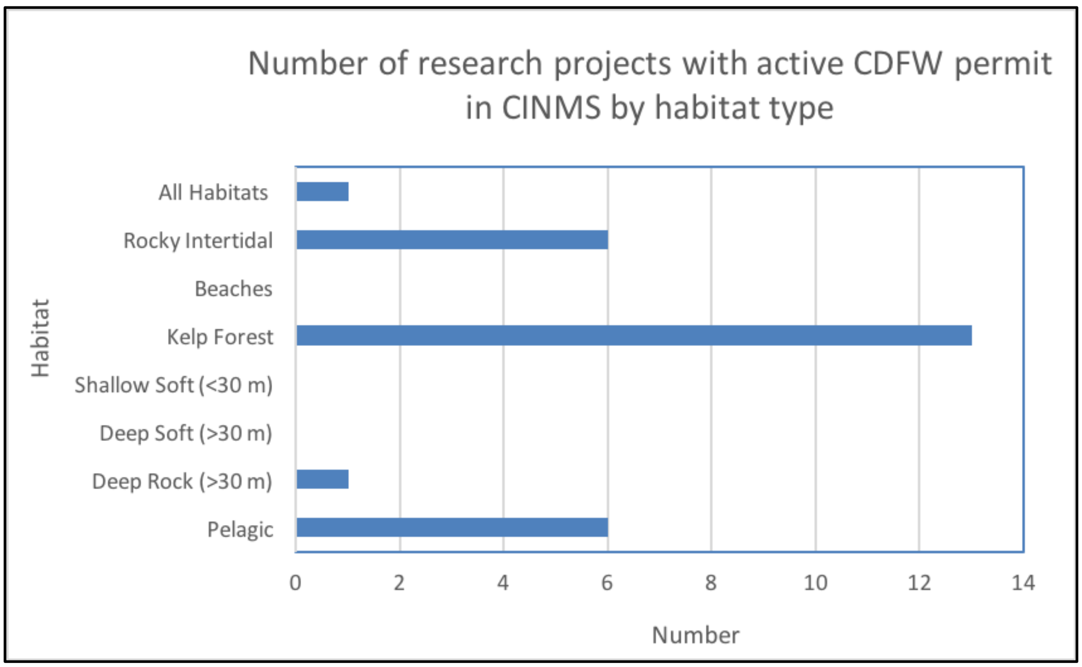


Figure App.C.4.18. (top) Annual number of unique research projects (green) and active research permits (red) in the California Department of Fish and Wildlife (CDFW) database for research permits in Channel Islands National Marine Sanctuary (CINMS) from 2010 to 2016. One permit could contain multiple projects. (bottom) Number of projects with active CDFW research permits in CINMS by habitat type. Active permits only include those that are currently in use; non-student permits are issued for three years and student permits are issued for only one year. Student permits issued before June 6, 2015 were not included in this summary. Data source: B. Owens/ CDFW; Figure: NOAA

APPENDIX D:
Water Quality Tables and Graphs

6. What are the eutrophic conditions of sanctuary waters and how are they changing?

Table App.D.6.1. Data presented to water quality experts at the May 31, 2016 workshop to update status and trend assessments for Channel Islands National Marine Sanctuary (CINMS).
**Denotes graphs that were unavailable for expert review during the workshop; however, a representative from the monitoring program was present at the workshop and discussed the data.

Indicator	Source	Figure #	Data Summary
Chlorophyll			
Chlorophyll-a concentrations	Plumes and Blooms; CalCOFI; NOAA SeaWIFS, MODIS, MERIS, VIIRS satellite data	App.D.6.2, App.D.6.3b, App.D.6.4b	*Status:* Fair *Trend:* Chlorophyll blooms are episodic in the region during seasonal upwelling and localized circulation events. Decreases in chlorophyll were observed in parallel with higher temperatures (a proxy for less mixing) from 2013–2015.
Nitrate			
Anomalies of nitrate concentrations	Plumes and Blooms	App.D.6.5, App.D.6.7b	*Status:* Fair *Trend:* Brief decrease in 2014–2015, but the long-term trend (1997–2015) for nitrate values are increasing at depth, no trend detected in surface waters.
Phosphate			
Anomalies for phosphate concentrations	Plumes and Blooms	App.D.6.6	*Status:* Fair *Trend:* Brief decrease in 2014–2015, but the long-term trend (1997–2015) for phosphate values are increasing at depth, no trend detected in surface waters.

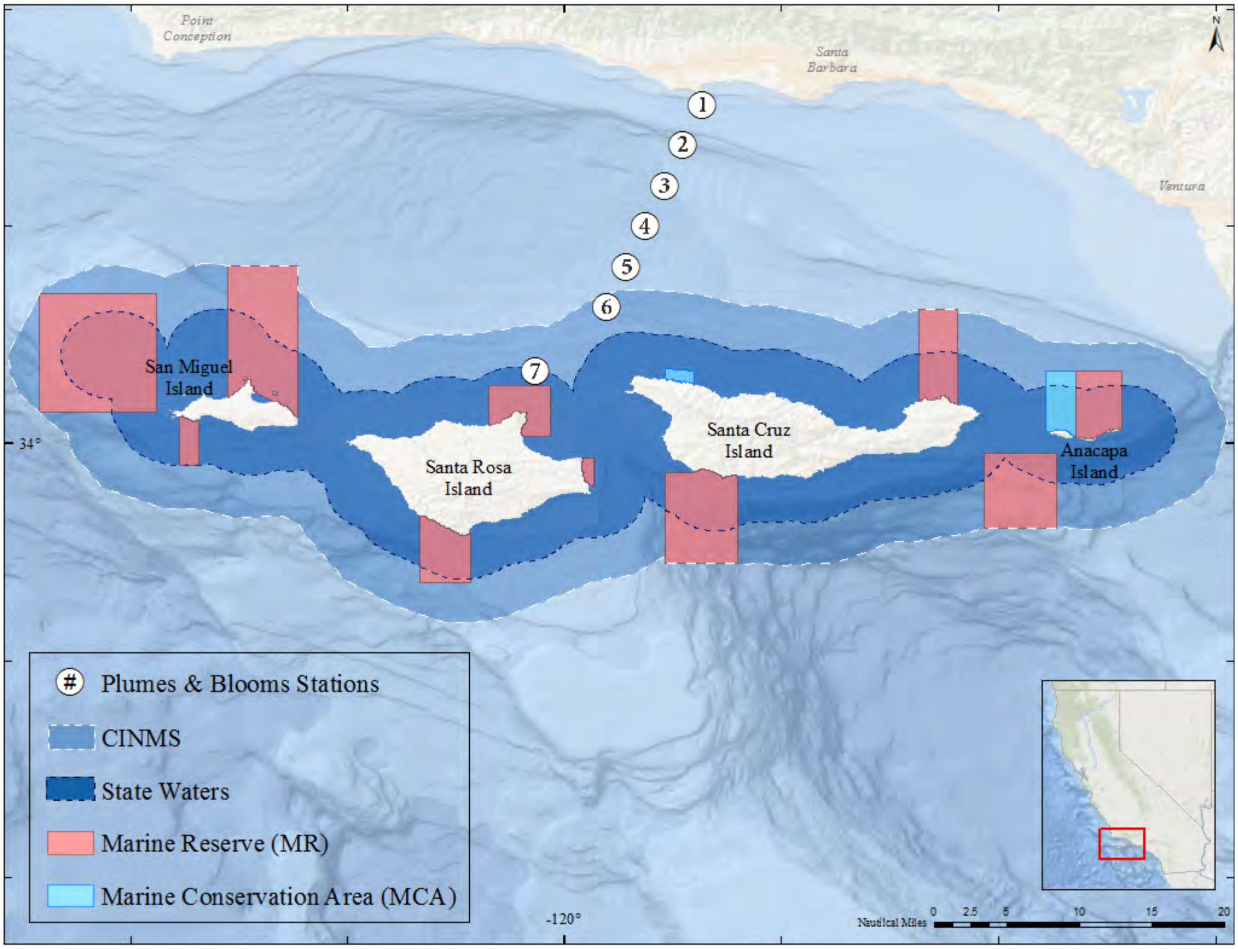


Figure App.D.6.1. Plumes and Blooms sampling stations (white dots) ranging from #1 at Goleta Point to #7 at the northernmost part of Santa Rosa Island, approximately eight miles west of Santa Barbara. Station #4 (34°15.01'N, 119°54.38'W) is near the middle of the Santa Barbara Channel and outside the CINMS boundary, but is the only station that includes a depth profile.
Data source: Plumes and Blooms, http://www.oceancolor.ucsb.edu/plumes_and_blooms/stations.html
Map: R. Freedman and M. Cajandig/NOAA

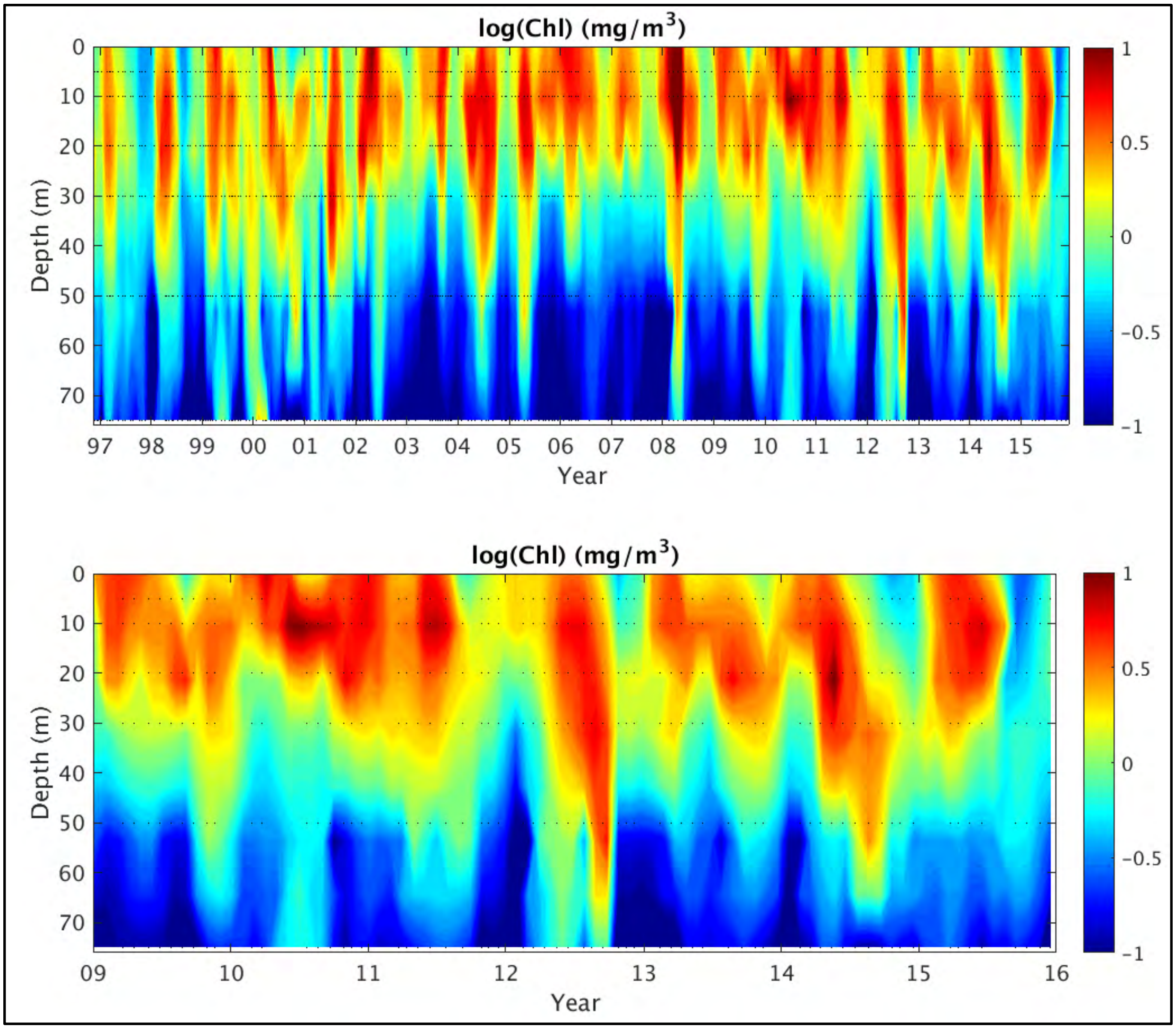


Figure App.D.6.2. Log chlorophyll-a concentrations (log(Chl) mg/m^3) at Plumes and Blooms sampling station #4 (34°15.01'N, 119°54.38'W, see Figure D6.1) for (a) 1997–2015; and (b) 2009–2015 a subset of Figure D6.4a of the years since the last condition report. While station #4 is outside the sanctuary boundary and there are other sampling sites within the sanctuary, it is the only sampling site that collects measurements throughout the water column, versus from just surface waters. This time-depth contour plot was generated via ordinary krigging with a generalized exponential-Bessel fitting model (GLOBEC Kriging Software Package v3.0), with interpolation length scales of 30 days (time axis) and ten meters (depth axis). The time and location of each actual sample are shown as black dots, allowing the observation of periods where data gaps exist. Figure: Siegel et al. *submitted*. Plumes and Blooms: http://www.oceancolor.ucsb.edu/plumes_and_blooms

Note: This is variant of a similar figure shown during the expert workshop.

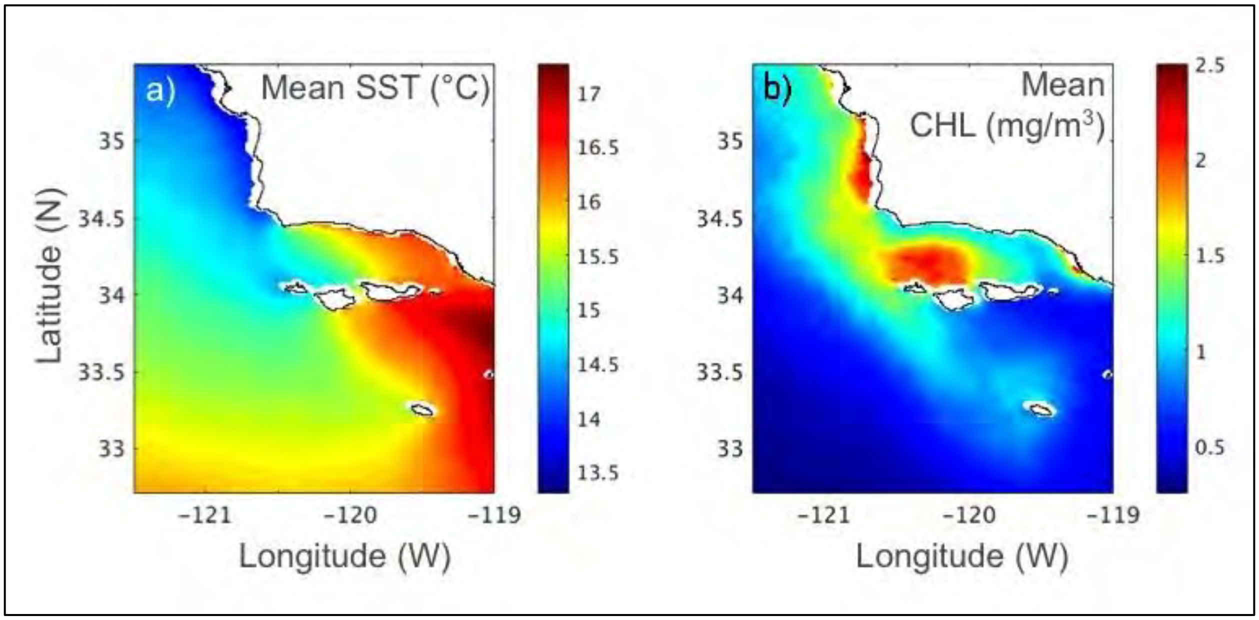


Figure App.D.6.3. (a) Composite average sea surface temperature (°C) from Advanced Very High Resolution Radiometer (AVHRR) (1997–2000), Moderate Resolution Imaging Spectroradiometer (MODIS)–Terra (2000–2015), and MODIS–Aqua satellite data (2002–2015). (b) Composite average chlorophyll (CHL) values (mg/m^3) for the northern Channel Islands region from SeaWiFS (1997–2010), MODIS–Aqua (2002–2015), Medium Resolution Imaging Spectroradiometer (MERIS) (2002–2012), and Visible Infrared Imaging Radiometer Suite (VIIRS) satellite data (2013–2015). Data source: NASA Goddard Space Flight Center, Ocean Ecology Laboratory, Ocean Biology Processing Group. MODIS, MERIS, SeaWiFS, VIIRS: https://oceancolor.gsfc.nasa.gov/. NOAA AVHRR: http://coastwatch.pfeg.noaa.gov/erddap/griddap/erdATssta8day.html. Figure: Henderikx Freitas et al. 2017

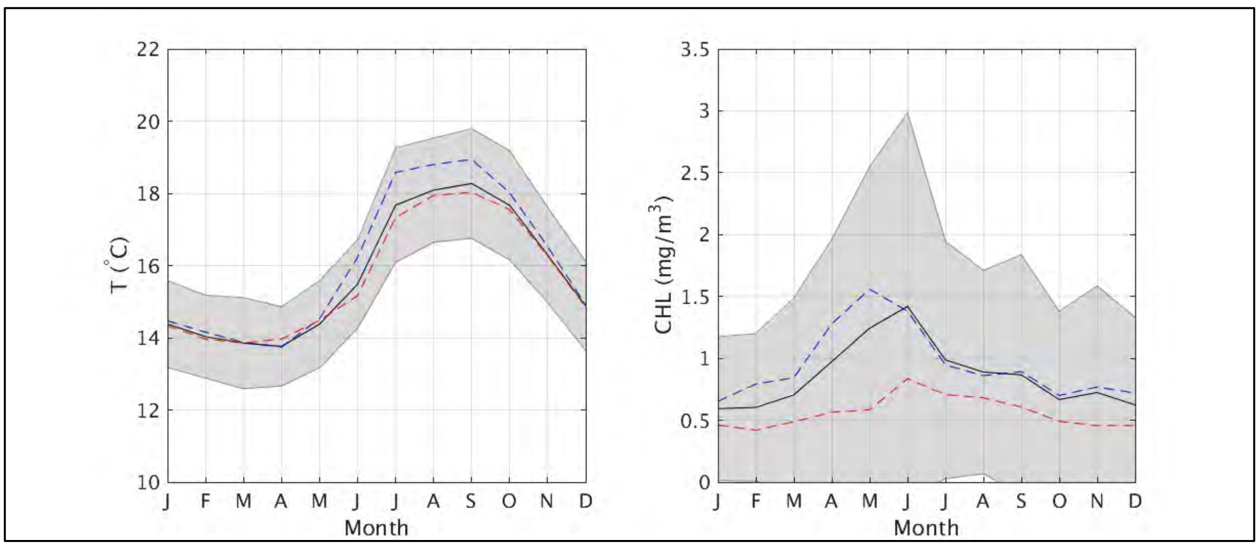


Figure App.D.6.4. Mean seasonal cycle of Sea surface temperature (SST) (left panel) and chlorophyll (CHL) (right panel) across the region shown in Figure D6.3 (black) and variability (grey areas denote one standard deviation about the mean). Blue dashed line refers to the mean values within the Santa Barbara Channel north of the northern Channel Islands, and red dashed line refers to mean values from Point Buchon State Marine Conservation Area south the Point Conception.
Figure: Henderikx Freitas et al. 2017

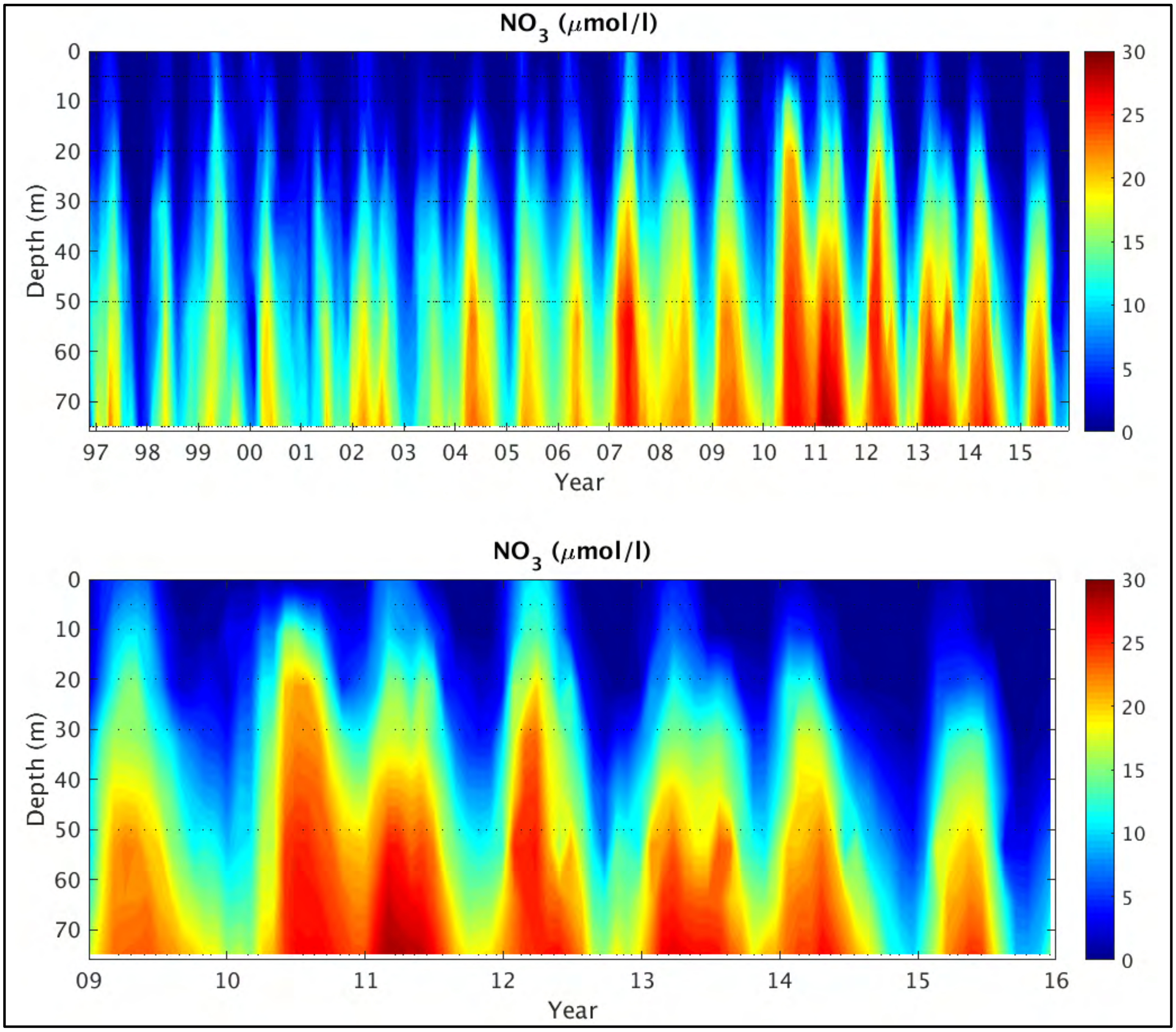


Figure App.D.6.5. Nitrate concentrations (NO_3 μmol/L) at Plumes and Blooms sampling station #4 (34°15.01'N, 119°54.38'W, see Figure D6.2) for (a) 1997–2015; and (b) 2009–2015, a subset of Figure D6.6a of the years since the last condition report. While station #4 is outside the sanctuary boundary and there are other sampling sites within the sanctuary, it is the only sampling site that collects measurements throughout the water column, versus from just surface waters. This time-depth contour plot was generated via ordinary krigging with a generalized exponential-Bessel fitting model (GLOBEC Kriging Software Package v3.0), with interpolation length scales of 30 days (time axis) and ten meters (depth axis). The time and location of each actual sample are shown as black dots, allowing the observation of periods where data gaps exist. Figure: Siegel et al. *submitted*. Plumes and Blooms: http://www.oceancolor.ucsb.edu/plumes_and_blooms

Note: This is variant of a similar figure shown during the expert workshop.

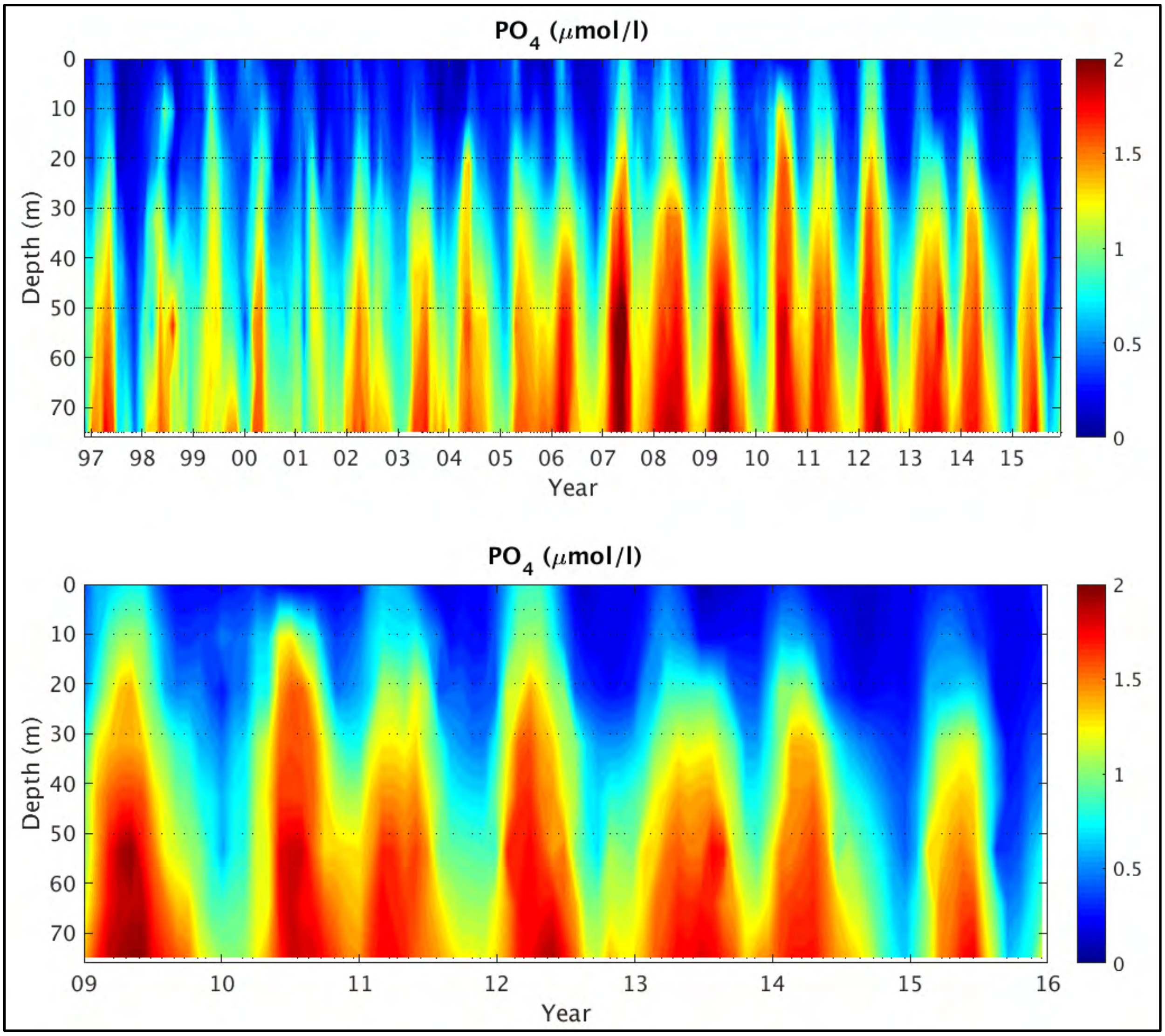


Figure App.D.6.6. Phosphate concentration (PO_4 μg/L) at Plumes and Blooms sampling station #4 (34°15.01'N, 119°54.38'W, see Figure D6.2) for (a) 1997–2015; and (b) 2009–2015 a subset of Figure D6.7a of the years since the last condition report. While station #4 is outside the sanctuary boundary and there are other sampling sites within the sanctuary, it is the only sampling site that collects measurements throughout the water column, versus from just surface waters. This time-depth contour plot was generated via ordinary kriging with a generalized exponential-Bessel fitting model (GLOBEC Kriging Software Package v3.0), with interpolation length scales of 30 days (time axis) and ten meters (depth axis). The time and location of each actual sample are shown as black dots, allowing the observation of periods where data gaps exist. Figure: Siegel et al. *submitted*. Plumes and Blooms: http://www.oceancolor.ucsb.edu/plumes_and_blooms

Note: This is variant of a similar figure shown during the expert workshop.

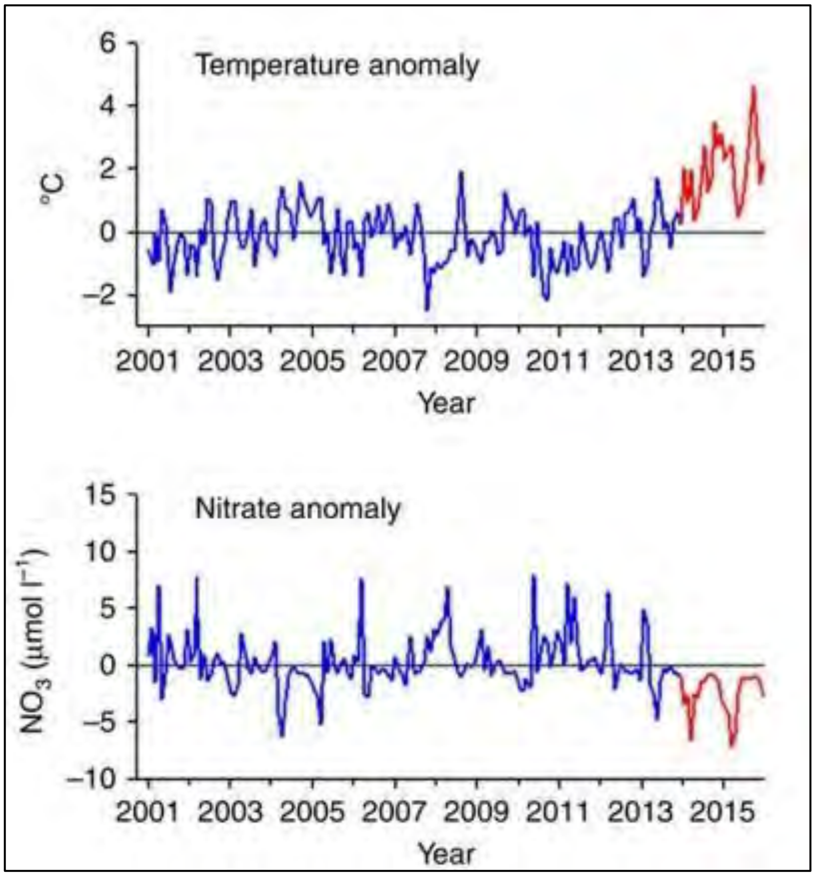


Figure App.D.6.7.** Monthly anomalies in (top panel) observed bottom temperature (°C) at 7–10 meters depth and (bottom panel) modeled bottom nitrate concentrations (µmol/L) at 7–10 meters depth along the Santa Barbara Channel mainland nearshore (nine sampling sites roughly spanning from Gaviota east to Ventura). The anomalously warm years of 2014–2015 are shown in red. Similar trends were seen at the islands. Figure: Reed et al. 2016/Santa Barbara Coastal Long-term Ecological Research

7. Do sanctuary waters pose risks to human health and how are they changing?

Table App.D.7.1. Data presented to water quality experts at the May 31, 2016 workshop to update status and trend assessments for Channel Islands National Marine Sanctuary (CINMS).
**Denotes graphs that were unavailable for expert review during the workshop; however, a representative from the monitoring program was present at the workshop and discussed the data.

Indicator	Source	Figure #	Data Summary
Domoic Acid Levels in Crab/Shellfish Tissue			
Domoic acid levels within the Santa Barbara Channel in invertebrate tissue	C. Culver, CA Sea Grant; McCabe et al. 2016	App.D.7.1–App.D.7.2	*Status:* Domoic acid is present within tissue samples of local fisheries species long after a toxigenic bloom event. *Trend:* Domoic acid events are increasing in frequency.
Presence of Pseudo-nitzschia			
Pseudo-nitzschia abundance and concentration	Sekula-Wood et al. 2011; McCabe et al. 2016; Plumes and Blooms sampling, analysis by S. Amiri, CINMS; Krause et al. 2013; Cavole et al. 2016; McKibben et al. 2017	App.D.7.1, App.D.7.3, App.D.7.4b	*Status:* Presence is cyclic and most frequent when upwelling anomalies are positive. 2015 bloom was unprecedented in abundance and spatial extent. *Trend:* Blooms became more pronounced starting in 2001. HAB events seem to be influenced by long-term climatic oscillations (e.g., PDO).
Domoic Acid Levels in Water Samples			
Domoic acid flux (e.g., HAB)	Sekula-Wood et al. 2011; Anderson et al. 2006, 2008, 2009 and 2016; McCabe et al. 2016	App.D.7.4a	*Status:* Presence is episodic. There have been no known human illnesses related to Santa Barbara Channel HABs; however, there have been a number of HAB-related health effects observed in other organisms with nervous systems. *Trend:* HABs are increasing in frequency and spatial distribution. Domoic acid presence peaks became more frequent starting in 2001.

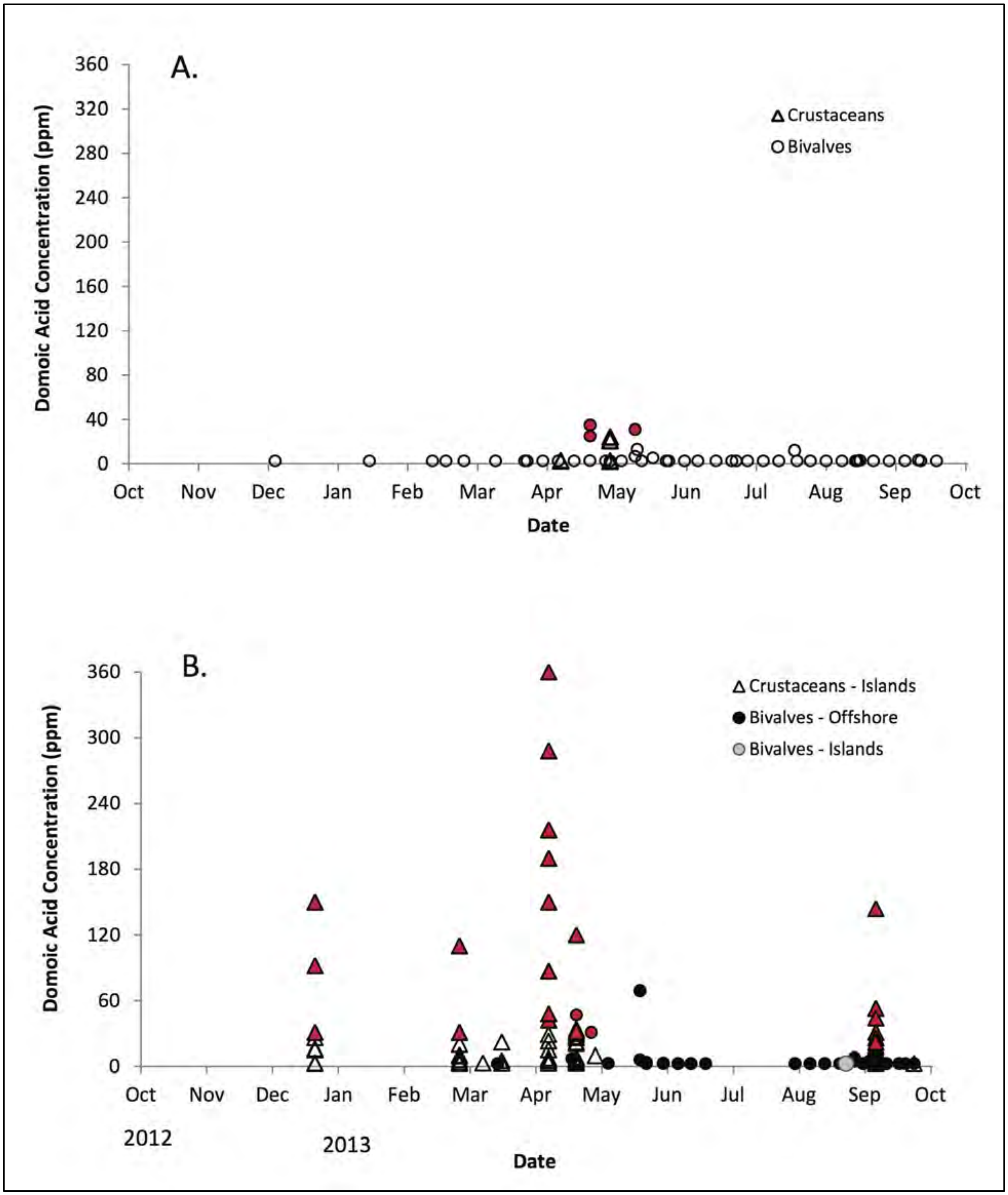
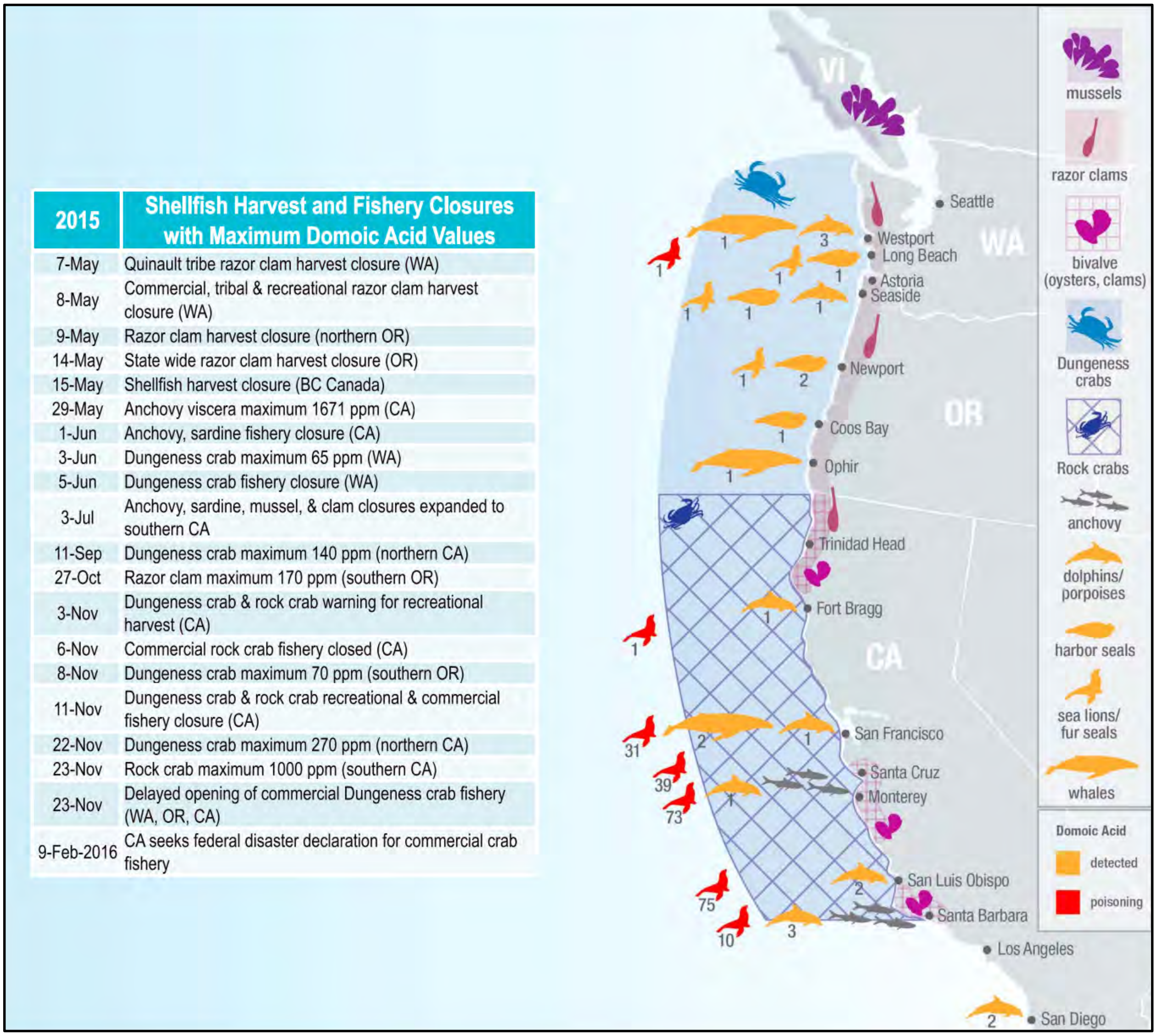


Figure App.D.7.1. Domoic acid levels in parts per million (ppm) in commercially-important crustaceans (triangles) and bivalves (circles) collected from the Santa Barbara Channel between 2012 and 2013 are shown on the y-axis for (A) animals collected near the shore of the mainland coast, and (B) animals collected offshore the mainland coast or near the northern Channel Islands. In the cases that are colored red, domoic acid levels measured above the California Department of Public Health and U.S. Food and Drug Administration action limits: 20 ppm for meat and 30 ppm for viscera. Figure: C. Culver/CA Sea Grant, unpublished data



2015	Shellfish Harvest and Fishery Closures with Maximum Domoic Acid Values
7-May	Quinault tribe razor clam harvest closure (WA)
8-May	Commercial, tribal & recreational razor clam harvest closure (WA)
9-May	Razor clam harvest closure (northern OR)
14-May	State wide razor clam harvest closure (OR)
15-May	Shellfish harvest closure (BC Canada)
29-May	Anchovy viscera maximum 1671 ppm (CA)
1-Jun	Anchovy, sardine fishery closure (CA)
3-Jun	Dungeness crab maximum 65 ppm (WA)
5-Jun	Dungeness crab fishery closure (WA)
3-Jul	Anchovy, sardine, mussel, & clam closures expanded to southern CA
11-Sep	Dungeness crab maximum 140 ppm (northern CA)
27-Oct	Razor clam maximum 170 ppm (southern OR)
3-Nov	Dungeness crab & rock crab warning for recreational harvest (CA)
6-Nov	Commercial rock crab fishery closed (CA)
8-Nov	Dungeness crab maximum 70 ppm (southern OR)
11-Nov	Dungeness crab & rock crab recreational & commercial fishery closure (CA)
22-Nov	Dungeness crab maximum 270 ppm (northern CA)
23-Nov	Rock crab maximum 1000 ppm (southern CA)
23-Nov	Delayed opening of commercial Dungeness crab fishery (WA, OR, CA)
9-Feb-2016	CA seeks federal disaster declaration for commercial crab fishery

Figure App.D.7.2. Impacts of domoic acid (DA) on fisheries and marine mammals in 2015. Shaded areas with shellfish symbols on land denote shellfish closures. Fish symbols indicate northern anchovy closures at designated landing sites. Shaded or hatched areas offshore (Dungeness crab and rock crab) correspond to the closures listed on the left. Stranded marine mammals with detectable DA (orange) and California sea lions diagnosed with DA poisoning (red) are pictured with the number of individuals indicated. DA poisoning is defined as the presentation of at least two of the following: neurologic signs (i.e., seizures, head weaving, ataxia), detectable DA, histopathologic lesions, and/or blood chemistry changes. Figure: McCabe et al. 2016

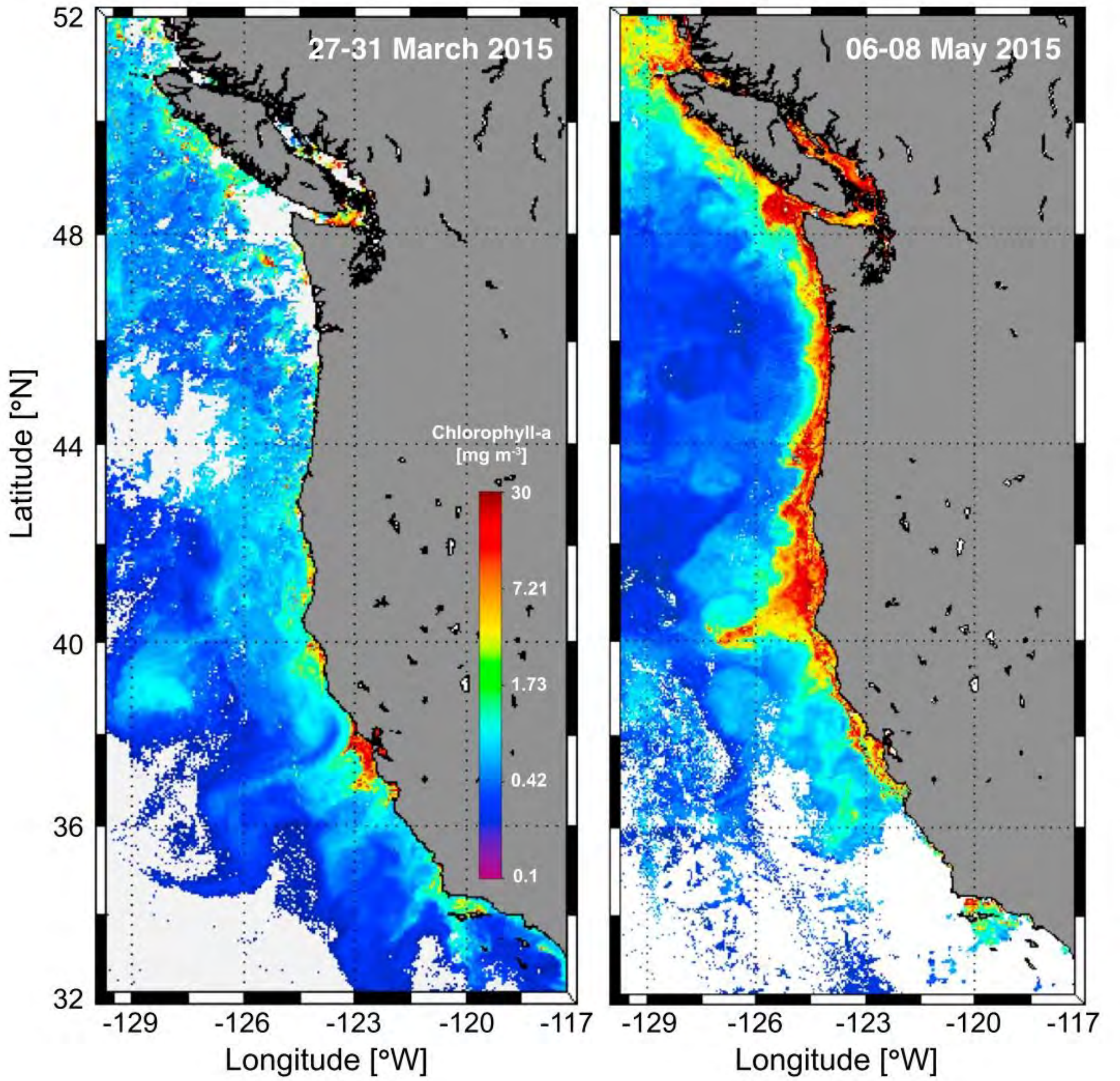


Figure App.D.7.3. In May 2015, an unprecedented West Coast-wide harmful algal bloom (HAB) extended from the Gulf of Alaska to southern California. The bloom was composed of *Pseudo-nitzschia*, a toxigenic diatom that has the ability to produce domoic acid, a potent neurotoxin that can cause amnesic shellfish poisoning (ASP) and threaten human health if affected shellfish are consumed. These satellite images show chlorophyll-a estimates averaged over the periods of March 27–31, 2015 (left panel), and May, 6–8, 2015 (right panel). Data source: Satellite data were obtained from the National Aeronautics and Space Administration Ocean Biology Processing Group (OBPG) using a combination of the MODerate resolution Imaging Spectroradiometer (MODIS) on Aqua and Visible Infrared Imaging Radiometer Suite (VIIRS) chlorophyll products. Data were processed using standard OBPG processing with 4 kilometer imagery. Figure: McCabe et al. 2016

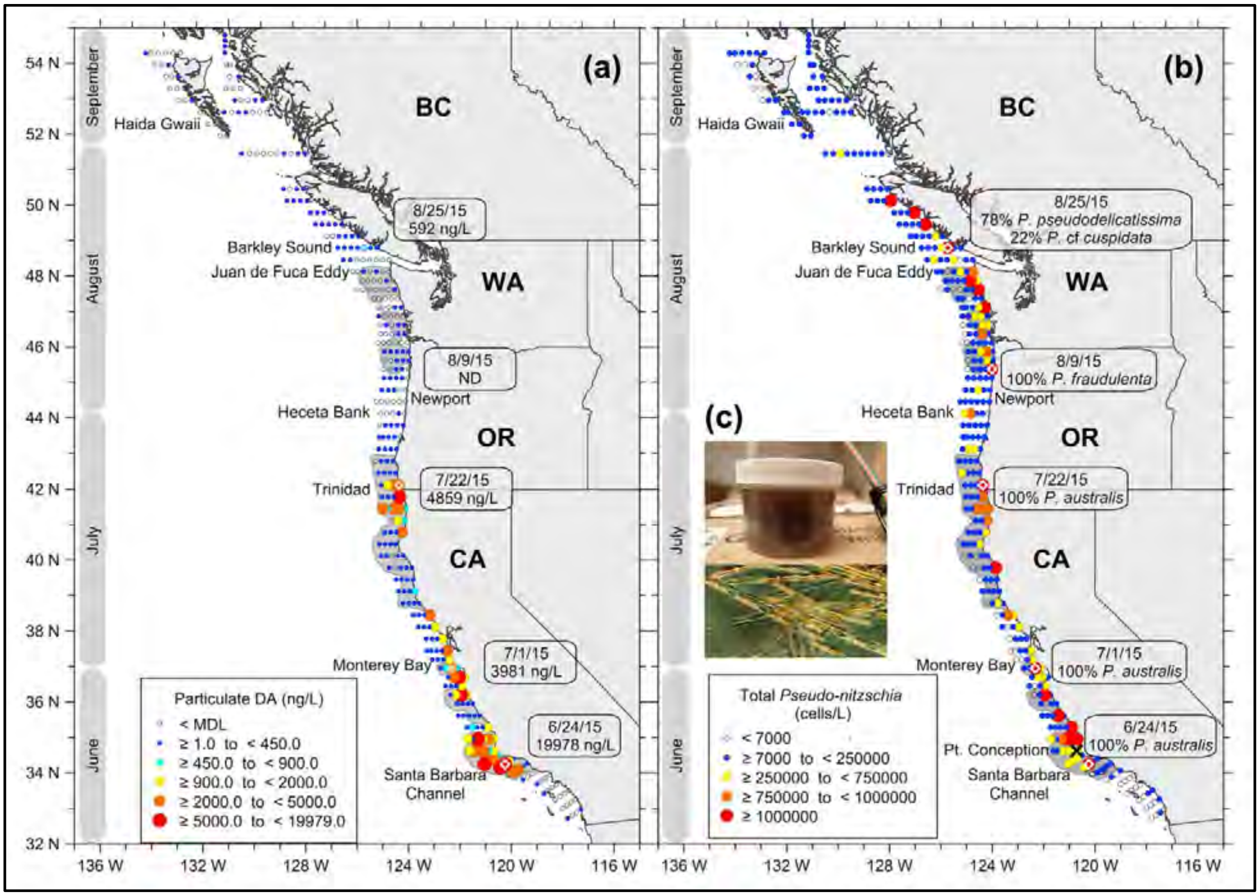


Figure App.D.7.4 (a) Particulate domoic acid (pDA) and (b) *Pseudo-nitzschia* abundance in surface (3 meter) seawater samples collected aboard the NOAA ship *Bell M. Shimada* from June through September 2015 (months shown in shaded boxes, left side of both panels). Red "targets" in (b) are locations where representative pDA and *Pseudo-nitzschia* abundances are shown on select dates in adjacent boxes. Gray shading along the coast indicates regions where *Pseudo-nitzschia* was the dominant phytoplankton. (c) A Bongo net tow sample off Point Conception on June 24, 2015 (concentrated sample, top panel; microscopic image of approximately 100X diluted sample at 200X magnification, bottom panel). ND = not detected. Highest domoic acid levels from the bloom were identified within the Santa Barbara Channel (19,978 ng/L), but no known related human illness cases were reported. Figure: McCabe et al. 2016

8. Have recent changes in climate altered water conditions and how are they changing?

Table App.D.8.1. Data presented to water quality experts at the May 31, 2016 workshop to update status and trend assessments for Channel Islands National Marine Sanctuary (CINMS).
**Denotes graphs that were unavailable for expert review during the workshop; however, a representative from the monitoring program was present at the workshop and discussed the data.

Indicator	Source	Figure	Data Summary
Pacific Decadal Oscillation (PDO)			
PDO Index	NOAA	App.D.8.2–D.8.3 (middle panel)	*Status:* Recent years have been marked by strong positive PDO, thus warm surface water temperatures in the North Pacific. *Trend:* PDO state is predicted to continue to fluctuate between positive and negative.
Oceanic Niño Index (ONI)			
ONI	NOAA	App.D.8.3 (top panel)	*Status:* There was a strong El Niño event that peaked in the winter of 2015–2016, but the influence on productivity in the California Current was not as pronounced as previous strong El Niño events. *Trend:* La Niña conditions are predicted to follow during fall and winter 2017-2018; changing weather patterns may lead to more extreme ENSO fluctuations in the future.
North Pacific Gyre Oscillation (NPGO)			
NPGO Index	NOAA	App.D.8.3 (bottom panel)	*Status:* 2007–2013 NPGO was positive, indicating higher upwelling and productivity in the California Current; and 2014–2016 NPGO was negative, indicating lower upwelling and productivity. *Trend:* NPGO state is predicted to continue to fluctuate between positive and negative.
Temperature (SST)			
Sea surface temperature (SST) anomaly	Plumes and Blooms; CalCOFI and SCCOOS; Kapsenberg and Hofmann 2016; NOAA ERSST (Jacox et al. 2016); see *The Warm Water Event*	App.D.8.4–D.8.5**, App.D.8.6–D.8.7 (bottom panel)	*Status:* The recent El Niño and the warm water event have led to abnormally high SST, the highest in the 18-year time series. *Trend:* SST has been gradually increasing and warming is predicted to continue. It is unknown if marine heat waves will reoccur, and if so, at what frequency.
Dissolved Oxygen (DO)			
O_2 levels at CalCOFI Stations	CalCOFI; Bograd et al. 2008; Meinvielle and Johnson 2013; Bograd et al. 2015; Schmidtko et al. 2017	App.D.8.7 (top panel)–, D.8.9	*Status:* Currently, surface DO values are oxic and slightly below the long-term mean. *Trend:* DO has declined in the Southern California BIght. It is believed that warming will cause continued DO declines off California.
pH			
pH	PMEL NOAA; Sutton et al. 2016; Kapsenberg and Hofmann 2016;	App.D.8.10, D.8.11a, App.D.8.12–	*Status:* pH is variable by location and season. pH decreases during upwelling events. *Trend:* pH values appear to be declining; however,

	Turi et al. 2016; Marshall et al. 2017	D.8.14**	ocean acidification refugia habitats (e.g., eelgrass) need to be further explored and described.

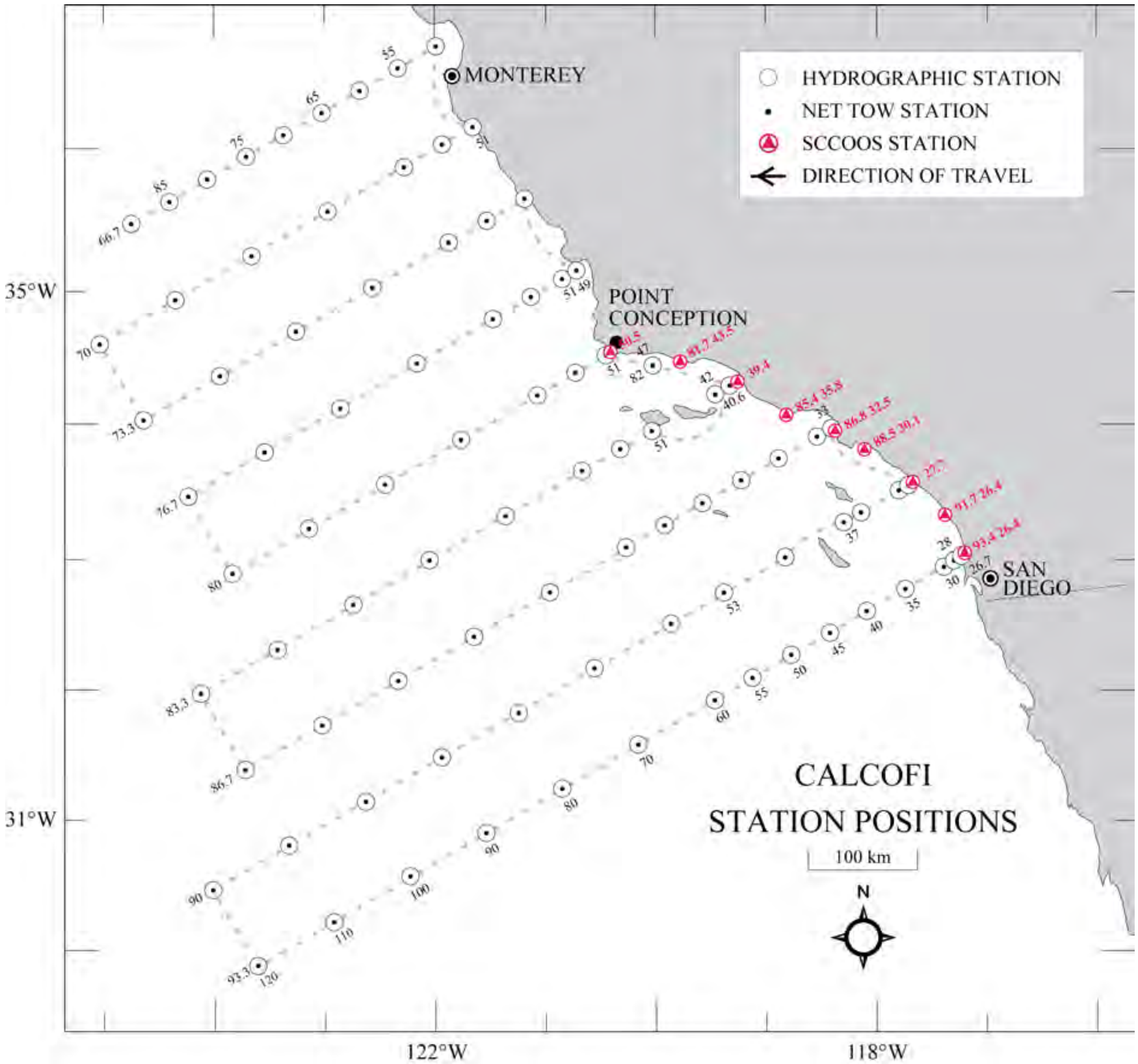


Figure App.D.8.1. California Cooperative Oceanic Fisheries Investigations (CalCOFI) sampling station positions. Southern California Coastal Ocean Observing System (SCCOOS) stations are in red. Figure: CalCOFI, http://calcofi.org/graphics/458-station-maps.html

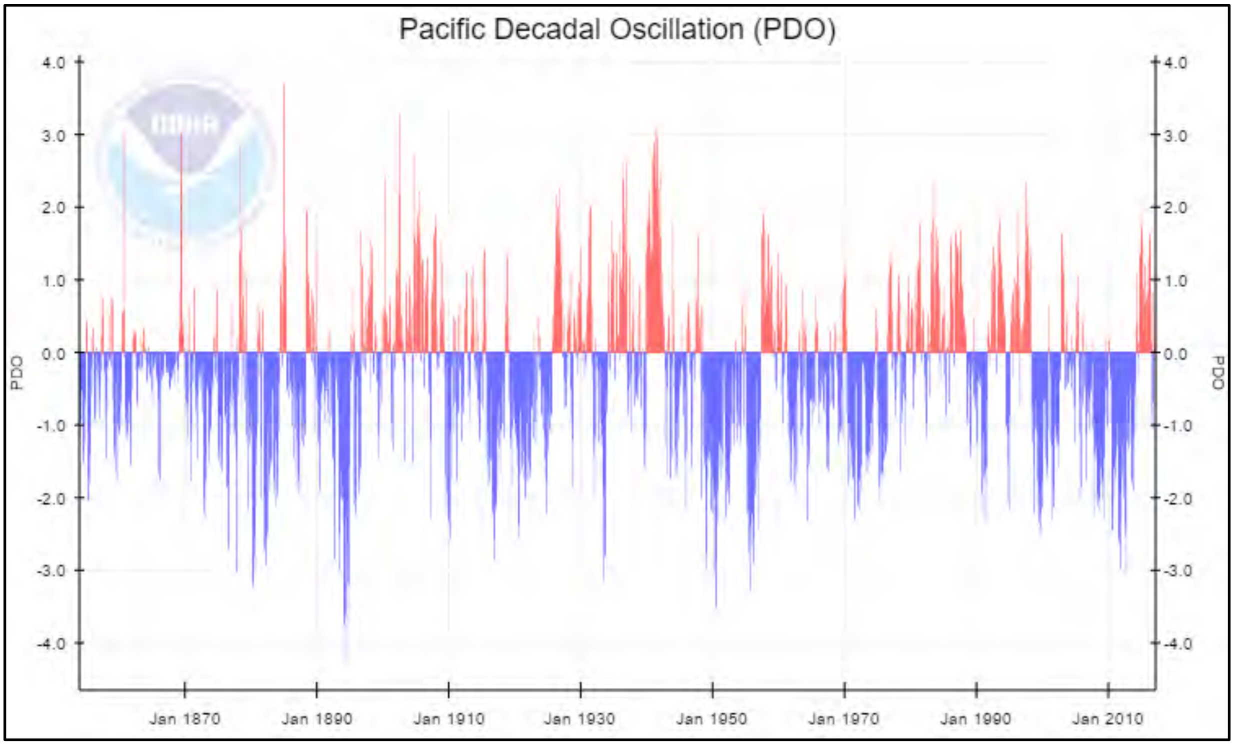


Figure App.D.8.2. To compute a PDO regression map for the North Pacific ERSST anomalies Extended Reconstructed Sea Surface Temperature (ERSST), https://www.ncdc.noaa.gov/data-access/marineocean-data/extended-reconstructed-sea-surface-temperature-ersst-v4) anomalies were regressed against the Mantua PDO index (http://research.jisao.washington.edu/pdo/PDO.latest.txt) to compute a PDO regression map for the North Pacific ERSST anomalies. The ERSST anomalies were then projected onto that map to compute the NCEI PDO index. The NCEI PDO index closely follows the Mantua PDO index. Data source: NOAA National Center for Environmental Information (NCEI), Figure: https://www.ncdc.noaa.gov/teleconnections/pdo/

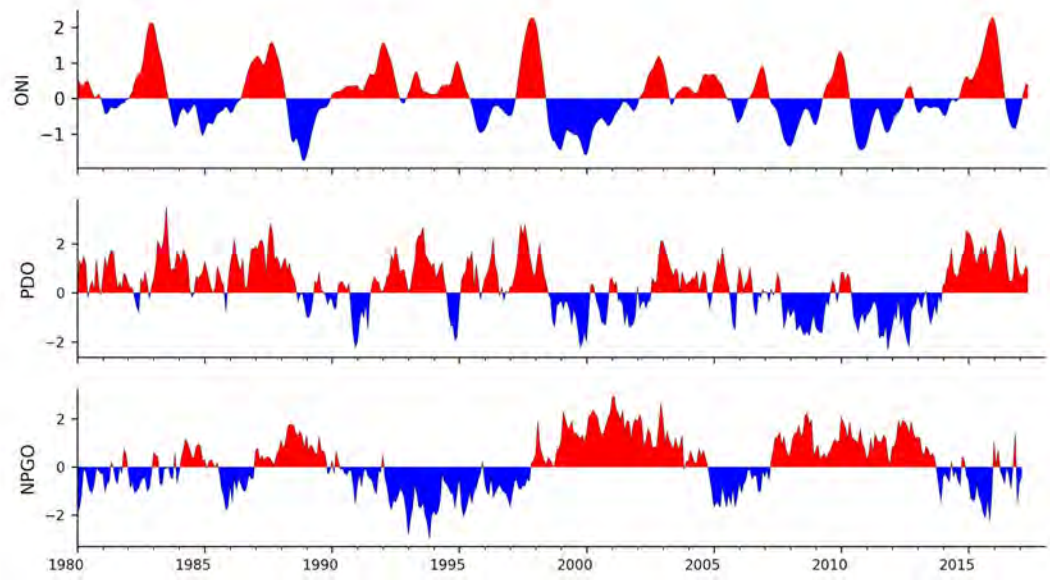


Figure App.D.8.3. Three indices of climate and ocean conditions in the North Pacific Basin shifted in 2014 from conditions promoting high primary productivity to less productive conditions. The Oceanic Niño Index (ONI) indicates the presence/absence of El Niño conditions with positive anomaly values (red) denoting El Niño conditions and negative values denoting La Niña conditions. The Pacific Decadal Oscillation (PDO) index is related to North Pacific sea surface temperature with cold regimes (blue) associated with higher productivity and warmer regimes (red) associated with lower productivity. The North Pacific Gyre Oscillation (NPGO) is influenced by sea level and circulation patterns. Positive values of the NPGO (red) are linked to stronger currents and higher productivity while negative values (blue) are linked to weaker currents and lower productivity. The graphs show the long-term mean (0) ± 3.0 standard deviations based on the full time series. Data source: NPGO data from: http://www.o3d.org/npgo/; PDO data from http://jisao.washington.edu/pdo/; ONI data from: http://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php. Figure: I. Schroeder/NOAA

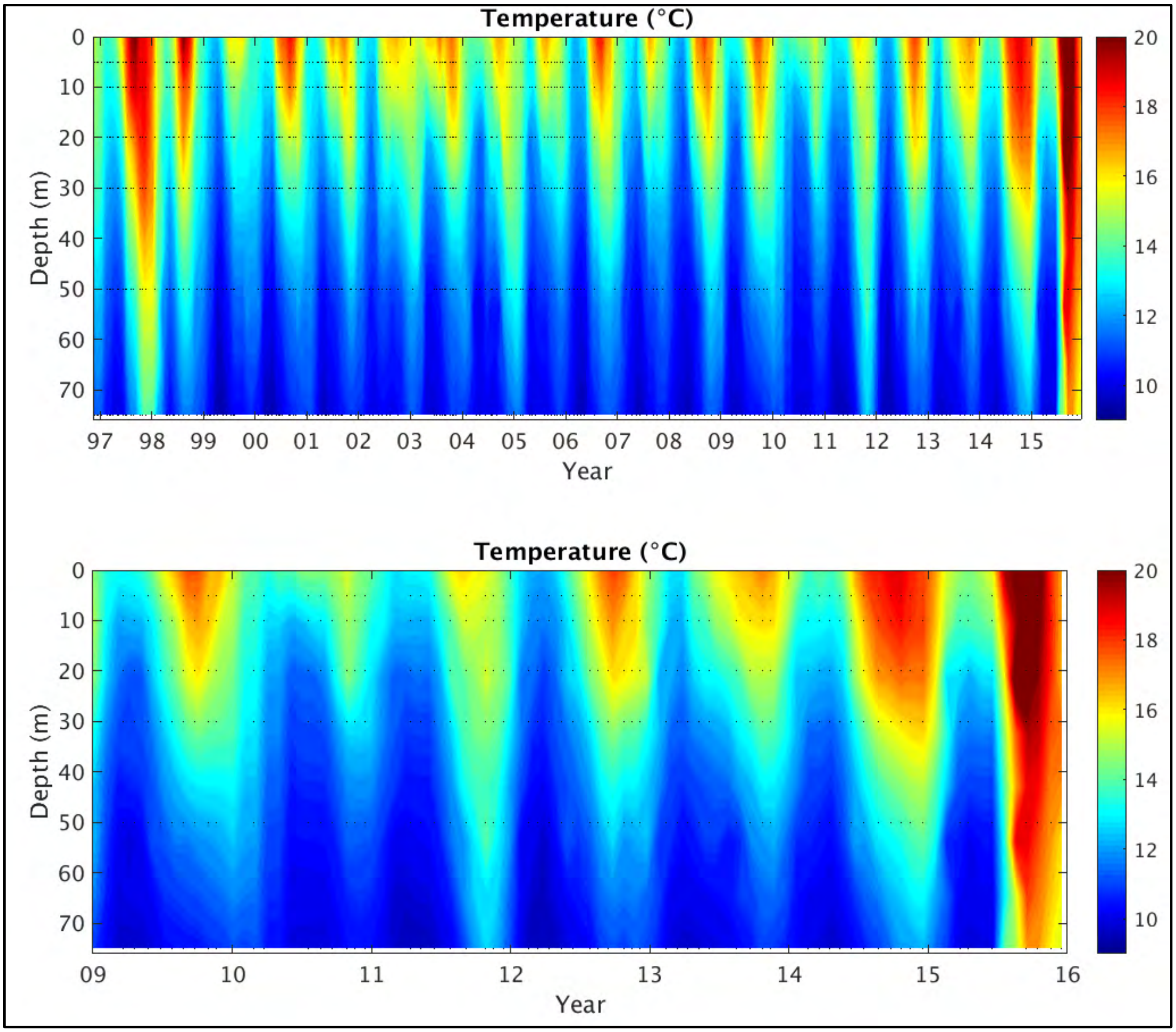


Figure App.D.8.4. Time-series of temperature (°C) profiles at Plumes and Blooms sampling station #4 (34°15.01'N, 119°54.38'W, see Figure D6.2) for (a) 1997–2015; and (b) 2009–2015 a subset of Figure D8.4a of the years since the last condition report. While station #4 is outside the sanctuary boundary and there are other sampling sites within the sanctuary, it is the only sampling site that collects measurements throughout the water column, versus from just surface waters. This time-depth contour plot was generated via ordinary krigging with a generalized exponential-Bessel fitting model (GLOBEC Kriging Software Package v3.0), with interpolation length scales of 30 days (time axis) and ten meters (depth axis). The time and location of each actual sample are shown as black dots, allowing the observation of periods where data gaps exist. Figure: Siegel et al. *submitted*. Plumes and Blooms: http://www.oceancolor.ucsb.edu/plumes_and_blooms

Note: This is variant of a similar figure shown during the expert workshop.

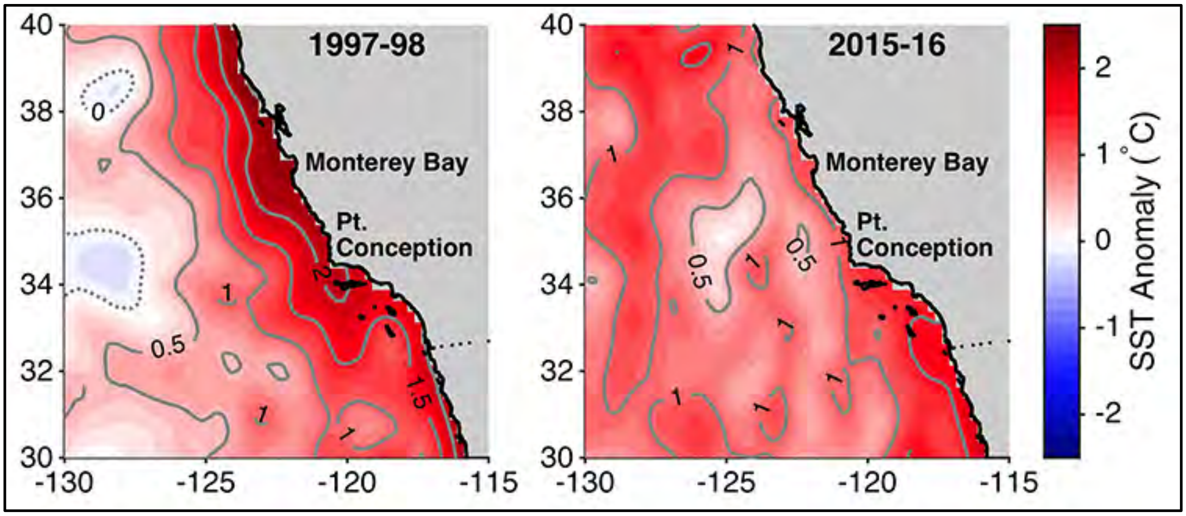


Figure App.D.8.5.** December to February mean sea surface temperature (SST) anomalies for the winters of 1997–1998 and 2015–2016, the last two major El Niño events. Anomalies were calculated using NOAA's 0.25° Optimum Interpolation Sea Surface Temperature (OISST) product with a 1981–2015 base period. The Channel Islands are shown in black and are roughly located at 34°N and 119°W. Equatorial Pacific temperature anomalies were characterized using the Niño 3.4 Index (http://www.cpc.ncep.noaa.gov/data/indices/), calculated using Extended Reconstructed Sea Surface Temperature v4 with five-year centered base periods to remove any long-term trends, and 20° C isotherm depth anomalies, averaged from 2°S to 2°N, from the Global Ocean Data Assimilation System. Figure: Jacox et al. 2016
Note: This figure was not shown at the expert workshop, but the information was discussed.

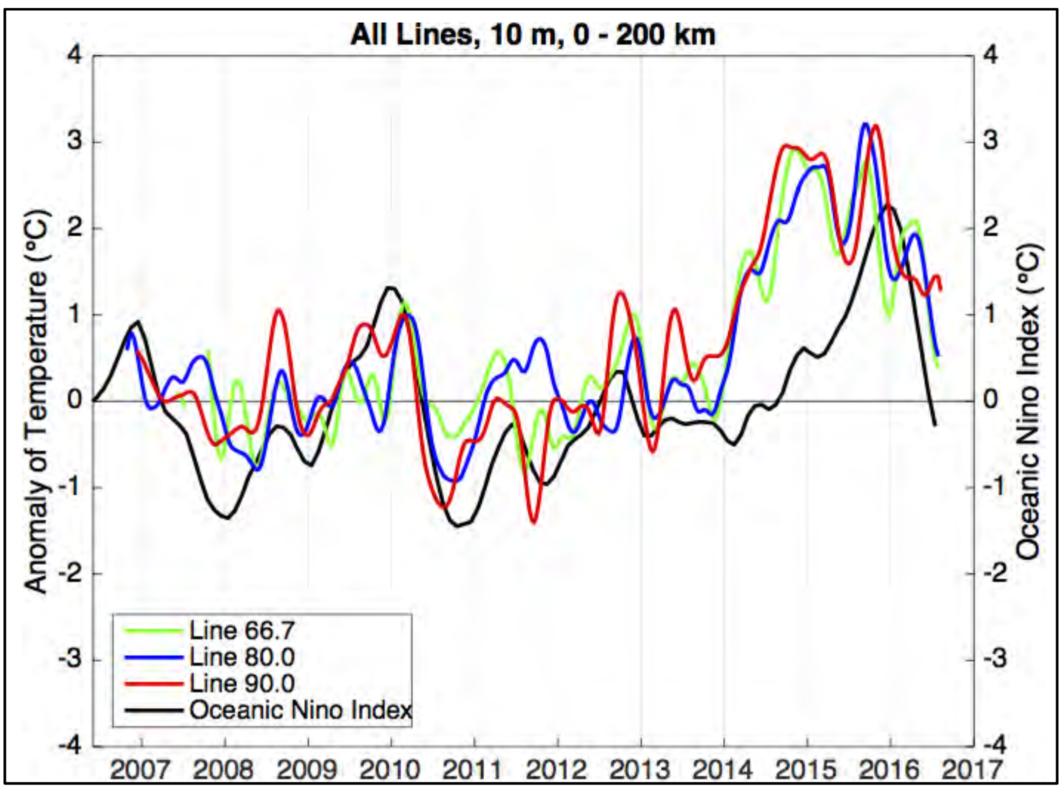


Figure App.D.8.6. Temperature anomaly (°C) at 10 meters in the Santa Barbara Channel from 2007–2015 observed via autonomous underwater vehicles. CalCOFI Line 66.7 (from Monterey Bay offshore) is displayed in green, Line 80.0 (from Point Conception offshore) in blue, and Line 90.0 (from San Clemente offshore) in red (see Figure D8.1). The current ENSO phase is often quantized by a deviation from normally observed SST using the Oceanic Niño Index or ONI (see http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_change.shtml), which is displayed in black. Data source: D. Rudnick/ SIO UCSD (Spray gliders: http://spray.ucsd.edu/pub/rel/index.php)
Figure: SCCOOS, http://www.sccoos.org/data/el-nino/

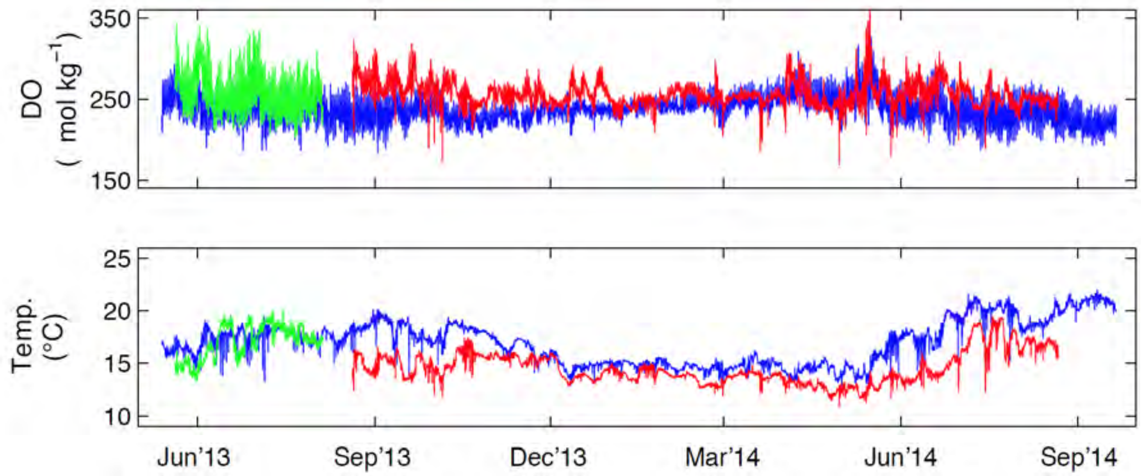


Figure App.D.8.7. Dissolved oxygen (DO) (top panel) and temperature (bottom panel) measured across the northern Channel Islands and in different habitat types, from east to west: Anacapa Island (ALC in blue, kelp forest), San Miguel Island (SMN in red, subtidal mooring), and Santa Cruz Island (PRZ in green, eelgrass bed). Figure: Kapsenberg and Hofmann 2016

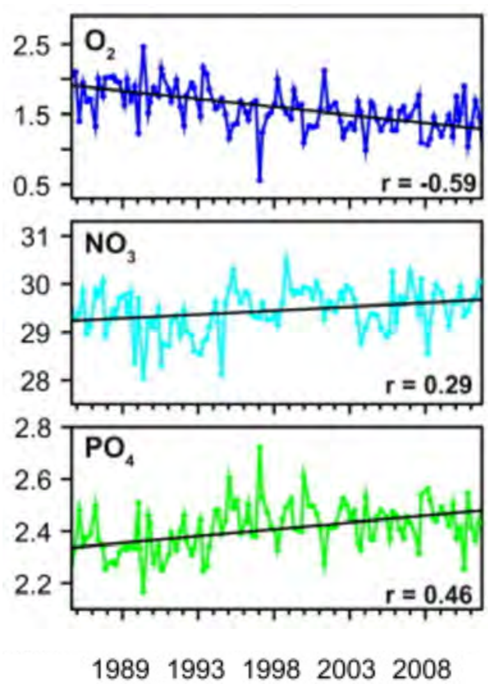


Figure App.D.8.8. Water property time series at Station 93.30 (north of San Diego, see Figure D8.1) on the σθ = 26.5 kg/m^3 isopycnal surface. From top to bottom, dissolved oxygen (mL/L), nitrate (μmol/kg), and phosphate (μmol/kg). Time series cover the period from 1984–2012. Significant linear regression ($p < 0.001$) shown with a black line. Figure: Bograd et al. 2015

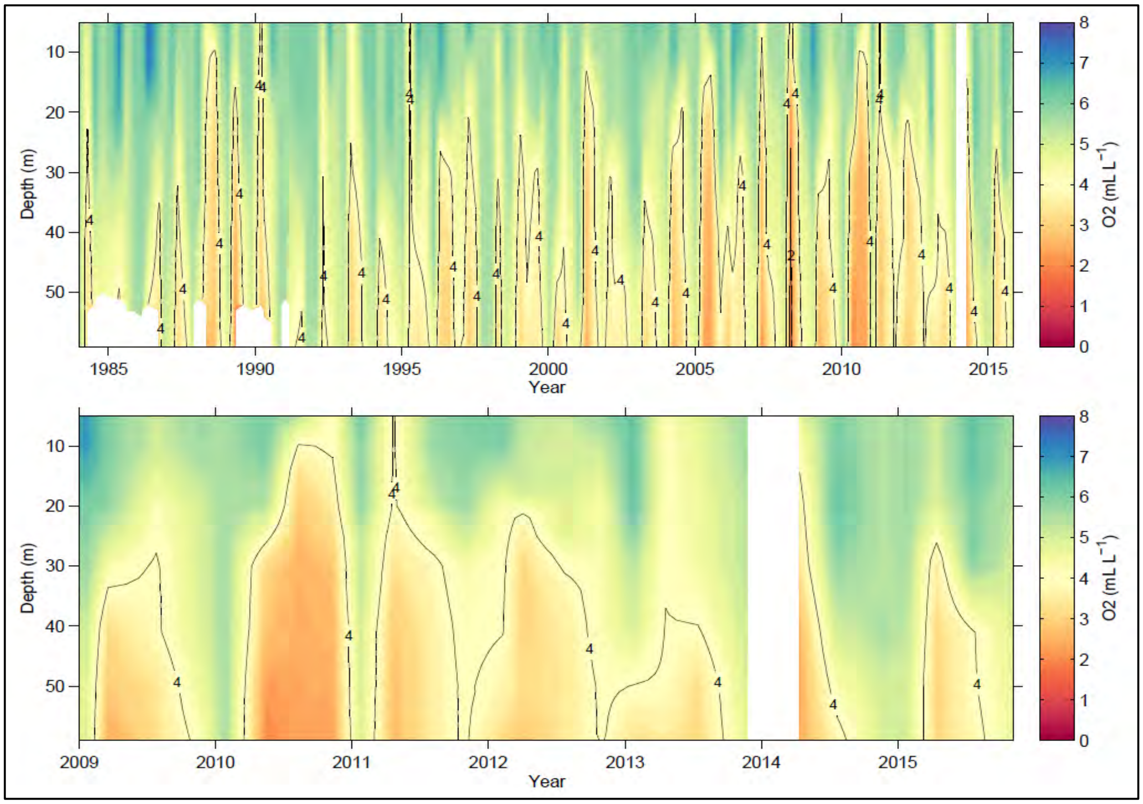
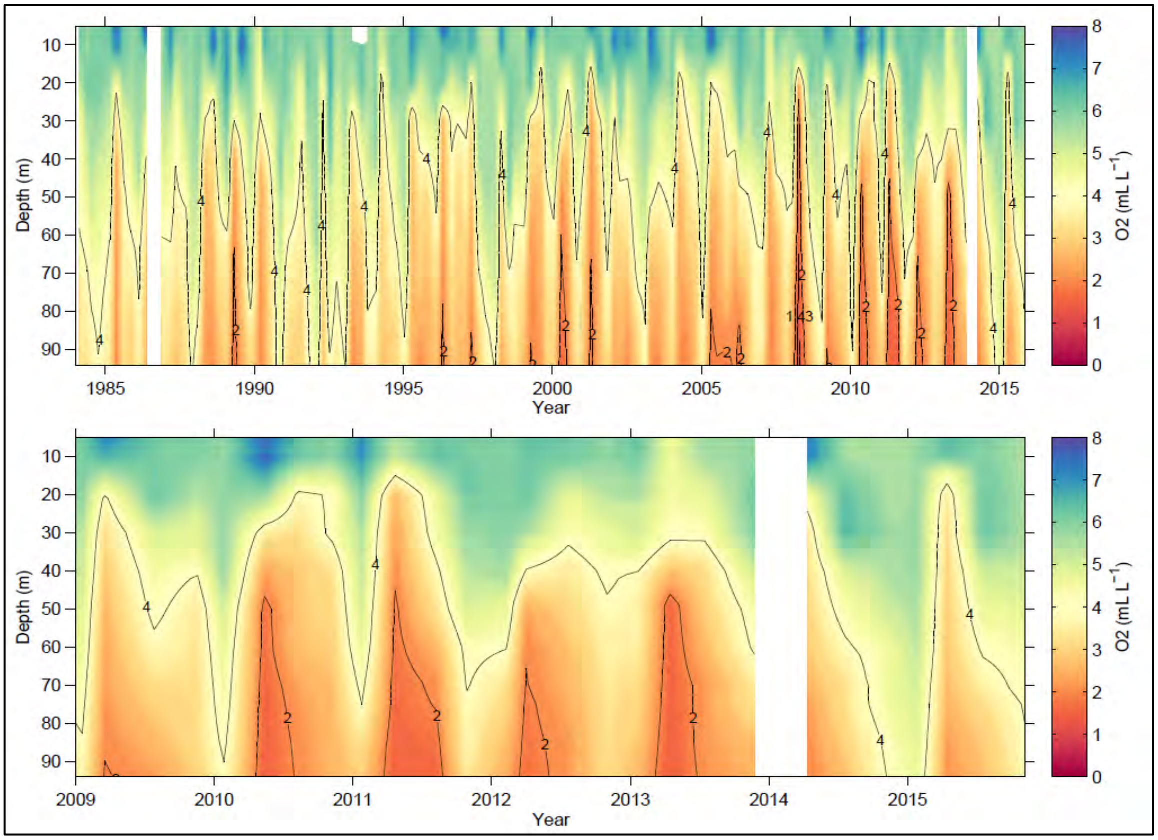


Figure App.D.8.9. Five dissolved oxygen (DO, mL/L) contour plots were created by extracting quarterly data from CalCOFI's CSV database (http://www.calcofi.org/data.html). The standard depths provided from the database were linearly interpolated on a depth profile of 1 meter resolution. White areas mark missing data. For each two-panel plot, two time periods are shown. Top panels show the full time-series of 1984–2015. Bottom panels shows the time period from the 2009 condition report to fall 2015. The y-limit shows 5-100 meters depth, unless the station has a shallower depth. Red indicates low DO, blue indicates higher DO. The five plots are shown in order of decreasing latitude along CalCOFI sampling locations, from Point Conception (top, 80_51) along the coast of the mainland (82_47, 83.3_40.6), into the Santa Barbara Channel (83.3_42), and then wrapping around Anacapa Island to the south side of Santa Rosa (83.3_51). See Appendix D Figure D8.1 to view sampling locations. Data source: CalCOFI; Figure: I. Schroeder/NOAA



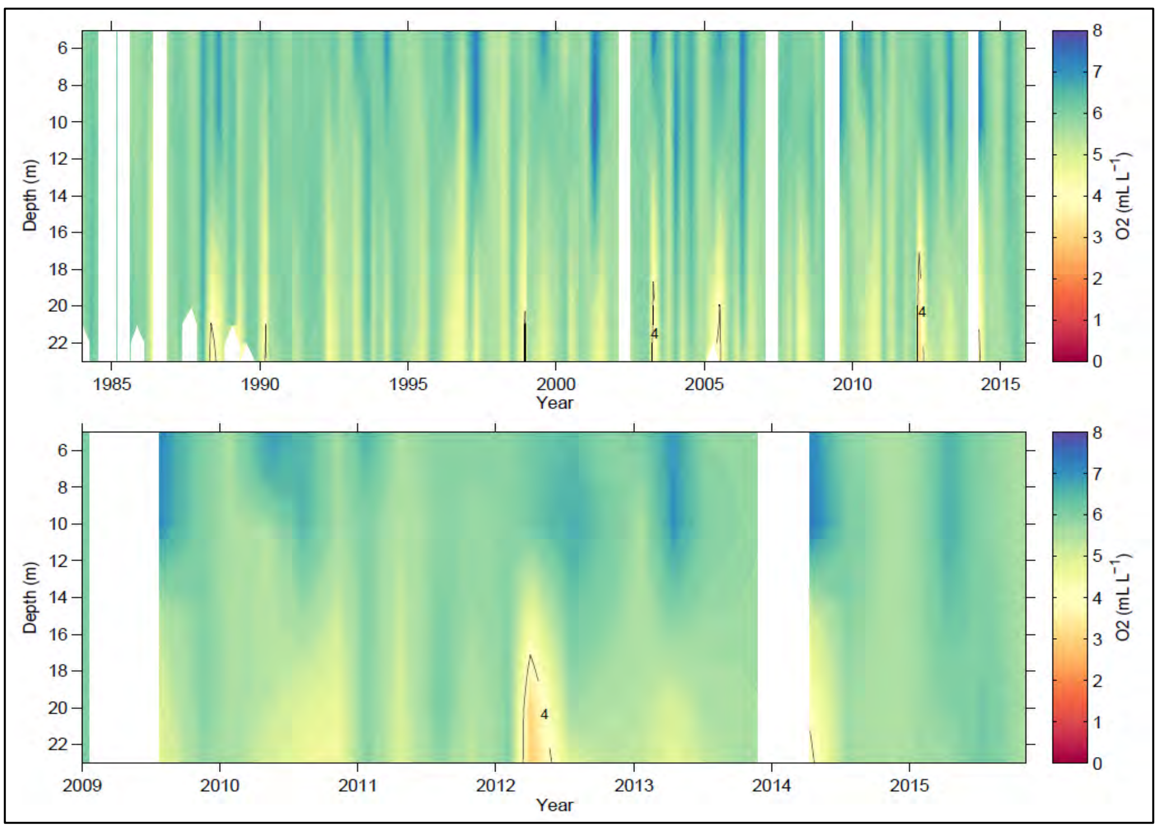
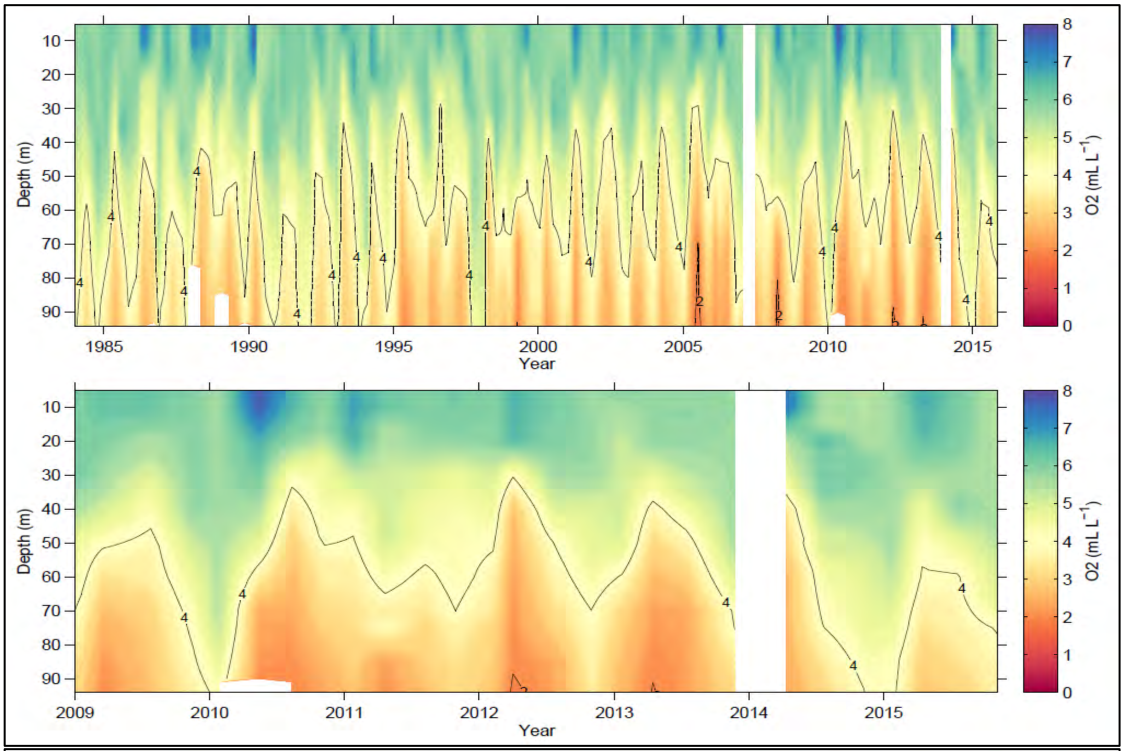


Figure App.D.8.9. (cont.)


Depth (m)
Year
O2 (mL L-1)
1985
1990
1995
2000
2005
2010
2015
2009
2011
2012
2013
2014

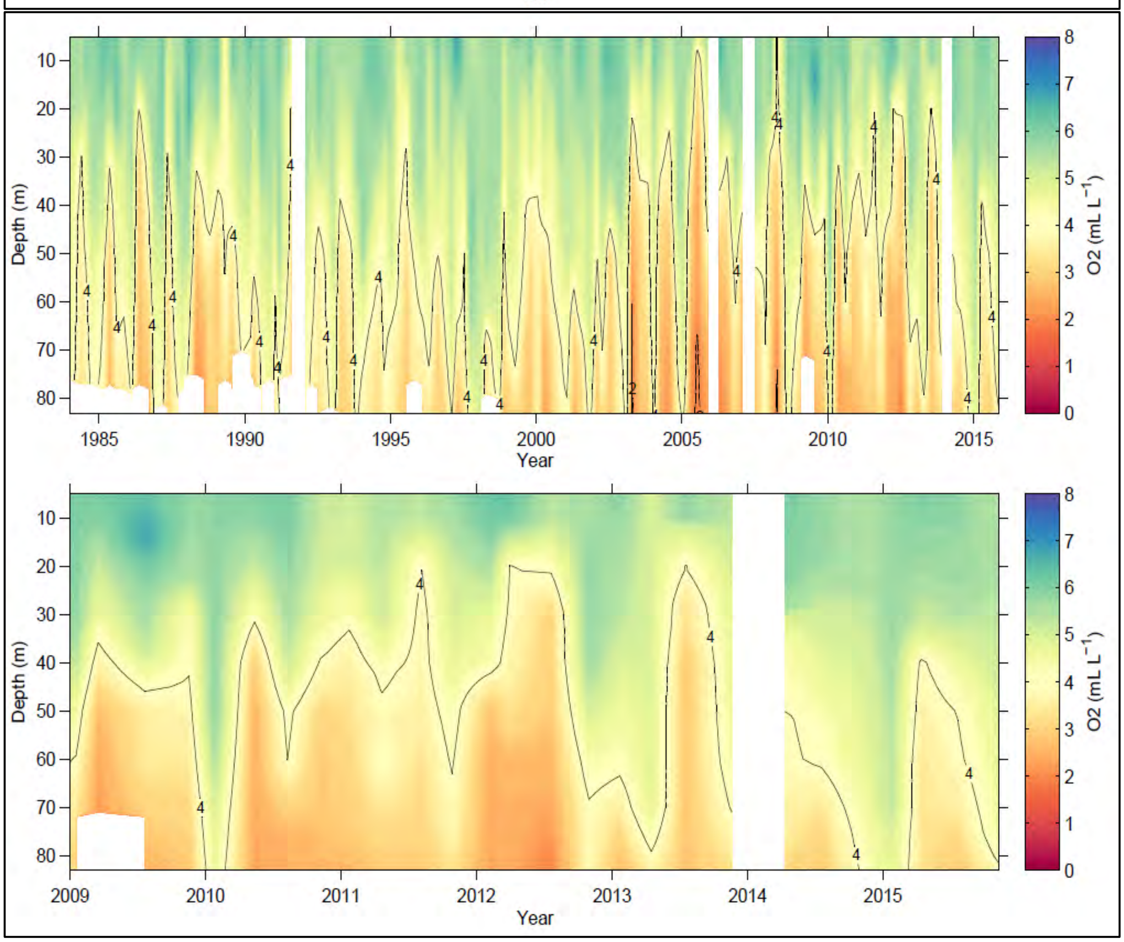

Depth (m)
Year
O2 (mL L-1)
1985
1990
1995
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Figure App.D.8.9. (cont.)

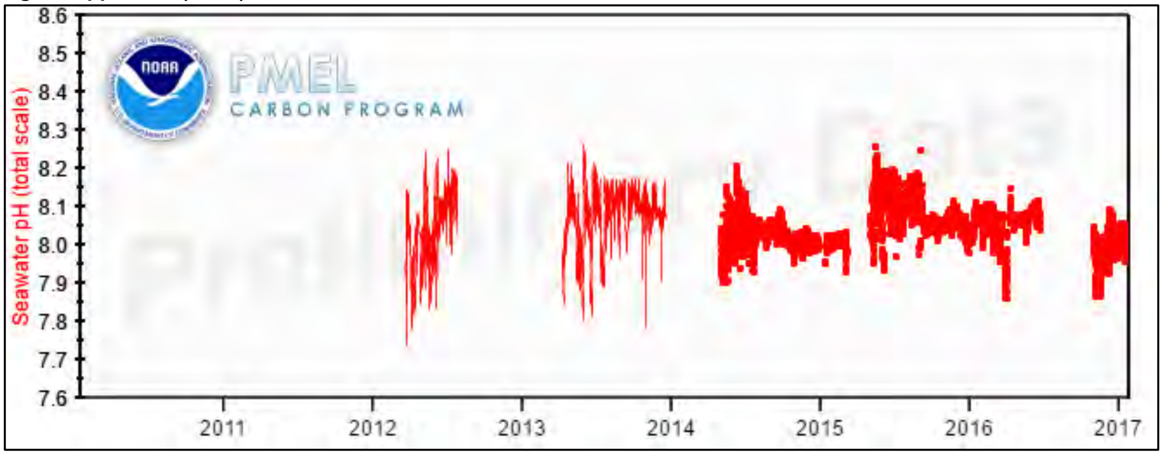


Figure App.D.8.10.** Time-series of pH at California Current ecosystem-2 (CCE-2) mooring near Point Conception (34.324°N, 120.814°W) from 2012–2016. CCE-2 is positioned on the shelf break, where localized upwelling is at a maximum. Data source: PMEL (http://www.pmel.noaa.gov/co2/story/CCE2); Figure: Sutton et al. 2016

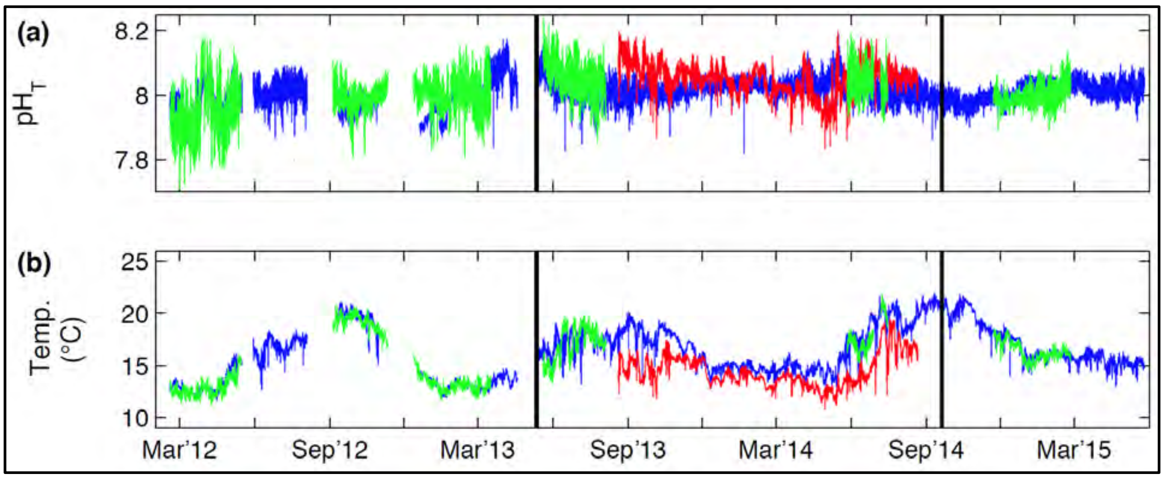


Figure App.D.8.11. (a) pH and (b) temperature (°C) measured across the northern Channel Islands and in different habitat types, from east to west: Anacapa Island (ALC in blue, kelp forest), San Miguel Island (SMN in red, subtidal mooring), and Santa Cruz Island (PRZ in green, eelgrass bed). Deployment period of CTDO sensors is marked by solid vertical lines. Figure: Kapsenberg and Hofmann 2016

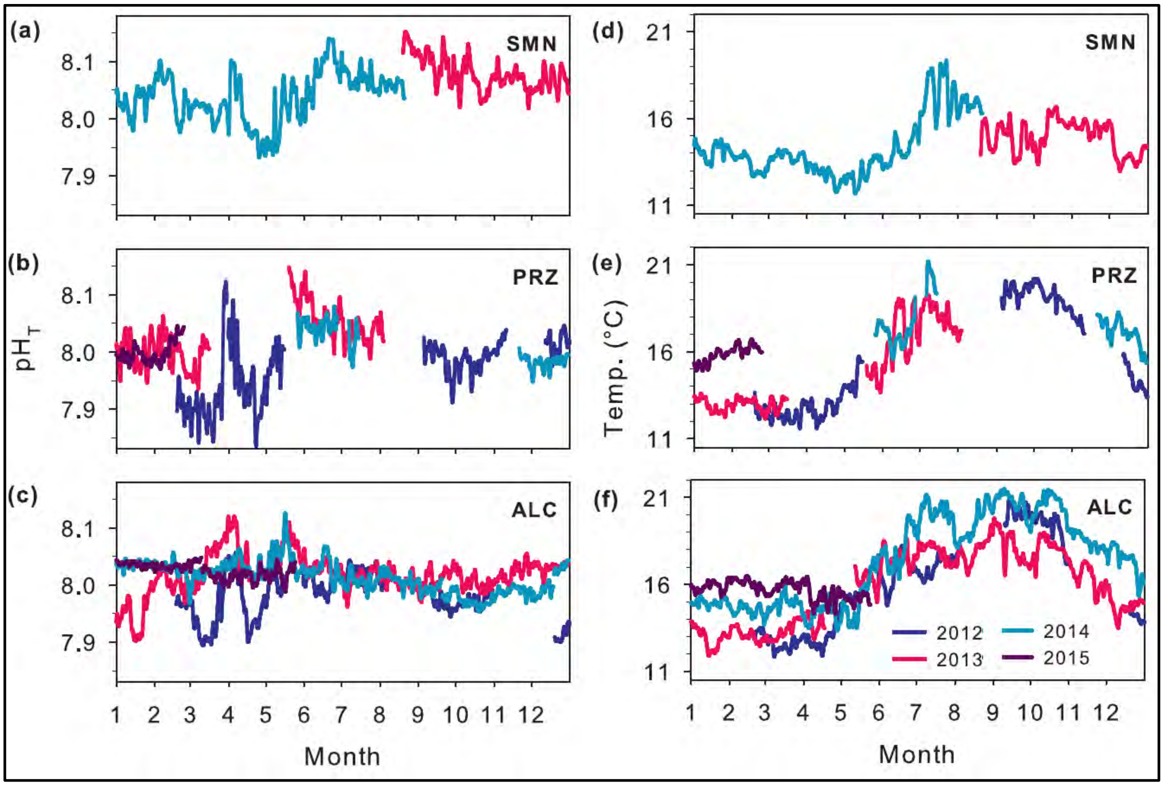


Figure App.D.8.12. Time-series of 48-hour low-pass filtered pH (a–c) and temperature (d–f) by site. Colors represent different years. Samples sites across the northern Channel Islands are in different habitat types, from west to east: San Miguel Island (SMN on top, subtidal mooring), Santa Cruz Island (PRZ in middle, eelgrass bed), and Anacapa Island (ALC on bottom, kelp forest). Figure: Kapsenberg and Hofmann 2016

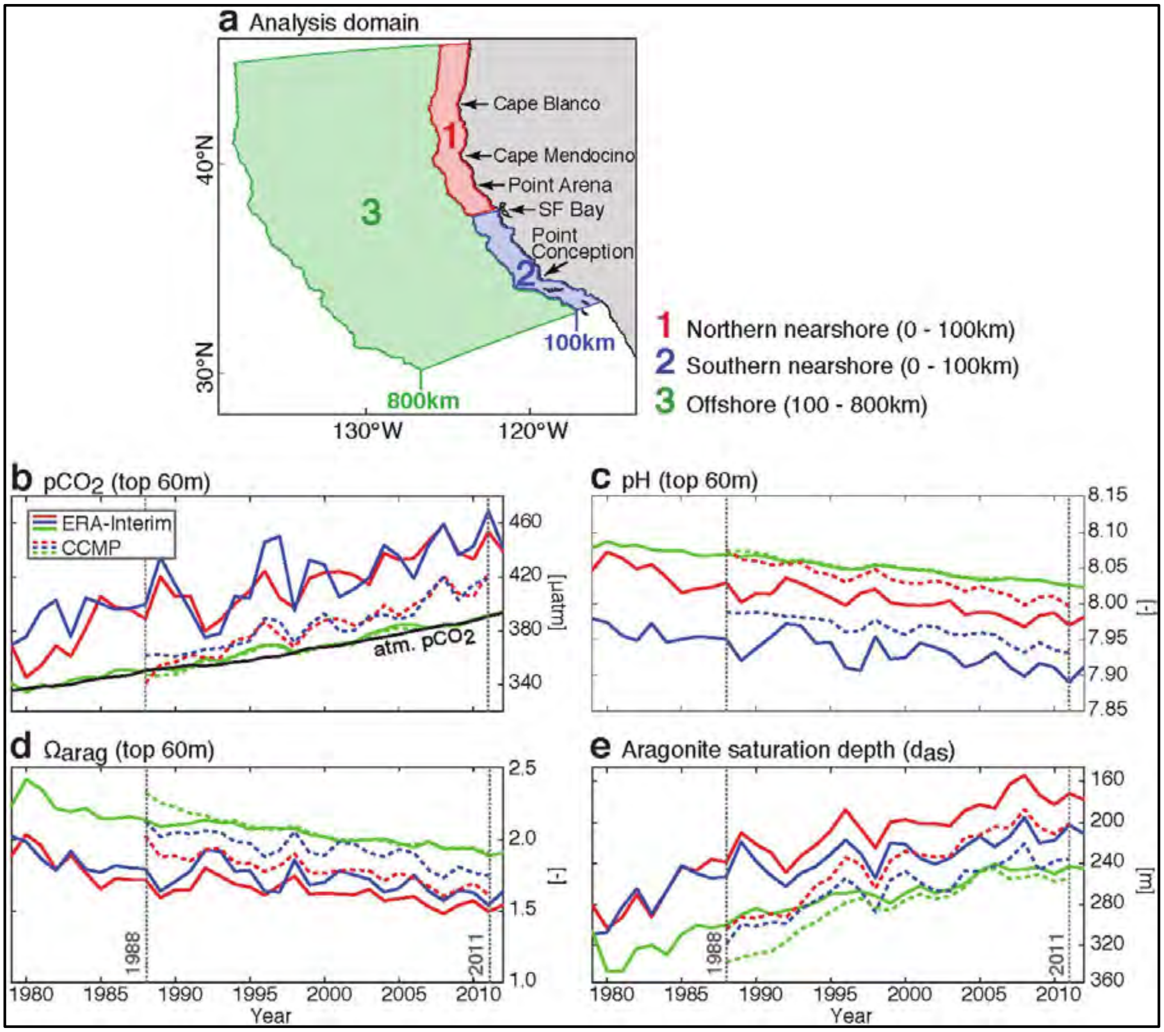


Figure App.D.8.13. (a) Model analysis domain, indicating three regions and highlighting prominent geographical features. The latitudinal extent of Regions 1 and 2 covers the coastal area roughly from the USA/Mexico border (~33°N) to just south of the Columbia River mouth (~46°N). The sanctuary is included in Region 2, highlighted in blue. Temporal evolutions from 1979 to 2012 of annual mean (b) pCO_2, (c) pH, (d) Ω_{arag} , and (e) d_{as} from hindcast model simulations (solid lines, HCast-ERAI; dashed lines, HCast-CCMP), averaged over the three regions shown in panel (a) (color-coded). The black line in panel (b) indicates the temporal evolution of the model's atmospheric CO_2 forcing. pCO_2, pH, and Ω_{arag} trends were averaged over the top 60 meters of the water column. The strong 1997–1998 El Niño is indicated by a vertical dotted date line. Figure: Turi et al. 2016

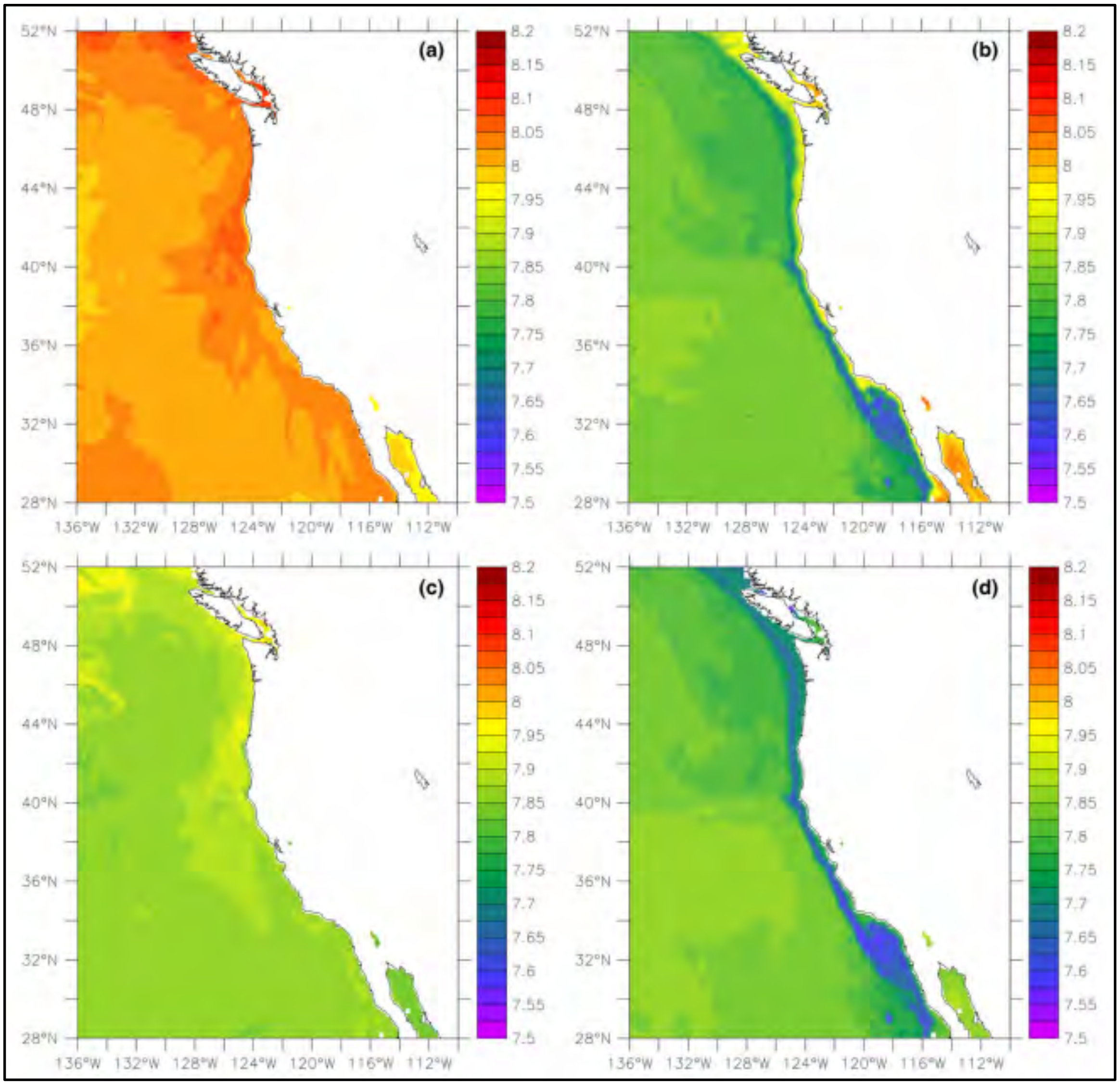


Figure App.D.8.14.** Regional Ocean Modeling System (ROMS) projections of pH in August 2013 (a, b) and August 2063 (c, d), at the surface (a, c) and bottom (b, d). ROMS runs are initialized January 1, 2010, or January 1, 2060, and are forced by Geophysical Fluid Dynamics Laboratory Earth System Model 2M under Intergovernmental Panel on Climate Change Representative Concentration Pathway 8.5. pH within ROMS is calculated from carbonate variables simulated using the model of Fennel et al. (2006, 2008). Figure: Marshall et al. 2017

Note: This figure was not available to be shown at the expert workshop.

9. Are there other stressors, individually or in combination, affecting water quality and how are they changing?

Table App.D.9.1. Data presented to water quality experts at the May 31, 2016 workshop to update status and trend assessments for Channel Islands National Marine Sanctuary (CINMS).

Indicator	Source	Figure #	Data Summary
Microplastics			
In-water microplastic concentration	Goldstein et al. 2013	App.D.9.1, and see Appendix C: App.C.4.14-C.4.16	*Status:* Data limited; however, microplastics are believed to be prevalent in all oceans. See Habitat State Section and Appendix C for more information regarding microplastics and other contaminants. *Trend:* Undetermined; however, thought to be increasing throughout the region (e.g., California Current).

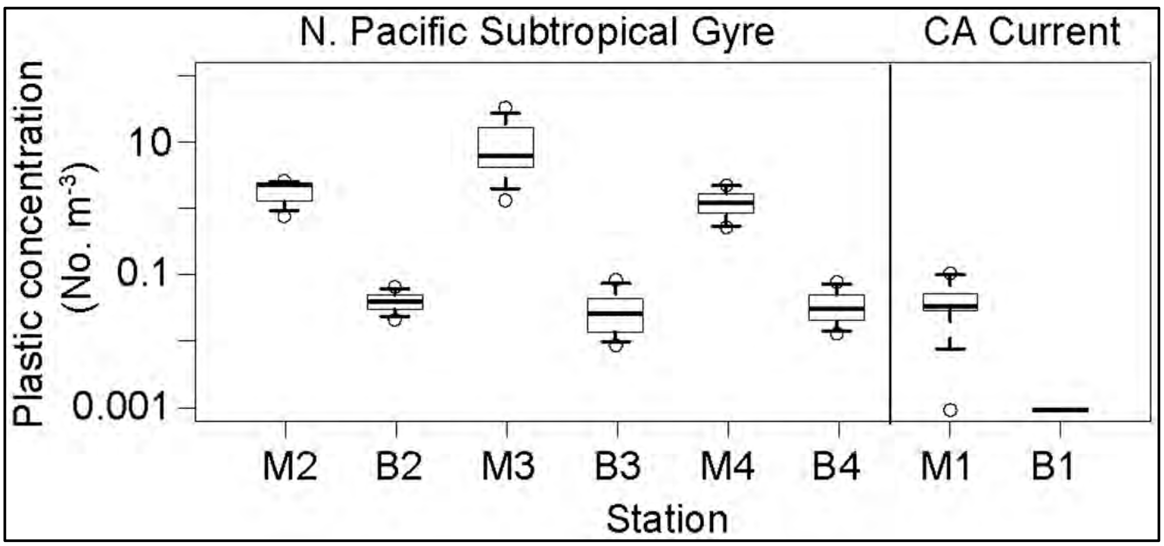


Figure App.D.9.1. Numerical concentrations (number/cubic meter) of microplastic from neuston samples and sub-surface samples in the California Current (M1 and B1) compared with concentrations in the North Pacific Subtropical Gyre (M2–M4, B2–B4). M indicates manta tows, B indicates bongo tows, and the number refers to the station. Boxes are middle 50 percent of the data, with the thick line denoting the median. Whiskers indicate 5th and 95th percentile of the data, and hollow circles indicate maximum and minimum values. Sample sizes are n=8 for each manta tow box plot and n=6 for each bongo tow boxplot, for a total of n=32 manta tows and n=24 bongo tows. Samples were collected in 2009 and 2010. Figure: Goldstein et al. 2013

APPENDIX E: Habitat Tables and Graphs

10. What is the integrity of major habitat types and how are they changing?

Table App.E.10.1. Data presented to the habitat experts at the workshop on June 1, 2016 to update status and trends assessments for Channel Islands National Marine Sanctuary (CINMS).
**Denotes graph that was received after the expert workshop and was not available for experts to view during the status and trend workshop; however, a representative from the monitoring program discussed this data set during the meeting.

Indicator	Source	Figure #	Data Summary
Rocky Intertidal Habitat			
Mussels — % cover	CINP	App.E.10.1–E.10.3	*Status:* Generally low abundance yet variable by island with record to near record low abundances at nine sites in recent years. *Trend:* Declining at three of five islands.
Algal groups — % cover/abundance	CINP	App.E.10.4–E.10.9	*Status: Silvetia* and *Hesperophycus* are in low abundance at most sites. *Endocladia* abundance is approximately at the long-term mean. *Trend: Silvetia* and *Hesperophycus* are in decline at most sites. *Endocladia* does not show significant decline.
Bare rock — % cover	CINP	See figures from algal group fixed plots	*Status:* Variable. *Trend:* No discernable trend.
Beach Habitat			
Macrophyte wrack abundance	CINP	App.E.10–.E.10..11	*Status:* Highly variable and primarily consisting of *Macrocystis* (giant kelp) or *Phyllospadix* (surfgrass) (Santa Rosa Island only). *Trend:* Declining.
Macrophyte wrack species composition	CINP	App.E.10.1–E.10.11	*Status:* Primarily *Macrocystis* or *Phyllospadix*, but eight recorded species in wrack. *Trend:* Recent decline in two primary wrack types.
Kelp Forest and Reef Habitat (< 30 meters)			
Giant kelp	SBC LTER	App.E.10.13	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.
Giant kelp	CINP	App.E.10.14**	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.
Giant kelp	T. Bell, UCSB; Cavanaugh et al. 2011	App.E.10.15–E.10.19	*Status:* Kelp biomass varies both inter and intra annually, but abundance is currently low. *Trend:* Generally declining from 2004–2014.

Understory kelp — abundance	SBC LTER	App.E.10.20, –EE.10.21	*Status:* Historically variable, but currently low. *Trend:* In decline along both the mainland and islands since 2007. In particular, brown algae is declining at a rapid rate.
Sandy Seafloor Habitat (< 30 meters)			
Eelgrass beds — areal extent	J. Altstatt, UCSB and CINMS; Altstatt et al. 2014	App.E.22–App.E.24	*Status:* Eelgrass extent is generally stable; potential losses at Anacapa. *Trend:* Stable with potential declines in non-protected areas off Anacapa Island.
Eelgrass beds — areal extent	NMFS	App.E.22, App.E.25	*Status:* Eelgrass extent is generally stable; potential losses at Anacapa. *Trend:* Stable with potential declines in non-protected areas off Anacapa Island
Deep Seafloor Habitat (> 30 meters)			
Structure-forming invertebrates — cover/density/condition	MARE; Etnoyer et al. 2015	App.E.26–.E.29	*Status:* Deep-sea structure forming inverts appear to be in very good overall condition (Etnoyer). Some exceptional abundances recorded around Santa Rosa. Some notable declines in condition of structure forming inverts around Santa Cruz and Anacapa Islands. The observations of injury were shallow (~30 meters) and deep (~400 meter). *Trend:* Declines observed in deep-sea coral health and abundance in eastern sanctuary waters.

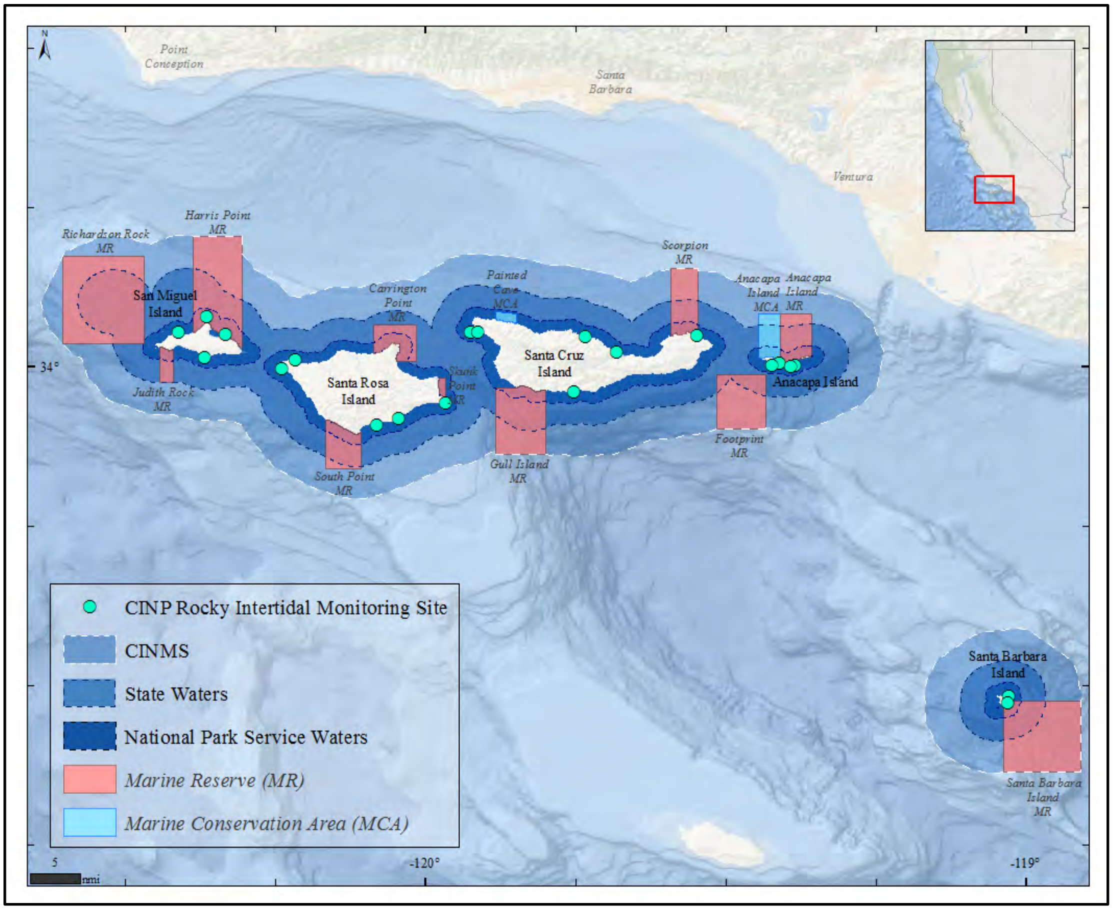
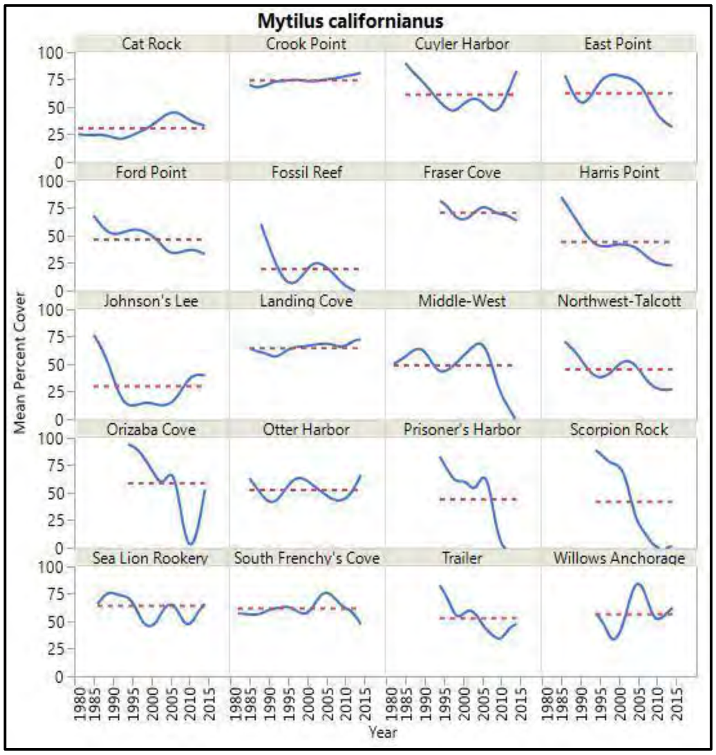


Figure App.E.10.1. Location of Channel Islands National Park Rocky Intertidal Community Monitoring survey sites within Channel Islands National Park and Channel Islands National Marine Sanctuary. Monitoring locations were established between 1982 and 1998. SMCA = State Marine Conservation Area, SMR = State Marine Reserve. Data source: Channel Islands National Park; Map: M. Cajandig/NOAA



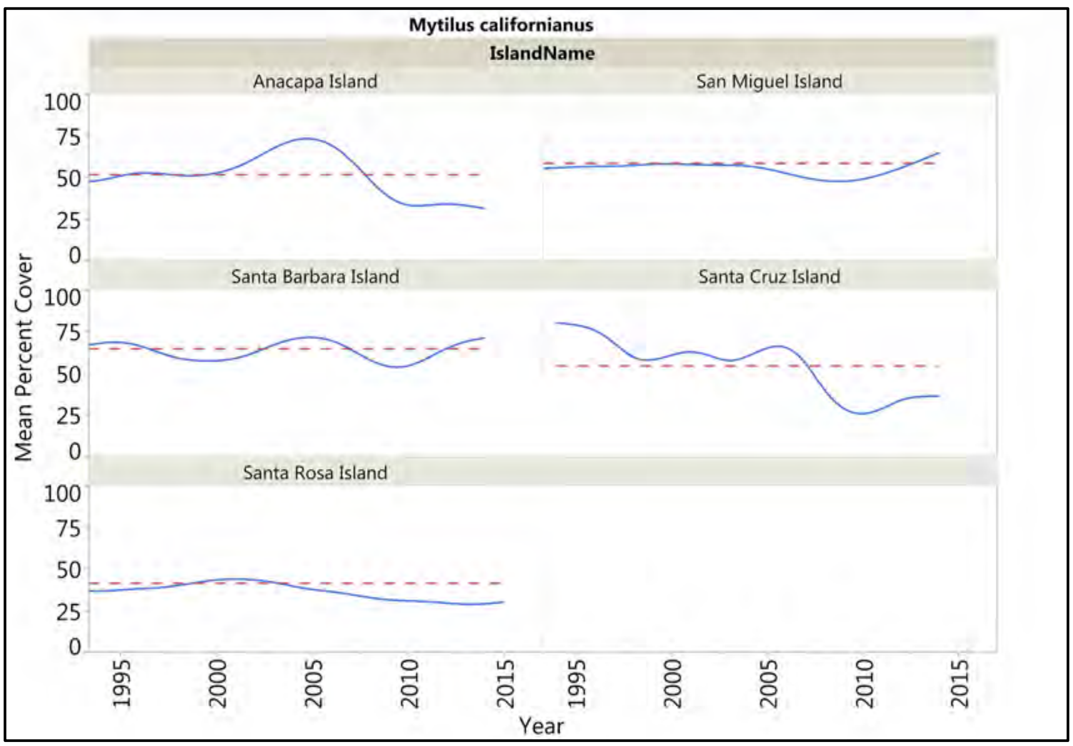


Figure App.E.10.2. Trend in percent cover of *Mytilus californianus* is shown by site (top graph) and also combined by island (bottom graph). Blue lines represent mean cover of *M. californianus* within the representative intertidal zone (aka *Mytilus* zone) pooled across plots. Red dashed lines represent long-term mean of the dataset. Trends are variable across sites; however, three of the five islands within the sanctuary have percent coverage of *M. californianus* below the long-term mean. Figure: Channel Islands National Park

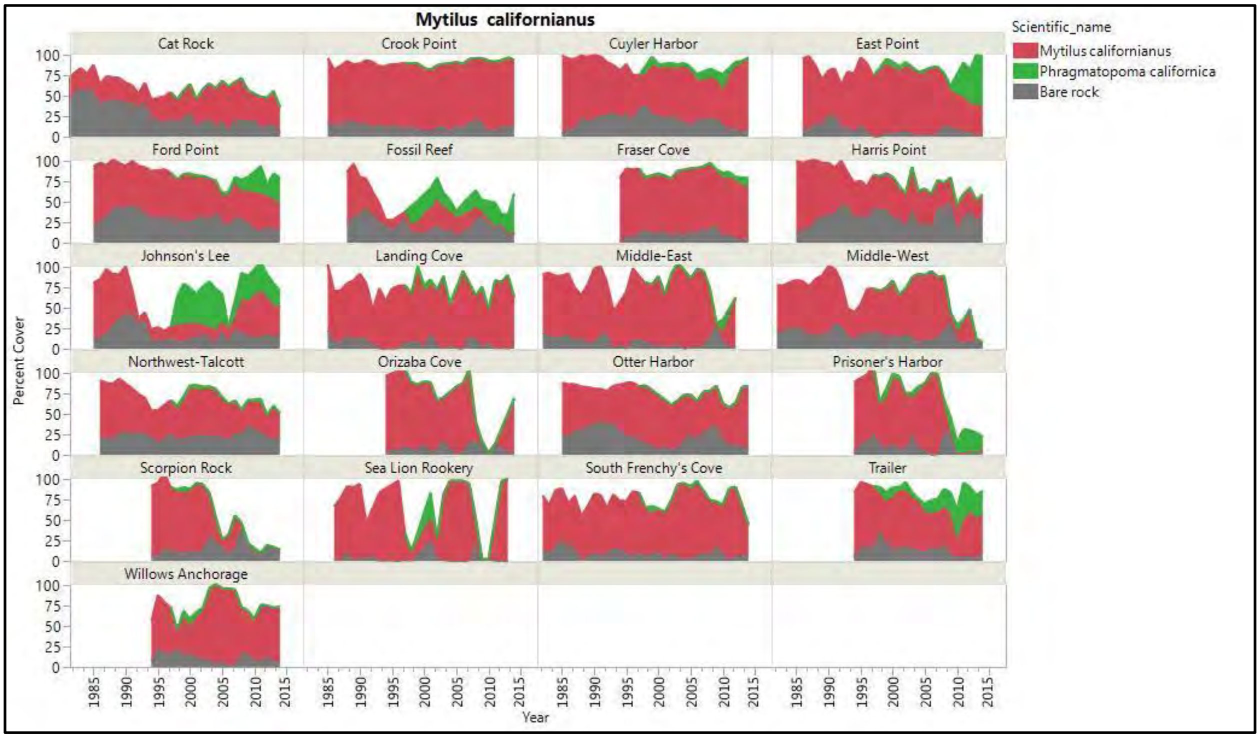


Figure App.E.10.3. Percent cover of *Mytilus californianus* (red) along with *Phragmatopoma californica* (green) and bare rock (grey) in fixed plots within the *Mytilus* zone at each site. Colored areas represent the mean percent cover for representative and dominant taxa/substrata from replicated (usually five) *Mytilus* plots. Trends within sites are highly variable. Figure: Channel Islands National Park

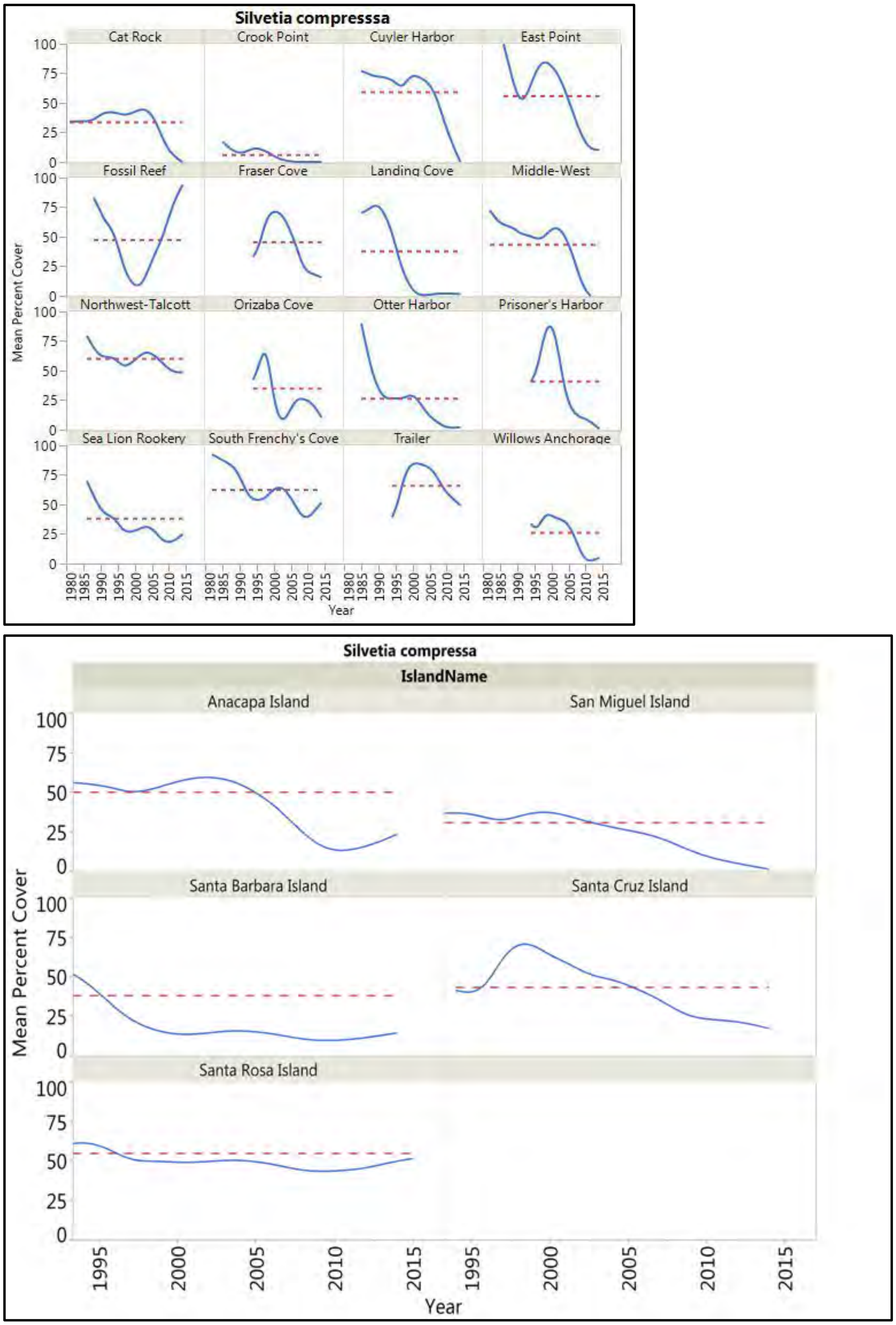


Figure App.E.10.4. Trend in percent cover of *Silvetia compressa*, a type of rockweed, is shown by site (top graph) and also by island (bottom graph). Blue lines represent mean cover of *S. compressa* pooled across plots within the representative site or across island. Red dashed lines represent long-term mean. *S. compressa* is in very low abundance in CINMS and has experienced marked decline in percent cover compared with previous years. Figures: Channel Islands National Park

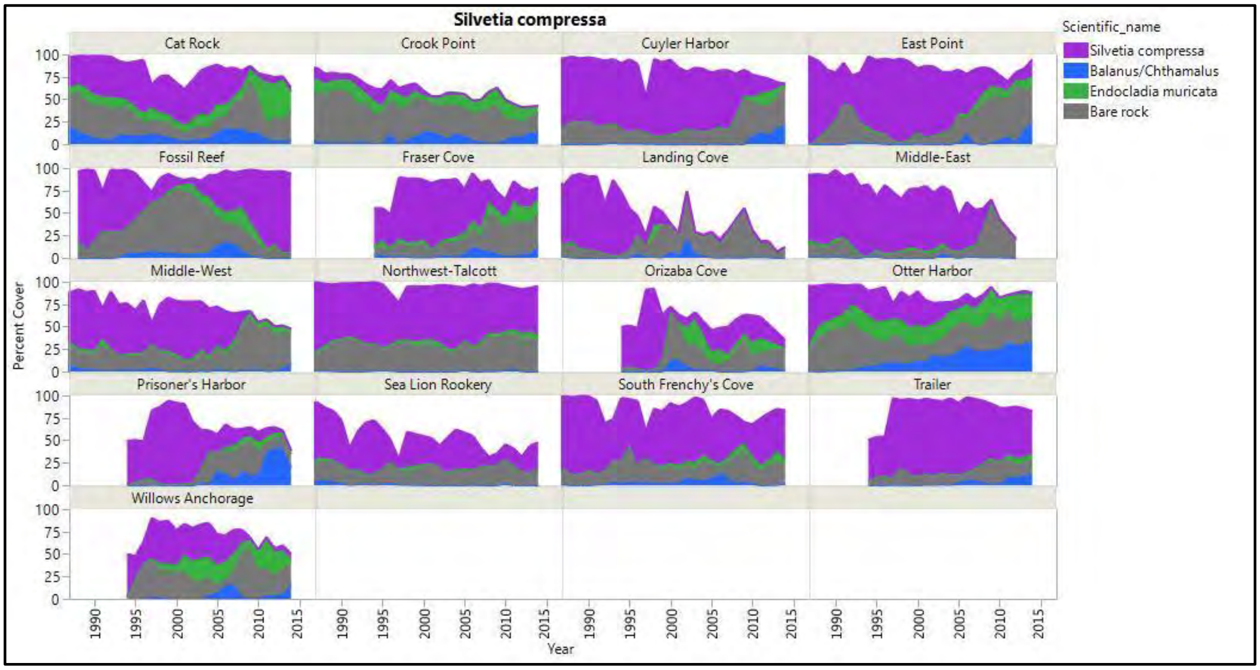


Figure App.E.10.5. Percent cover of *Silvetia compressa* (purple) along with other dominant taxa and bare rock (gray) in fixed plots within the *Silvetia* zone at each site. Colored areas represent the mean percent cover for representative and dominant taxa/substrata from replicated (usually five) *Silvetia* zone plots. *Silvetia* has been in decline at most sites across CINMS. Figure: Channel Islands National Park

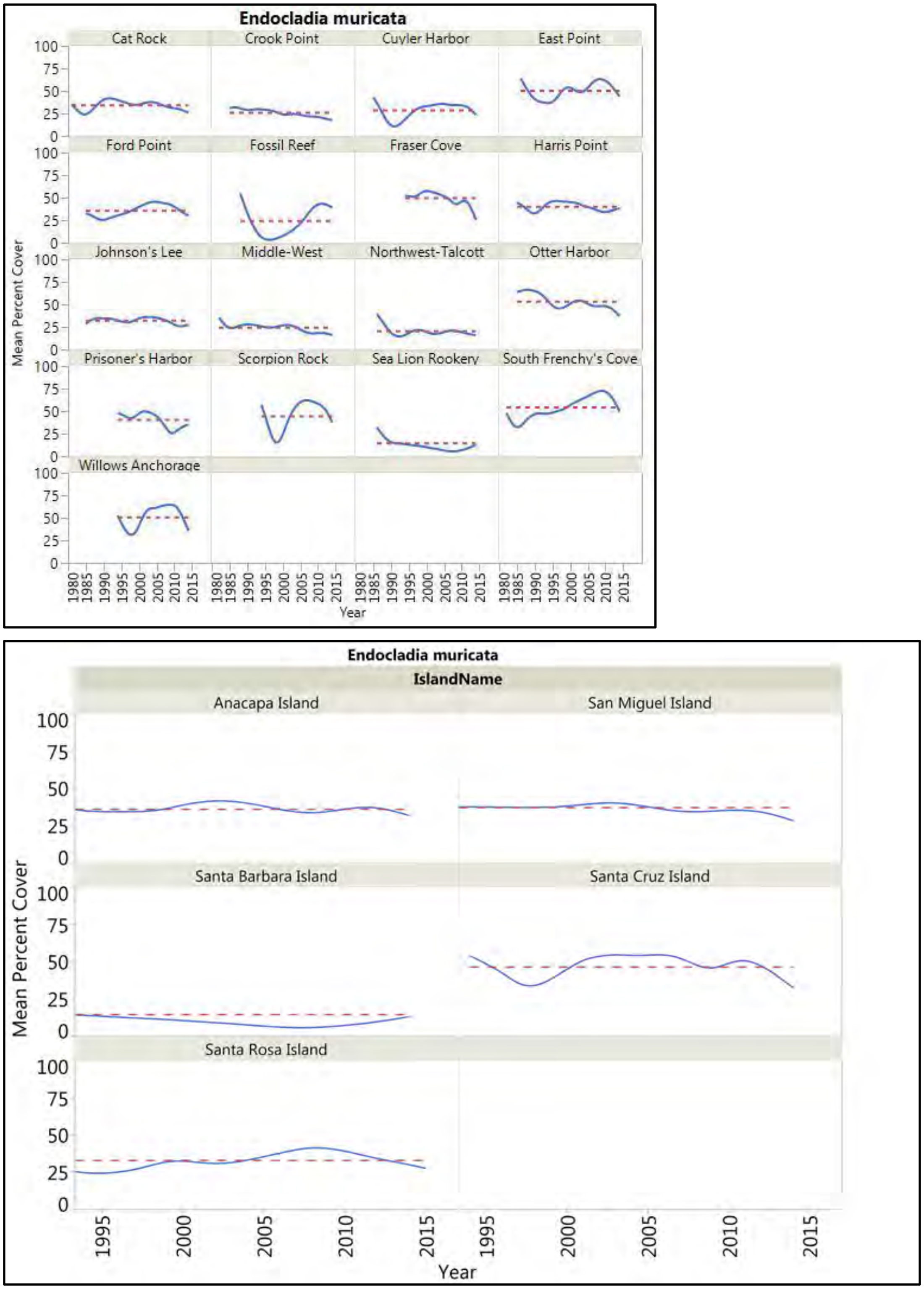


Figure App.E.10.6. Trend in percent cover of *Endocladia muricata*, a type of turfweed, is shown by site (top graph) and also by island (bottom graph). *E. muricata* is at percent cover levels roughly equivalent to the long-term mean except at a few sites. At Santa Barbara and Santa Rosa islands, *E. muricata* percent cover is close to average; while at Anacapa, Santa Cruz, and San Miguel islands, percent cover falls slightly below the mean. Blue lines represent mean cover of *E. muricata* within the representative zone pooled across plots and sites. Red dashed lines represent long-term mean. Figures: Channel Islands National Park

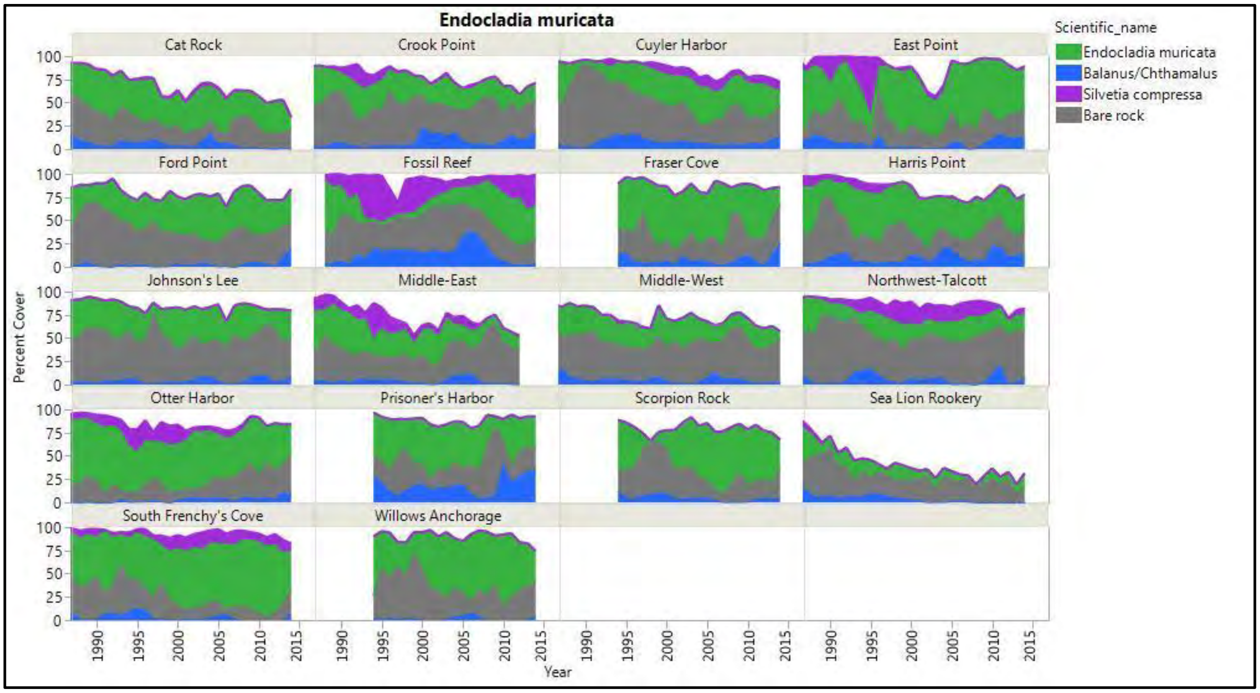
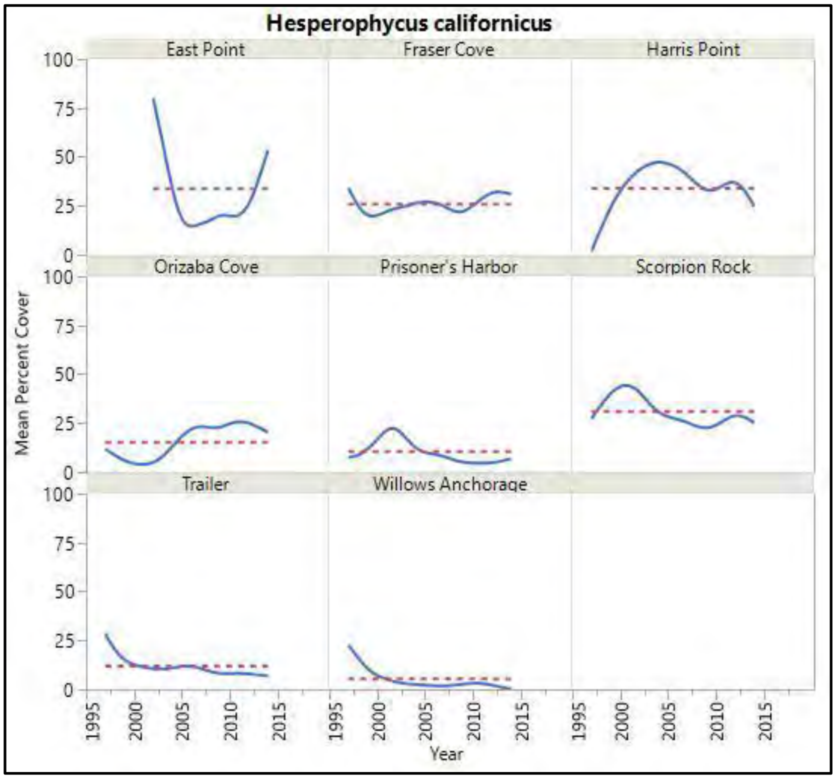


Figure App.E.10.7. Percent cover of *Endocladia muricata* (green) along with other dominant taxa and bare rock (gray) in fixed plots within the *Endocladia* zone at each site. Colored areas represent the mean percent cover for representative and dominant taxa/substrata from replicated (usually five) *Endocladia* plots. *E. muricata* percent cover has been relatively stable in recent years. Figure: Channel Islands National Park



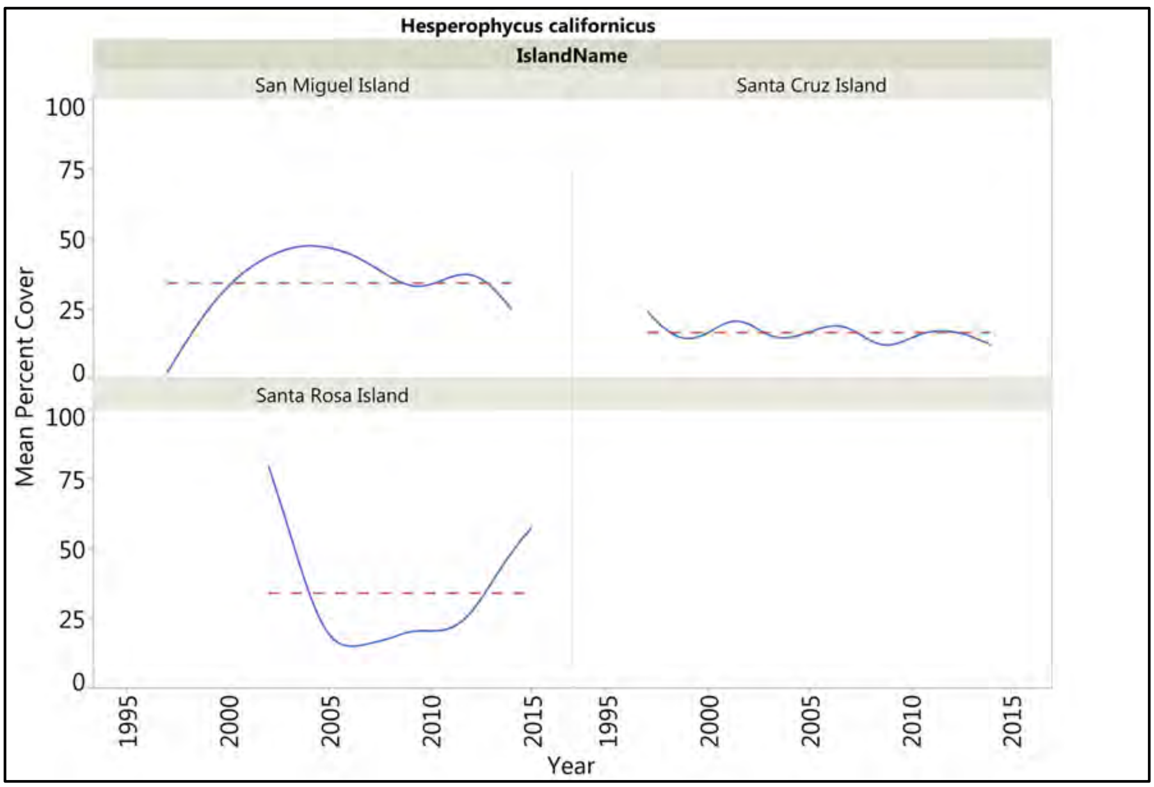


Figure App.E.10.8. Trend in percent cover of *Hesperophycus californicus,* a type of rockweed, is shown by site (top graph) and also by island (bottom graph). *H. californicus* is experiencing a percent cover decline at several sites, while high cover persists at others. Blue lines represent mean cover of *H. californicus* within the representative zone pooled across plots and sites. Red dashed lines represent long-term mean. Across islands, *H. californicus* percent cover is above the mean at Santa Rosa Island and below the mean at Santa Cruz and San Miguel Islands. Figures: Channel Islands National Park

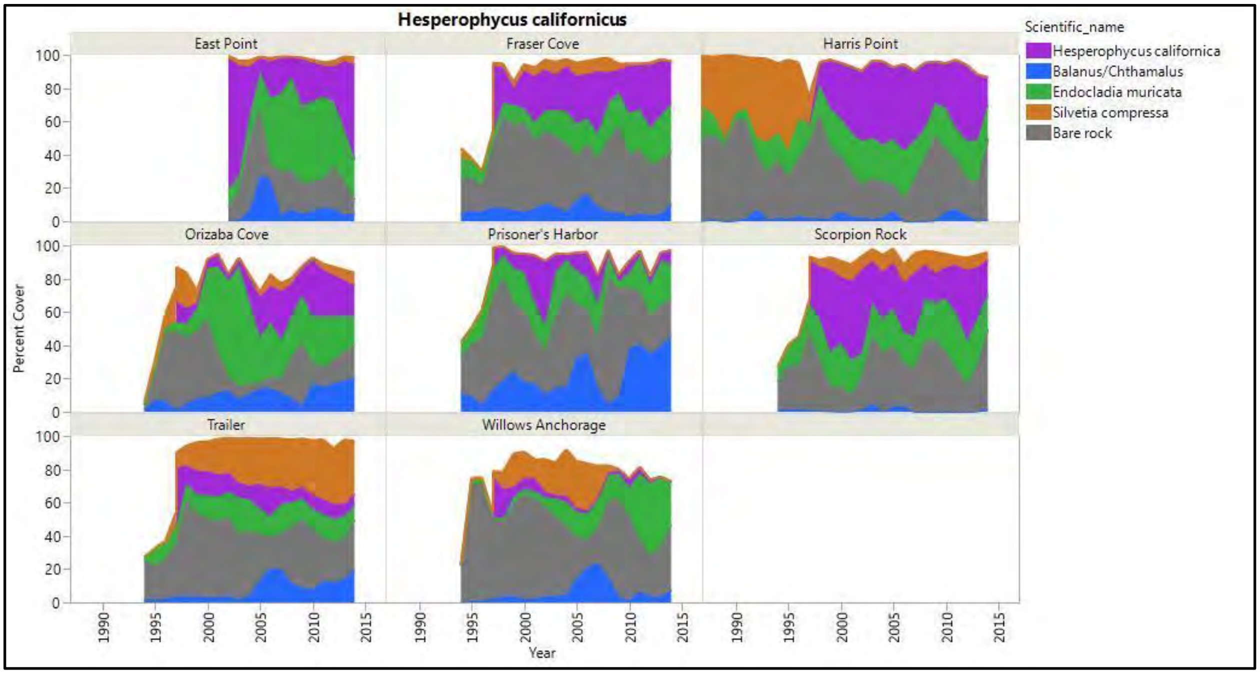


Figure App.E.10.9. Percent cover of *Hesperophycus californicus* (purple) along with other dominant taxa and bare rock (grey) in fixed plots within the *Hesperophycus* zone at each site. Colored areas represent the mean percent cover for representative and dominant taxa/ substrata from five *Hesperophycus* plots. Hesperophycus is not the dominant habitat type by percent cover and competes with other algal groups. Figure: Channel Islands National Park

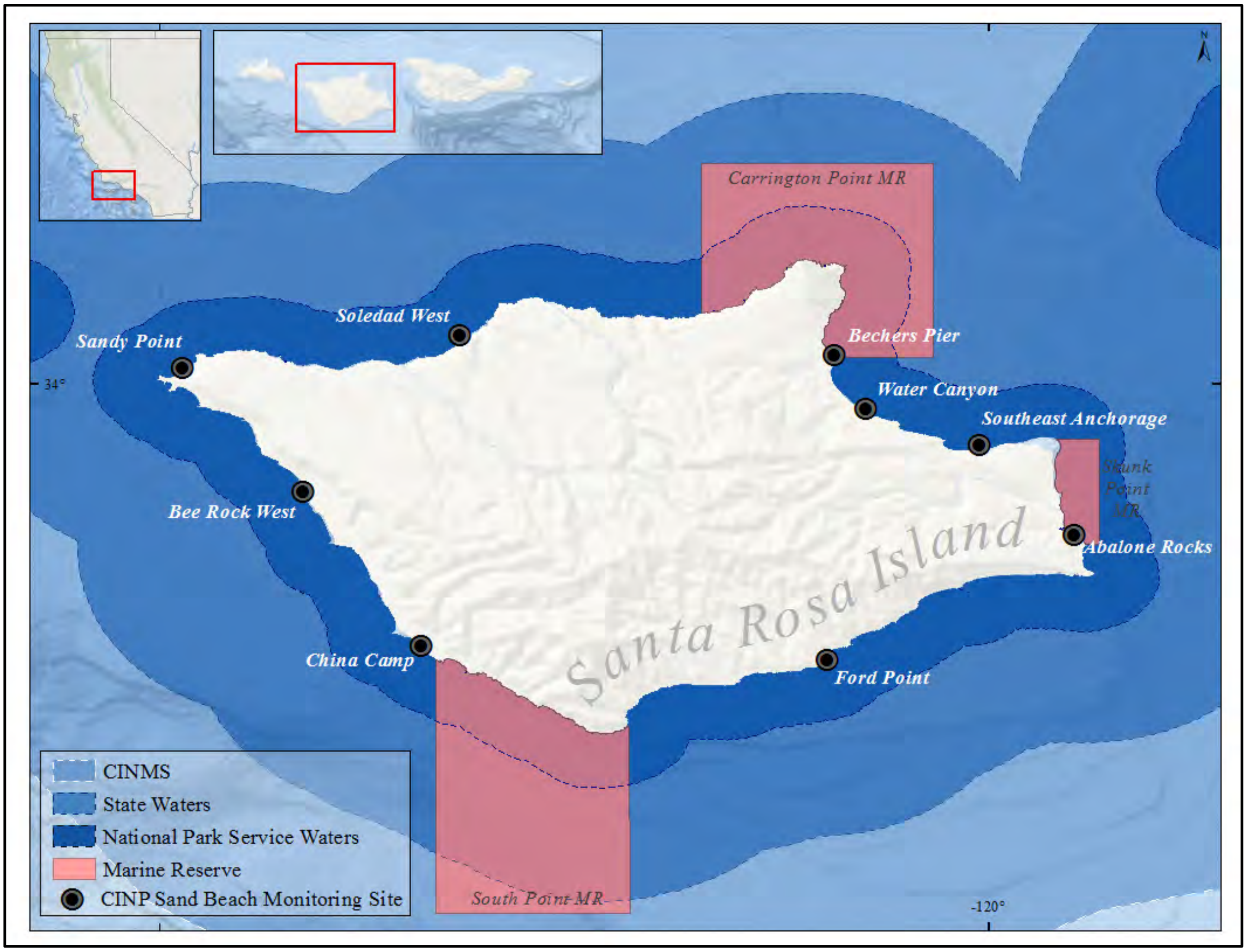


Figure App.E.10.10. Sandy beach monitoring locations as conducted by Channel Islands National Park are shown in the map above. Data source: Channel Islands National Park; Map: M. Cajandig/NOAA

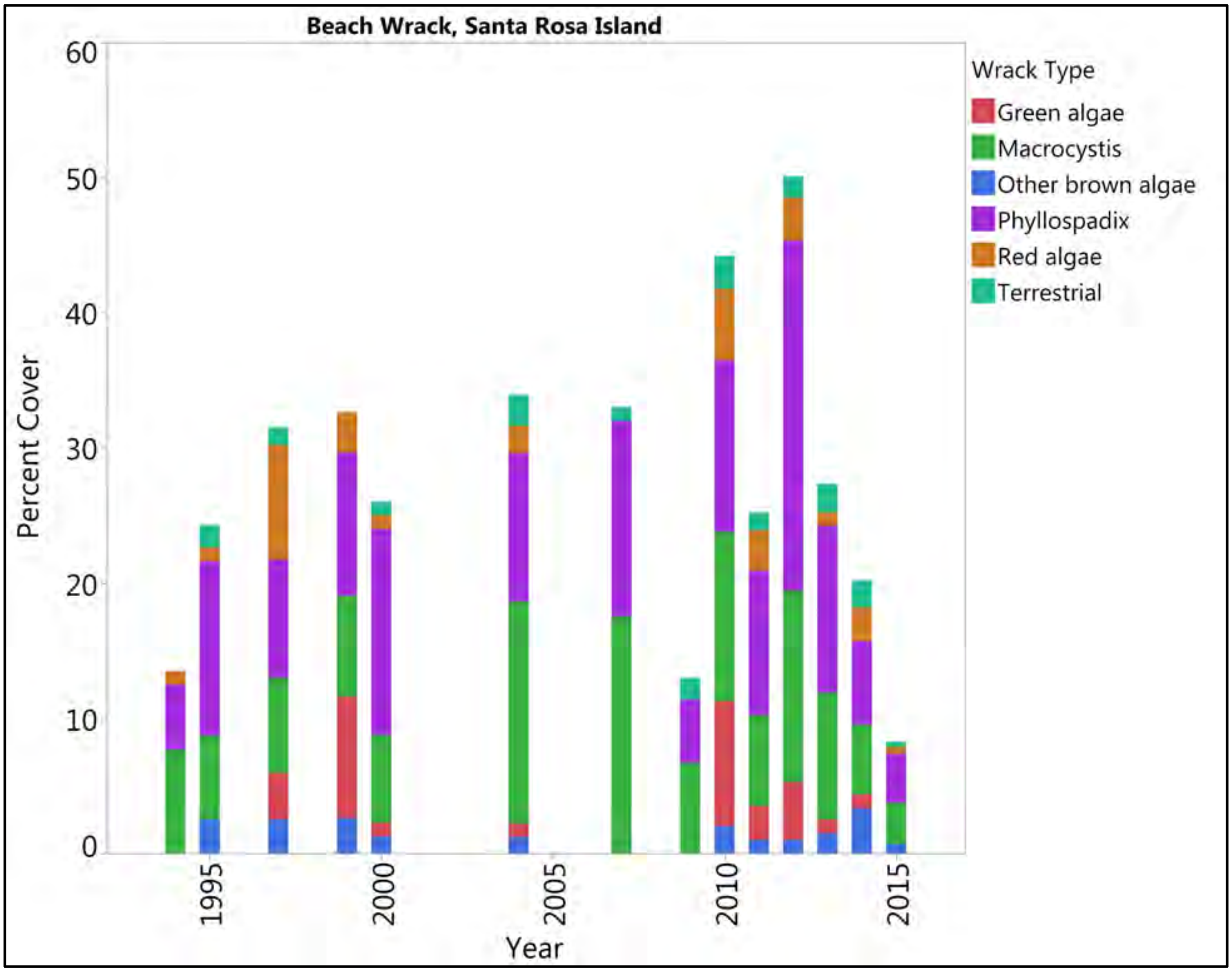


Figure App.E.10.11. Macrophyte beach wrack percent cover at Santa Rosa Island is shown by species. Wrack primarily consists of *Macrocystis* (Giant kelp*)* or *Phyllospadix* (surf grass); however these two key types of wrack show recent decreases in percent cover. Figure: Channel Islands National Park

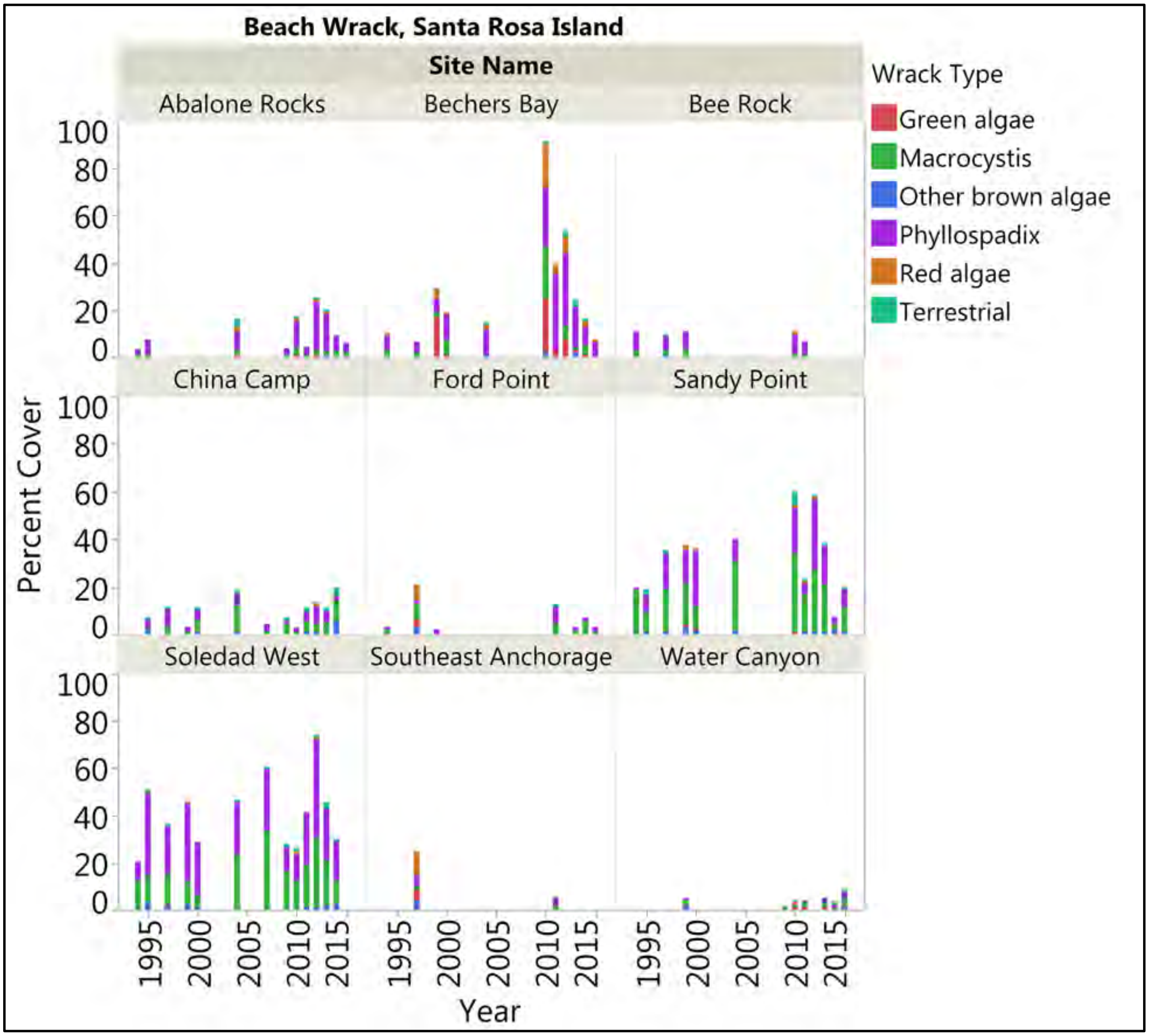


Figure App.E.10.12. Macrophyte wrack species composition at eight sites on Santa Rosa Island. Wrack primarily consists of *Macrocystis* (Giant kelp) and *Phyllospadix* (surf grass) which varies from 0 to > 50% coverage; however, these two key wrack types show recent decreases in percent cover. Figure: Channel Islands National Park

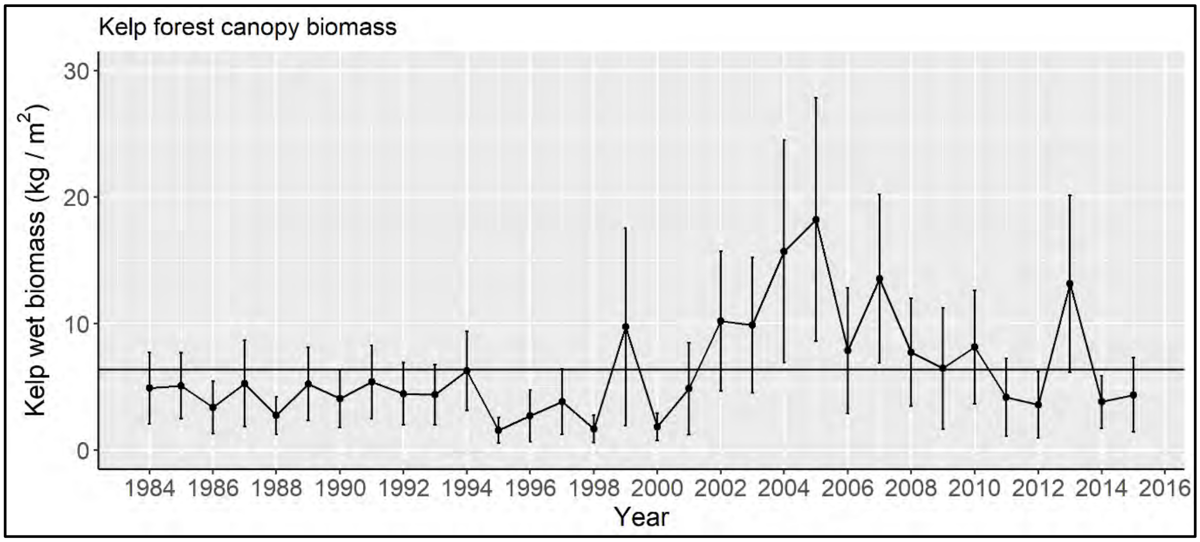


Figure App.E.10.13. 1984 to 2015 giant kelp biomass aerial extent varies seasonally and annually, with data showing high variation over three decades; however, recent data suggests kelp biomass as is near an all time low. Figure: R. Miller/UCSB

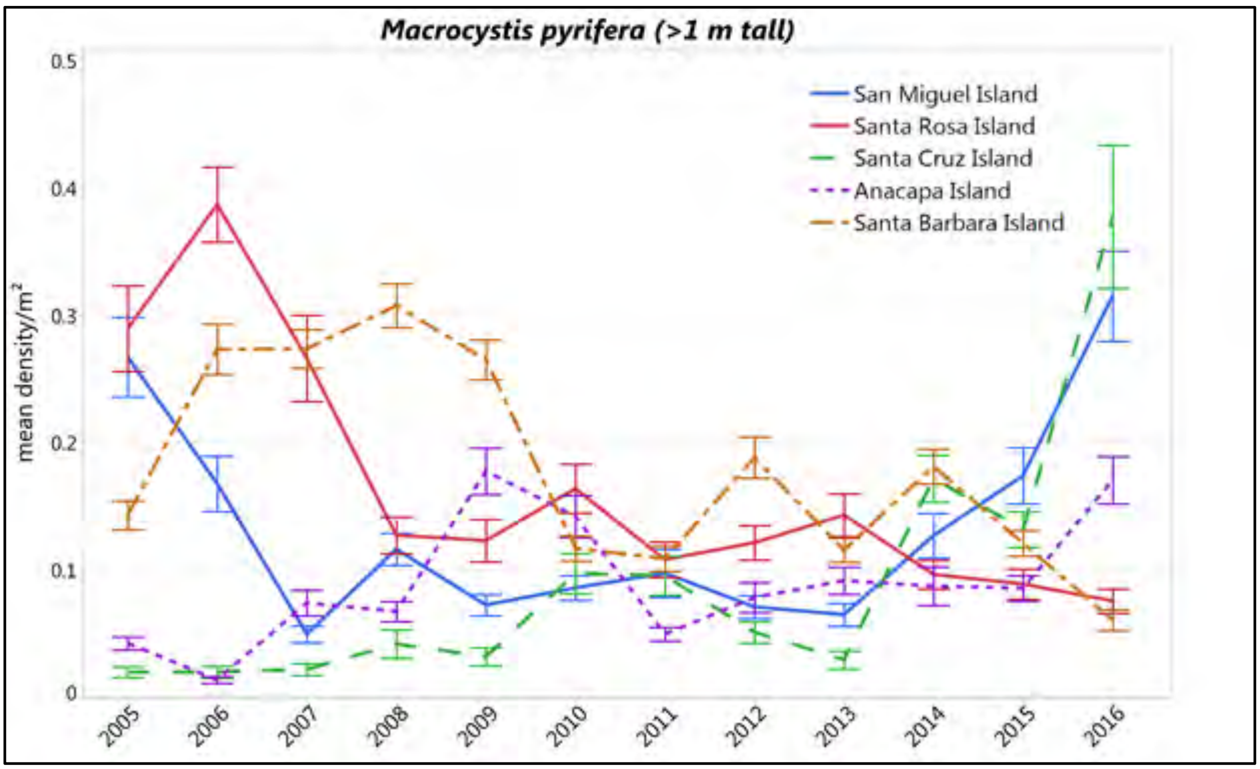


Figure App.E.10.14.** Giant kelp *(Macrocystis pyrifera*) density from 2005 to 2016 at all five sanctuary islands as counted by the national park subtidal surveys. Kelp density is currently at extreme lows for the three western islands, but the warmer islands (Anacapa and Santa Barbara islands) have recently experienced sharp increases in kelp density. Figure: Channel Islands National Park

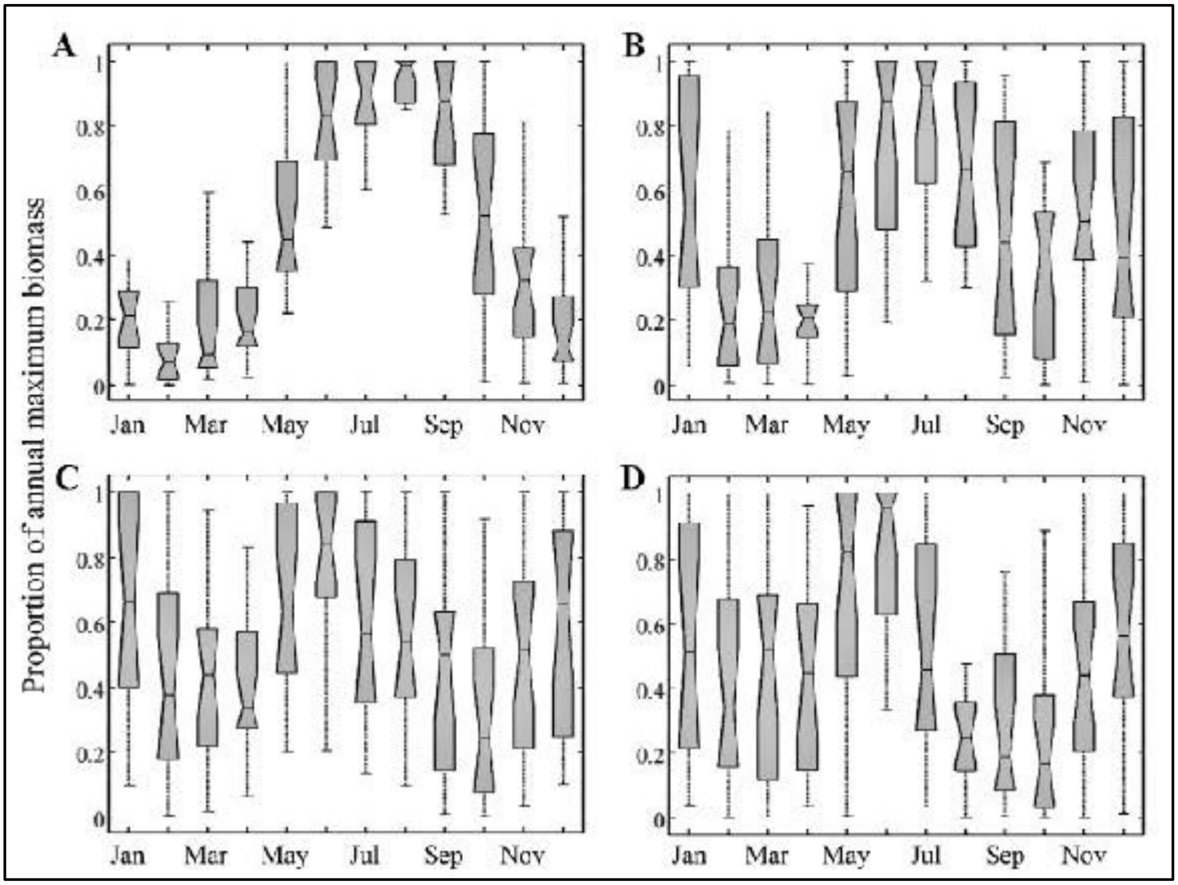


Figure App.E.10.15. *Macrocystis pyrifera* biomass varies monthly as shown across the subregions shown in Figure E10.16. Box and whisker plots show monthly kelp canopy biomass variation for data from 1984 to 2009 for each subregion (A to D). For each year between 1984 and 2009, the proportion of that year's maximum biomass was calculated for each month. Boxes represent the lower quartile, median, and upper quartile of the proportion of annual maximum biomass, and whiskers extend to the lower and upper extremes of the data. Longer boxes represent months with higher variability in their relative canopy biomass levels. Boxes whose notches (not whiskers) do not overlap have significantly different medians at a 95 percent confidence level. Subregions C and B, which are primarily found around the islands, have higher kelp biomass during summer months. Figure: Cavanaugh et al. 2011

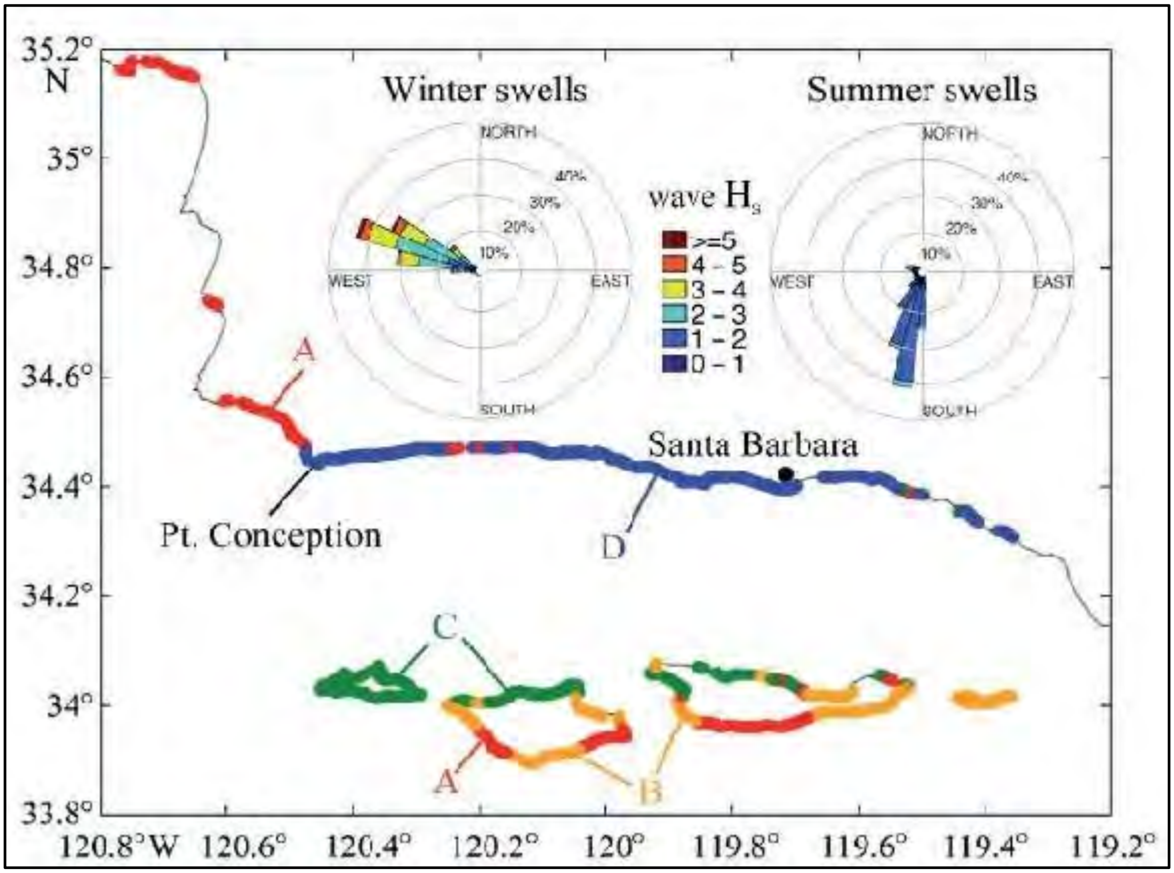


Figure App.E.10.16. Cavanaugh et. al. 2011 used cluster analysis to group one km sections of coastline by wave exposure and nutrient gradients, which are known drivers of kelp biomass. Analysis shows four distinct groups exist in the Santa Barbara Channel with the environment along the mainland coast being different from those at the islands. Environmental drivers pertinent to kelp growth are even unique between the north and south coasts of the Channel Islands. Subregions are labeled A to D in order of decreasing wave exposure. Histograms of significant wave height (Hs) and direction for swells with periods > 12 seconds are provided for winter (December to February) and summer (June to August) from the wave data collector at the Harvest platform. Coastlines are colored to differentiate subregions and are not related to the color key for the wave histograms. Figure: Cavanaugh et al. 2011

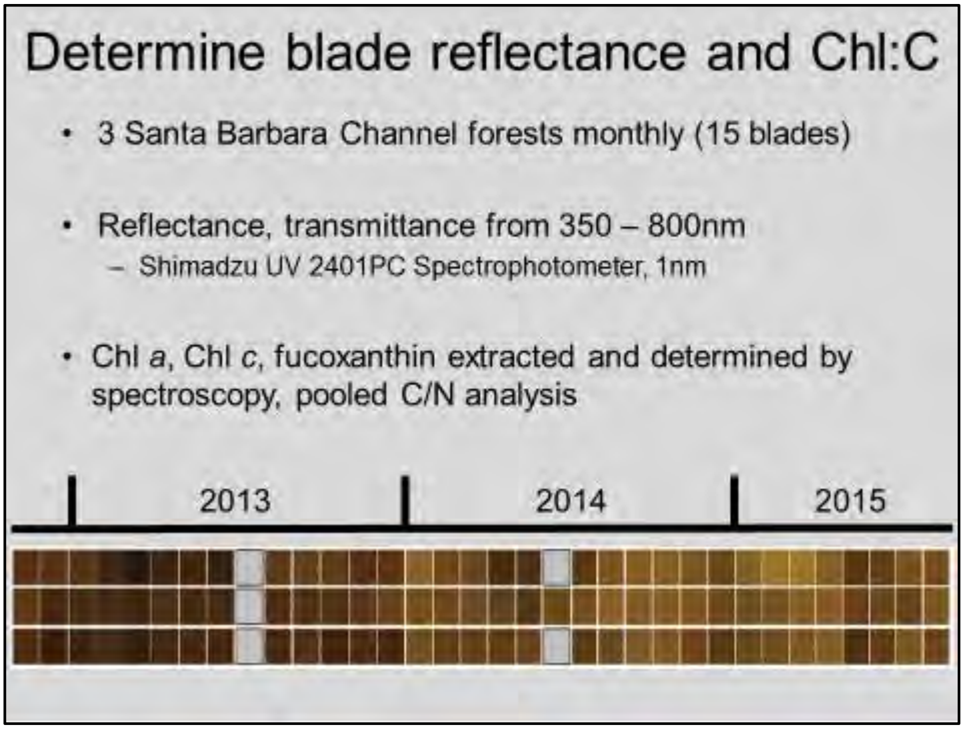


Figure App.E.10.17. Researchers use kelp (*M. pyrifera*) blade color changes to estimate organismal health with lighter colors suggesting poorer health. Between 2013 and 2015, researchers found that kelp health was declining at sample sites, with increasing sea temperatures likely to blame for poor kelp health. Figure: T. Bell/UCSB

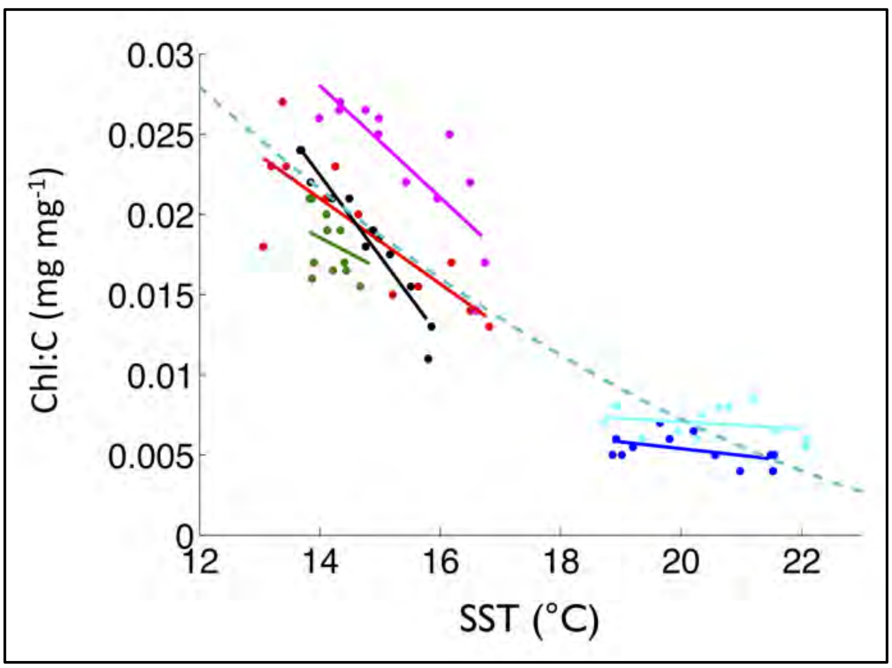


Figure App.E.10.18. Relationship between SST and Chl:C resembles the relationship between SST and NO_3. As NO_3 is important nutrient for kelp, the inverse relationship between temperature and NO_3 may lead to observed inverse relationships between temperature and kelp health. Figure: T. Bell/UCSB

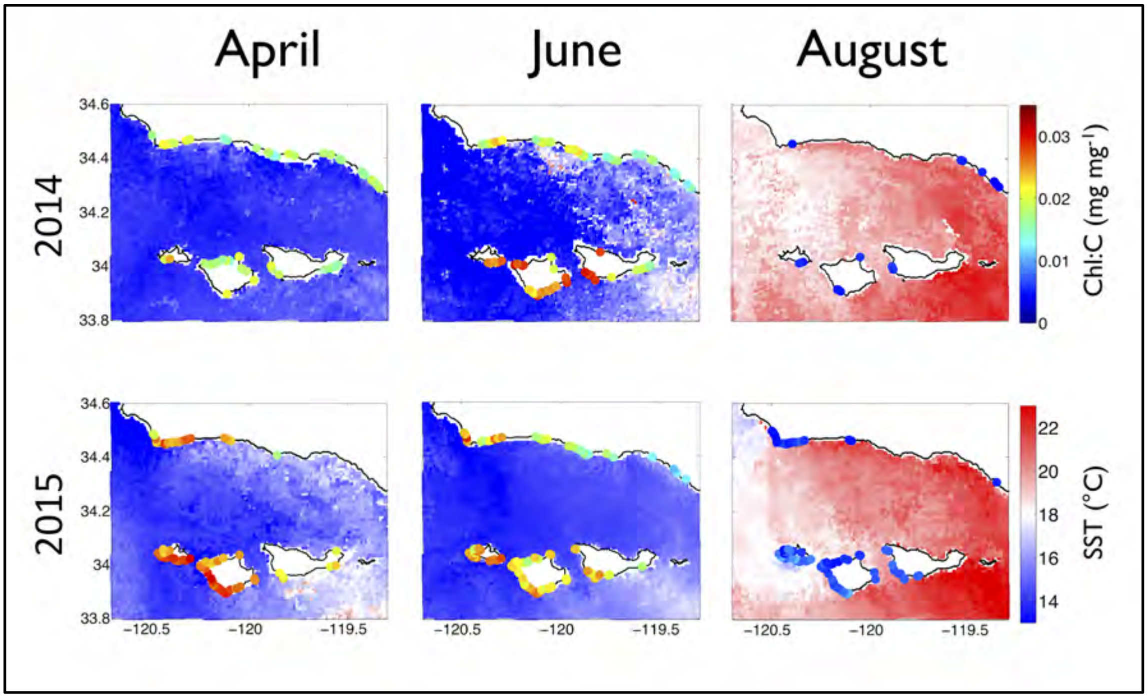


Figure App.E.10.19. Sea surface temperature (SST) and Chlorophyll:Carbon ratio (Chl:C) in the Santa Barbara Channel are shown above. The dots along the coast are the mean Chl:C of the kelp forests for each 1 kilometer section of coastline. Blue values denote lower Chl:C values while reds denote higher values. SST is shown as a raster color ramp across the ocean surface. Blue denotes lower SST while red notes higher SST. Cooler waters tend to be associated with higher Chl:C and warmer waters with lower Chl:C. Figure: T. Bell/UCSB

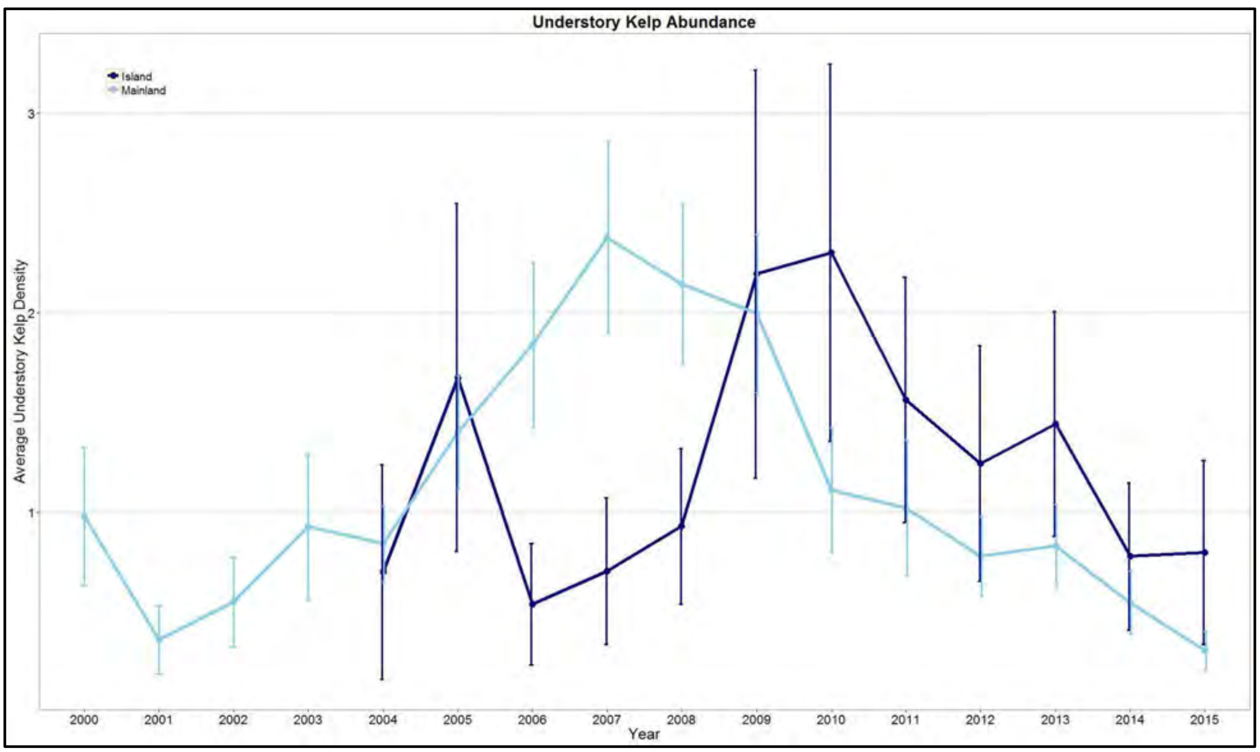


Figure App.E.10.20. Brown algae percent cover from LTER subtidal surveys at Santa Cruz Island (two sites, dark blue) and the mainland (nine sites, light blue) are shown in the trendlines above. Brown algae has been in decline since 2010 and is near record lows in the Santa Barbara Channel both at the mainland and in the sanctuary. Data source: SBC LTER; Figure: R. Freedman/NOAA

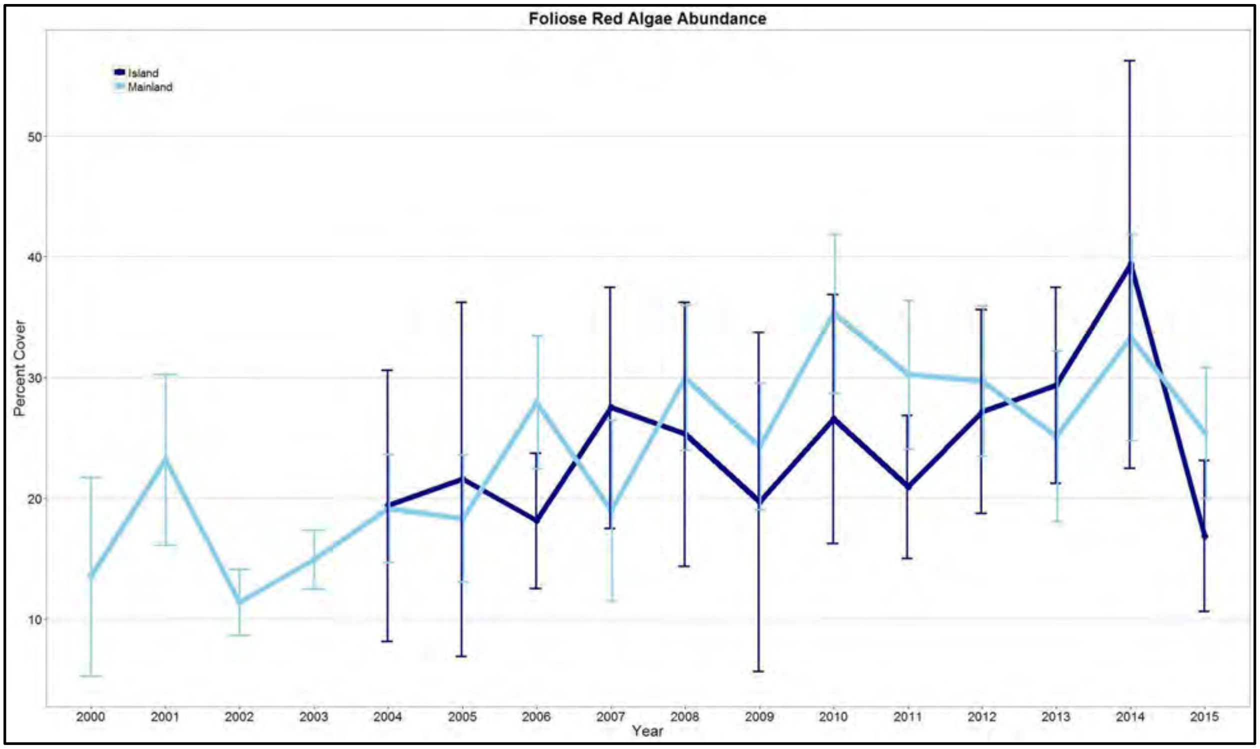


Figure App.E.10.21. Foliose red algae percent cover from LTER subtidal surveys at Santa Cruz Island (two sites, dark blue) and the mainland (nine sites, light blue) are shown. Red algae cover has been slowly increasing from the start of the dataset, but has remained stable at about 30 percent cover at both Santa Cruz Island and the mainland since 2010. Data source: SBC LTER; Figure: R. Freedman/NOAA

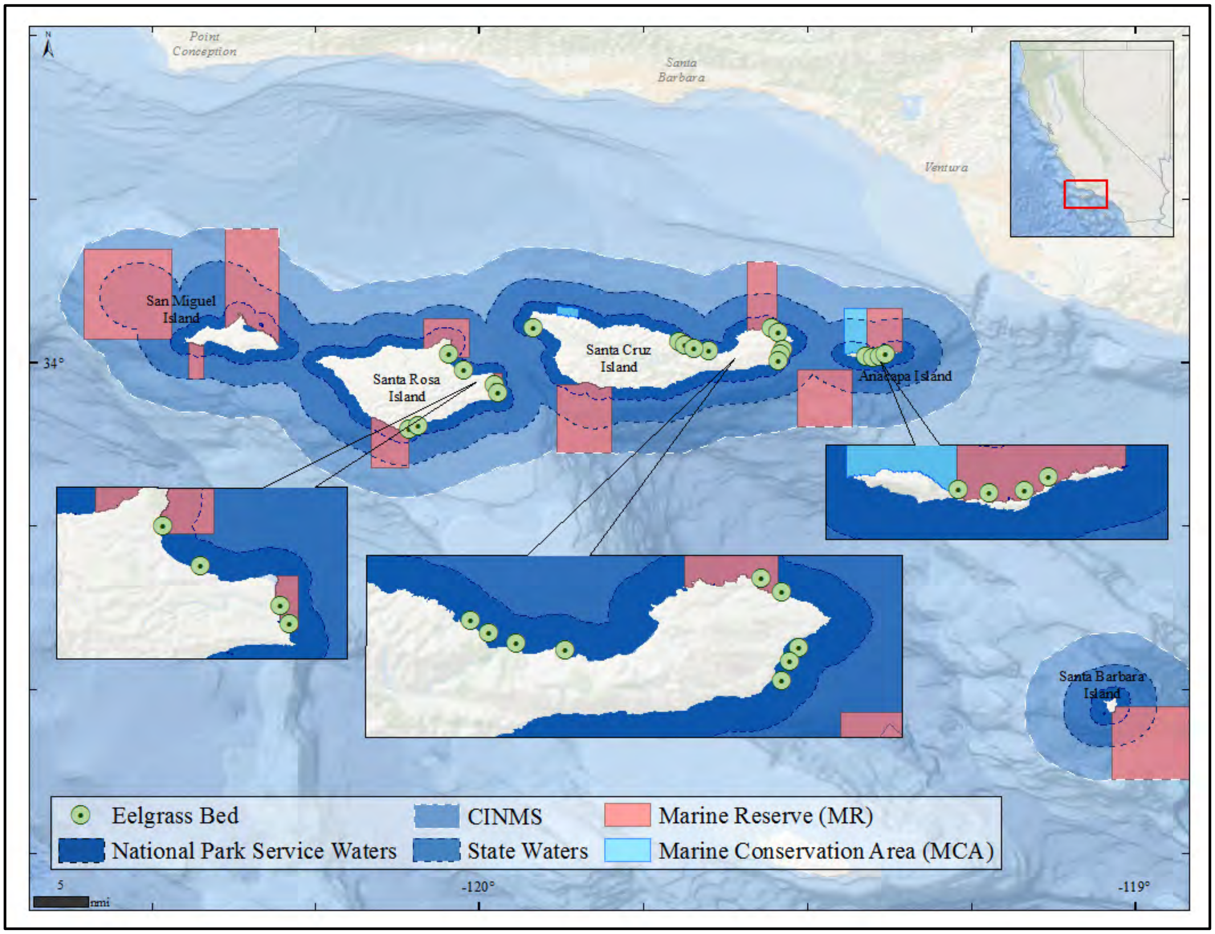


Figure App.E.10.22. CINMS eelgrass bed locations in the map above are a compilation from UCSB, NMFS, and CINMS data. Surveys for eelgrass occurred at different times and the bed persistence is unknown at many locations. UCSB data comes from transects performed by UCSB researchers while the NMFS data comes from sidescan sonar surveys along the coastline. Data source: NMFS, UCSB, and CINMS; Map: M. Cajandig/NOAA

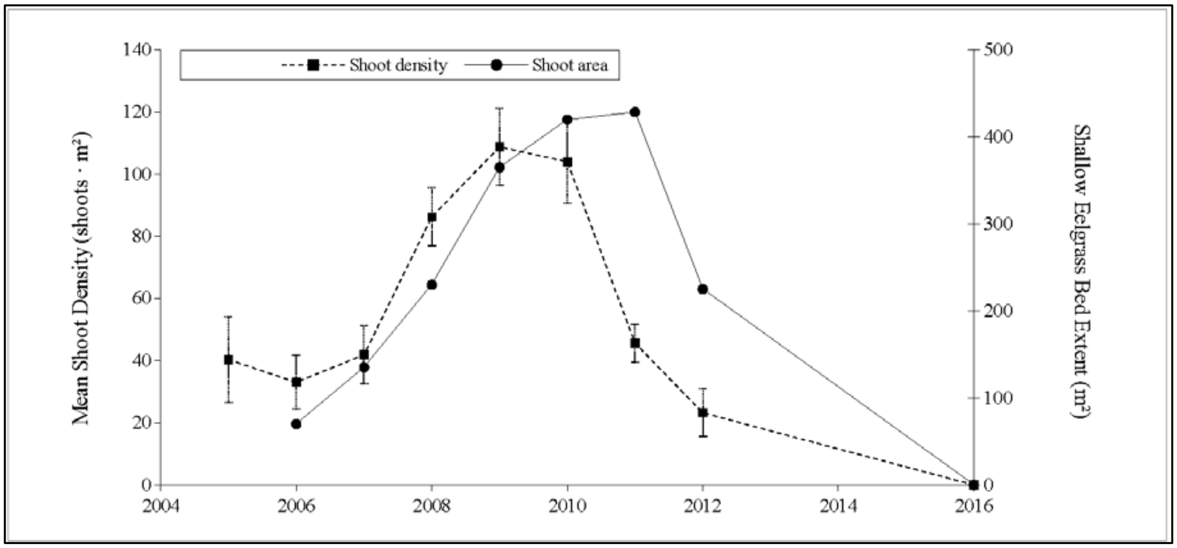


Figure App.E.10.23. The results of an experimental transplant of eelgrass (*Zostera pacifica*) to Frenchy's Cove, Anacapa Island are shown above. All eelgrass historically present at Anacapa was extirpated by white urchins in the 1980s. An experimental transplant in 2003 resulted in a small bed within the State Marine Conservation Area at Frenchy's Cove by 2010, with grass patches spreading east in the adjoining State Marine Reserve (not shown). As of 2016, eelgrass beds flourished over 3 kilometers east, but had disappeared from the original transplant site. Trap fishing, anchoring, and seafloor disturbance are thought to contribute to declines in bed extent and shoot density, with eelgrass beds inside the marine reserve faring better than those in areas with less protection. Figure: Altstatt et al. 2014

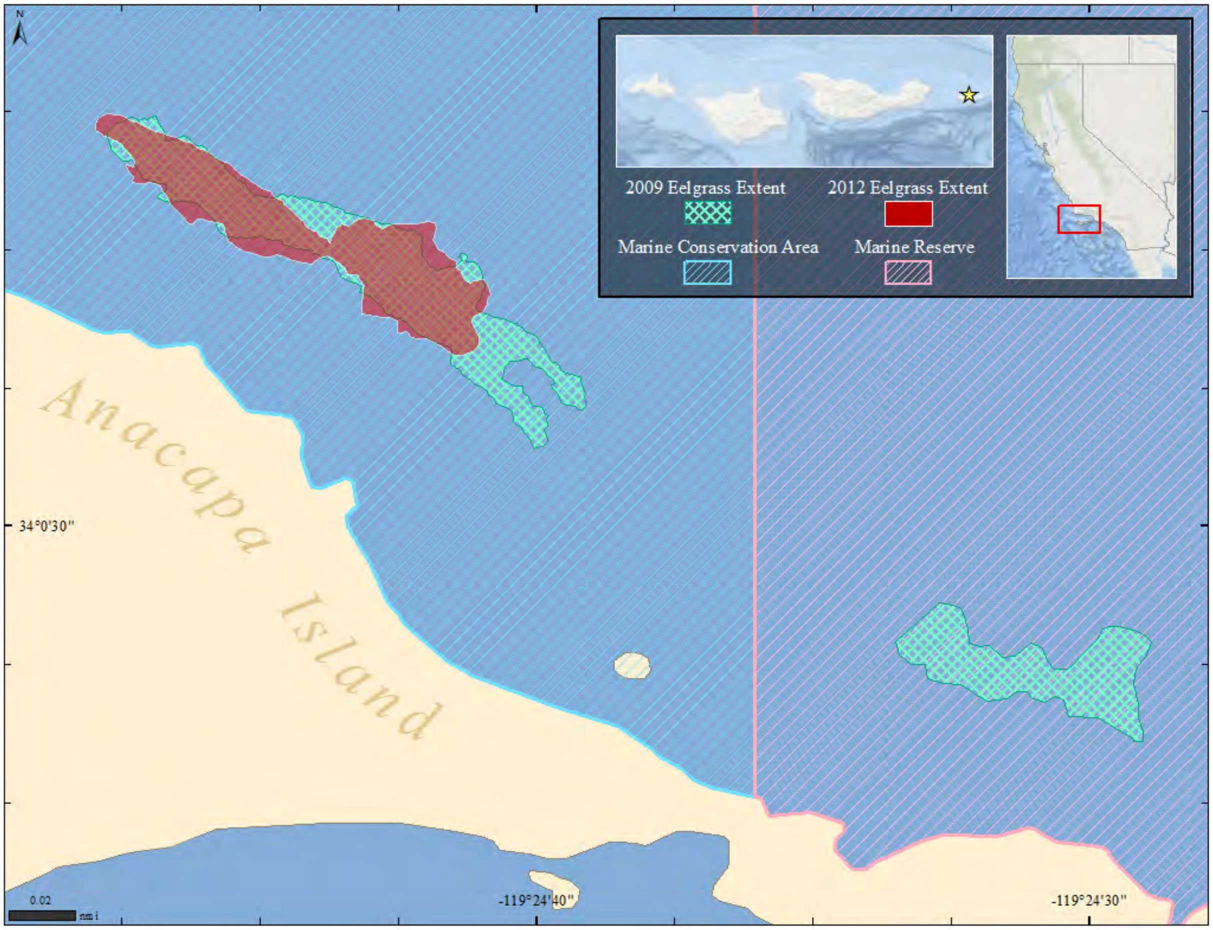


Figure App.E.10.24. Eelgrass bed extent from diver surveys at Anacapa Island in 2009 (light blue) and 2012 (dark red). Overall, bed extent appears to be declining at Anacapa between 2009 and 2012, with the eastern bed being extirpated. Trap fishing, anchoring, and seafloor disturbance are thought to contribute to declines in bed extent and shoot density, with eelgrass beds inside the marine reserve having higher shoot density than those in areas with less protection. Data source: J. Altstatt/ UCSB and CINMS; Map: M. Cajandig/NOAA

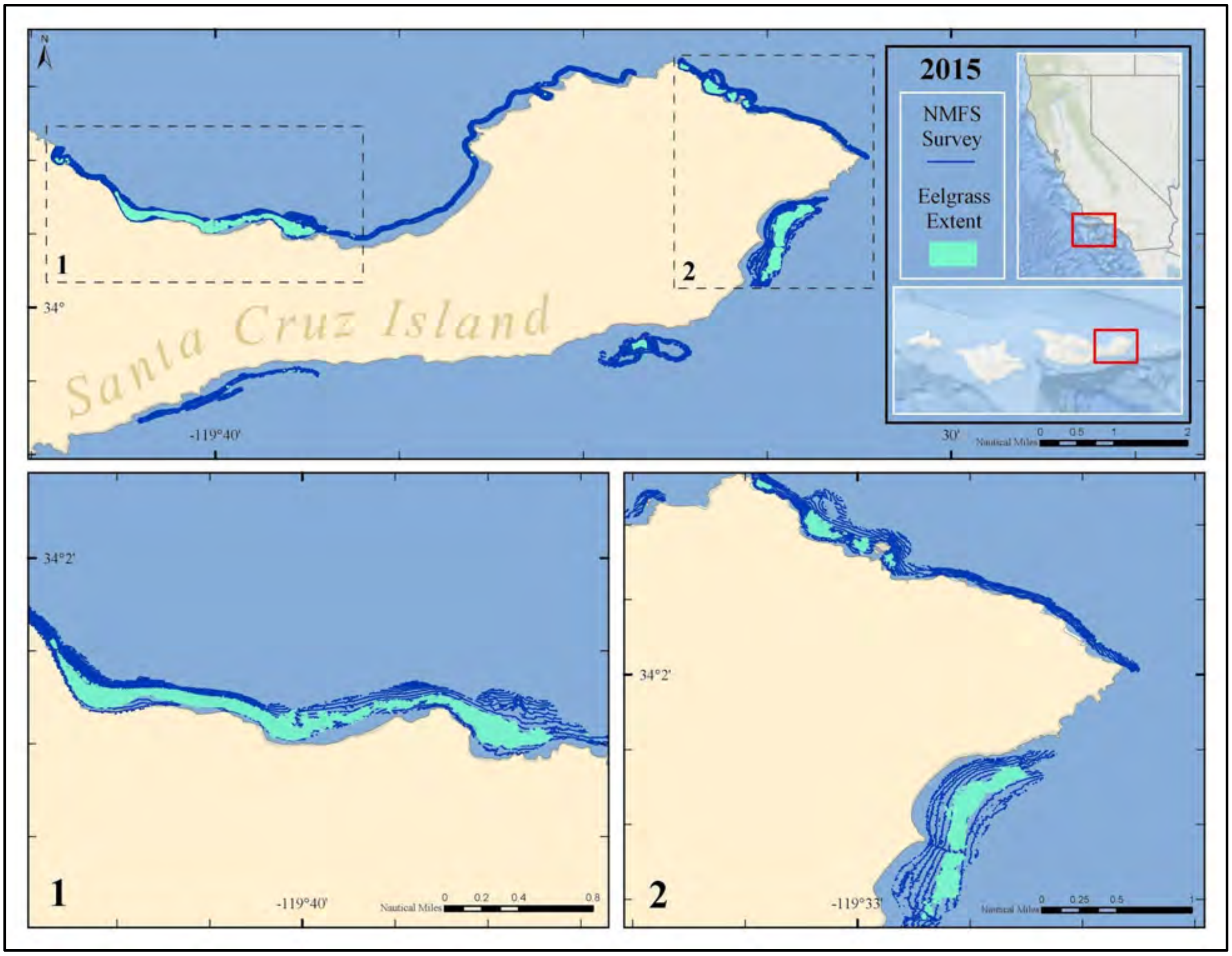


Figure App.E.10.25. National Marine Fisheries Service surveys in 2015 for eelgrass using interferometric sidescan sonar to map bed extent are shown. Dark blue represents bathylines generated from the sidescan data and area surveyed. Turquoise areas represents eelgrass bed extent generated from sidescan data. Eelgrass beds in these areas are thought to have persisted for long periods of time and appear to be relatively stable; however, surveys on the eelgrass health and shoot density have not been conducted. Data source: NMFS; Map: M. Cajandig/NOAA

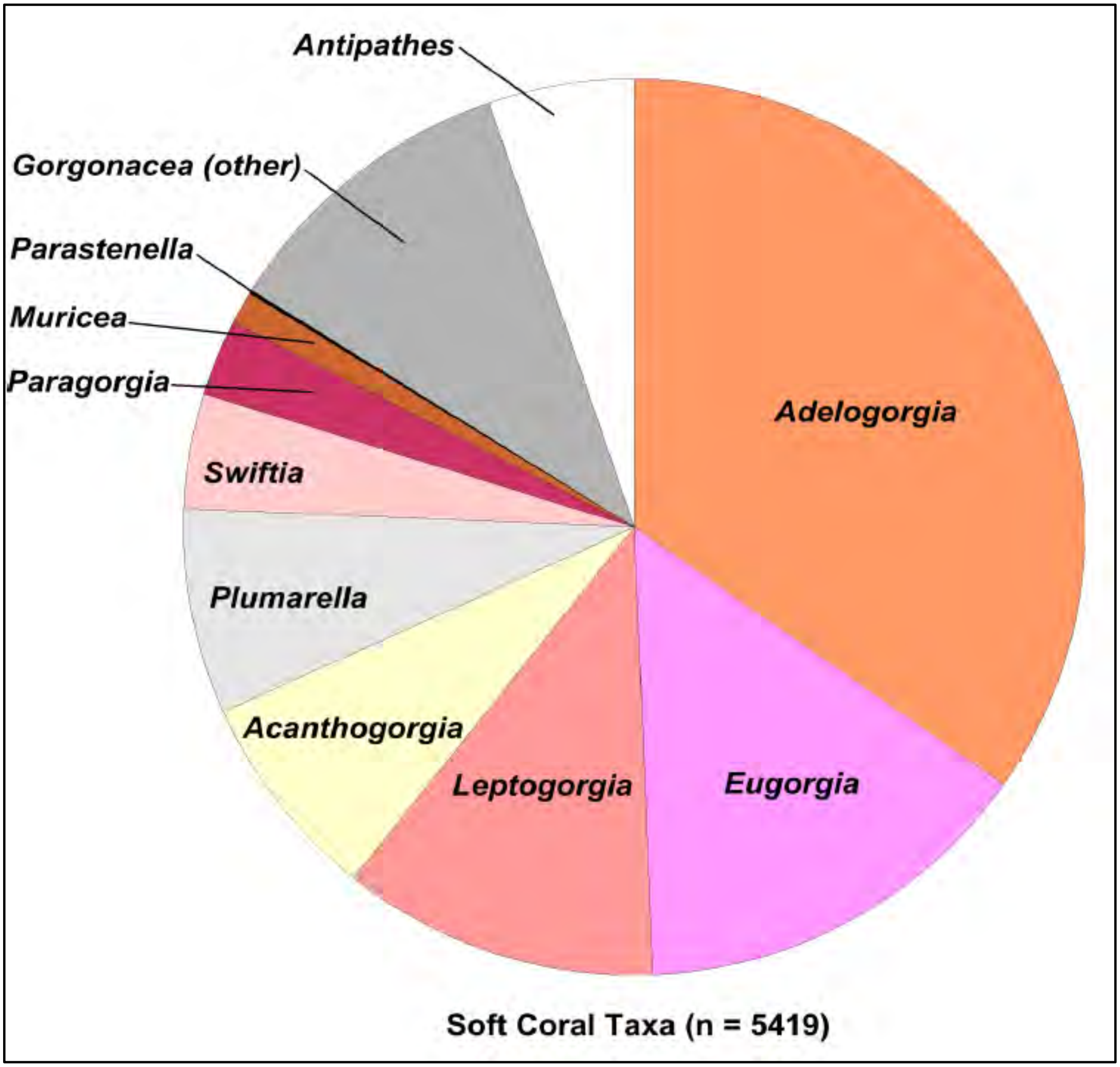


Figure App.E.10.26. The breakdown for the number of deep-water soft corals colonies observed in each genus for the Southern California Bight. Among the 34,792 images collected by the SWFSC Sebastes ROV between 2003 and 2011 throughout the entire Southern California Bight, researchers observed a total of 5,419 colonies. *Adelogorgia* was most common with 1,832 colonies in 535 observations. *Eugorgia* was second most common with 792 colonies in 436 observations. Figure: Etnoyer et al. 2015

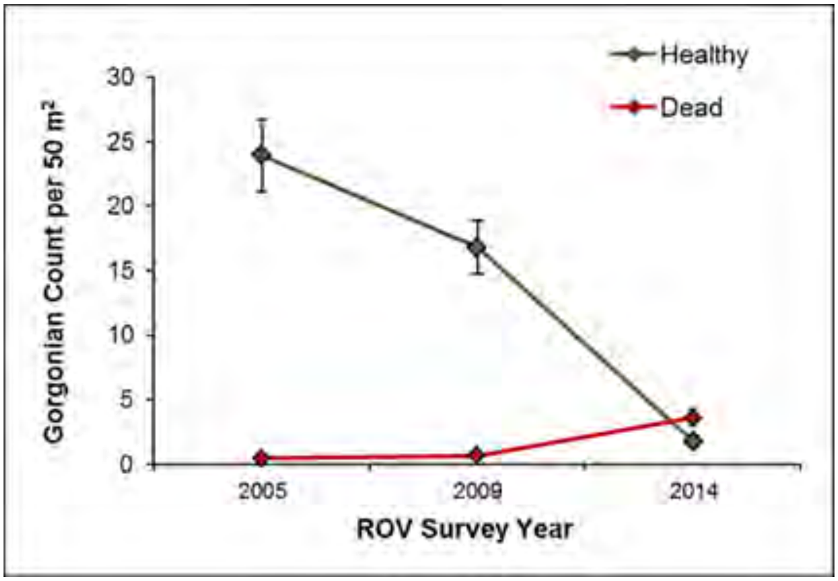


Figure App.E.10.27. Densities of healthy (green) and dead (red) gorgonians at Anacapa Island from ROV surveys in 2005, 2009, and 2014 are depicted above. Densities of healthy gorgonians have sharply declined since 2005 while the densities of observed dead gorgonians has risen. The decline in healthy gorgonians may be related to increased water temperature, impacts from fishing gear, and changes in acidic conditions. Since eastern islands are subject to warmer conditions and have increased fishing pressure compared to western islands, gorgonian populations at eastern islands are more susceptible to these impacts than those found at western islands. Figure: MARE and P. Etnoyer/NOAA

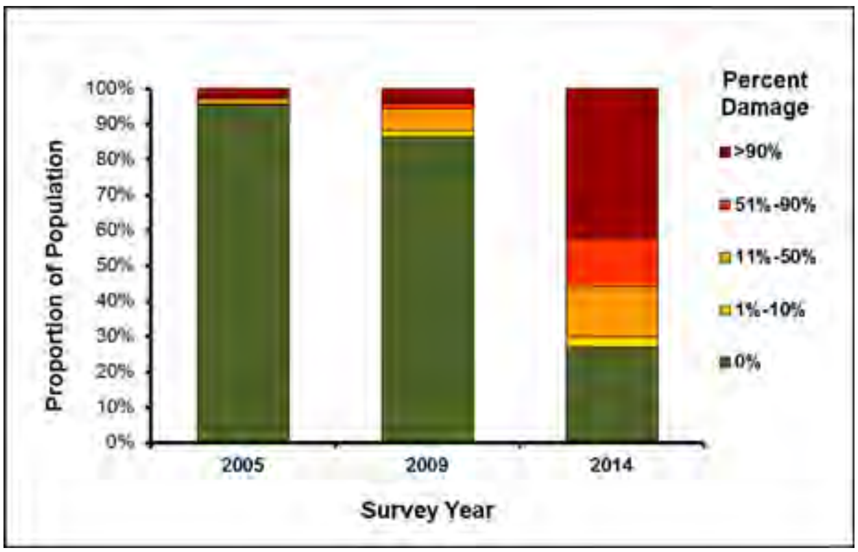


Figure App.E.10.28. Percent of gorgonians showing different levels damage at Anacapa Island during ROV surveys in 2005, 2009, and 2014. By 2014, less than 30 percent of observed gorgonians at Anacapa Island had no recognizable damage. Interactions with fishing gear and increasing water temperatures are thought to contribute to the increases in observed gorgonian damage at Anacapa Island. Gorgonian populations at more western islands are thought to fare better compared to Anacapa due to cooler water and less fishing effort. Figure: MARE

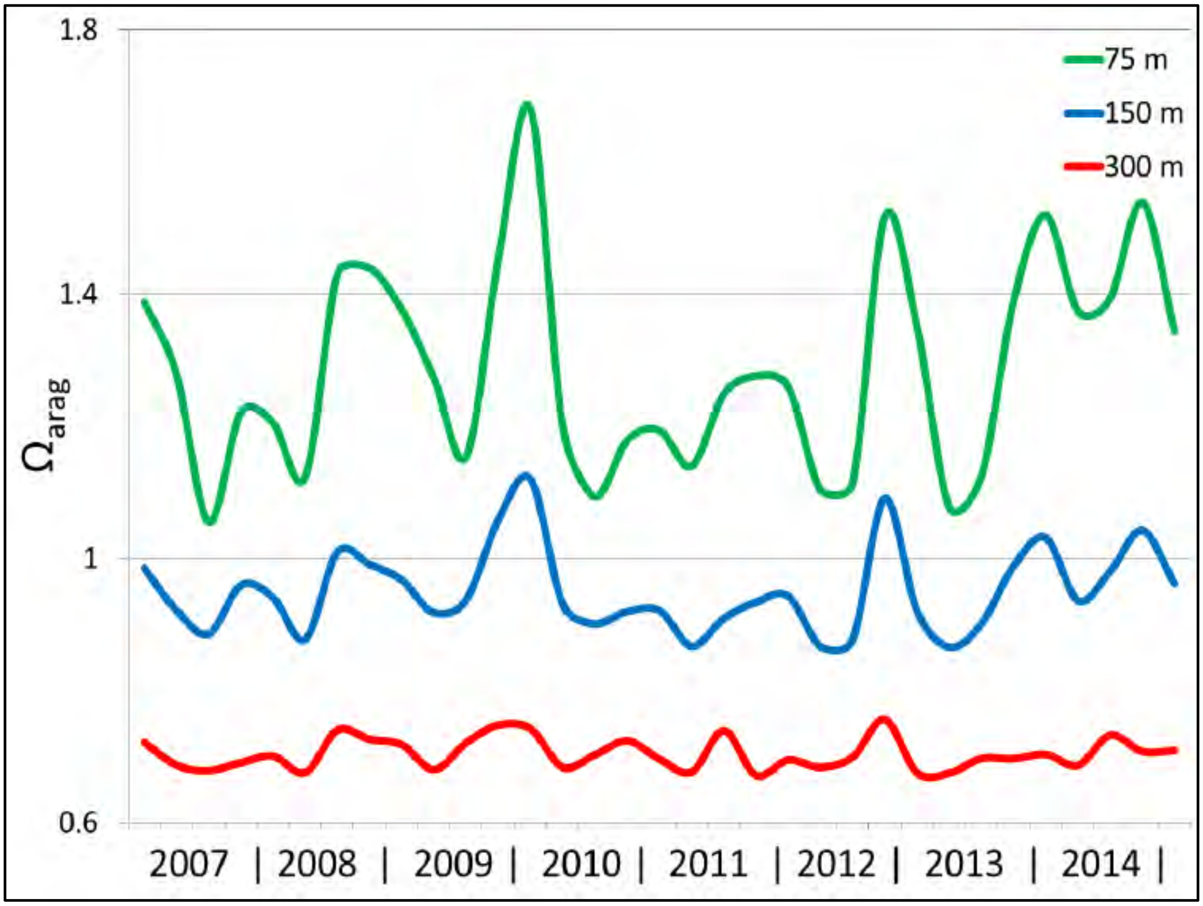


Figure App.E.10.29. Aragonite saturations are shown at 75 meters (m) (green), 150 m (blue) and 300 m (red) at Anacapa Island. As pH of seawater decreases (e.g., from the deposition of atmospheric CO^2), the saturation state of aragonite (Ωarg) decreases. Aragonite undersaturation (Ωarg < 1) favors dissolution over calcification, making it harder for organisms to make and maintain their shells or skeletons in the case of corals. In coastal upwelling zones, such as the California Current, the aragonite saturation state and depth are variable and shallow, respectively. With ocean acidification, aragonite saturation depths have shoaled over the past three decades and are now typically around 200 m in the California Current (Turi et al. 2016). At the local scale at Anacapa Island, the aragonite saturation depth has hovered around 130 m over the past eight years. As strong of a shoaling trend as at the California Current scale has not been seen. Instead, he usual seasonal variation but relatively stable aragonite saturation states over time (no trend), particularly in deep water, have been seen. Figure: Etnoyer et al. 2015

11. What are the contaminant concentrations in sanctuary habitats and how are they changing?

Table App.E.11.1. Data presented to the habitat experts at the workshop on June 1, 2016 to update status and trends assessments for Channel Islands National Marine Sanctuary (CINMS).
**Denotes graphs that were received after the expert workshops and were not available for experts to view during the status and trend workshop; however, a representative from the monitoring program discussed this data set during the meeting.

Indicator	Source	Figure #	Data Summary
Rocky Intertidal Habitat			
Mussels — tissue contaminants	NCCOS Mussel Watch	App.E.11.1–EE.11.6	*Status:* Variable by contaminant; exceeded 90th percentile for entire Southern California Bight: arsenic, cadmium, chromium, copper, mercury, nickel, one PBDE, one pesticide, two PAHs, and one PCB. *Trend:* Variable by contaminant; more consistent sampling effort needed.
Tar deposition — % cover	CINP	App.E.11.7–E.11.8	*Status:* Natural tar deposits on the islands are consistent and stable. *Trend:* Slight decline in percent cover (< 10%) in 2014 from long-term mean (limited data set because only five sites at one island).
Deep Seafloor Habitat (> 30 meters)			
Infauna contaminant levels	SCCWRP	App.E.11.9–E.11.11	*Status:* In the most recent survey, 20% of samples are marginally less than pristine with the rest of the samples marked as pristine. *Trend:* Declining, which indicates potential increasing contamination concentrations. Decreases primarily occurring around Santa Cruz Island. Other regions in southern California are not exhibiting similar declining trends.
Sediment contaminant levels	SCCWRP; Schiff et al. 2011	App.E.11.12–E.11.17	*Status:* Contaminants are present; however, they are typically in low concentrations compared to other regions in the bight. *Trend:* More monitoring data is needed.

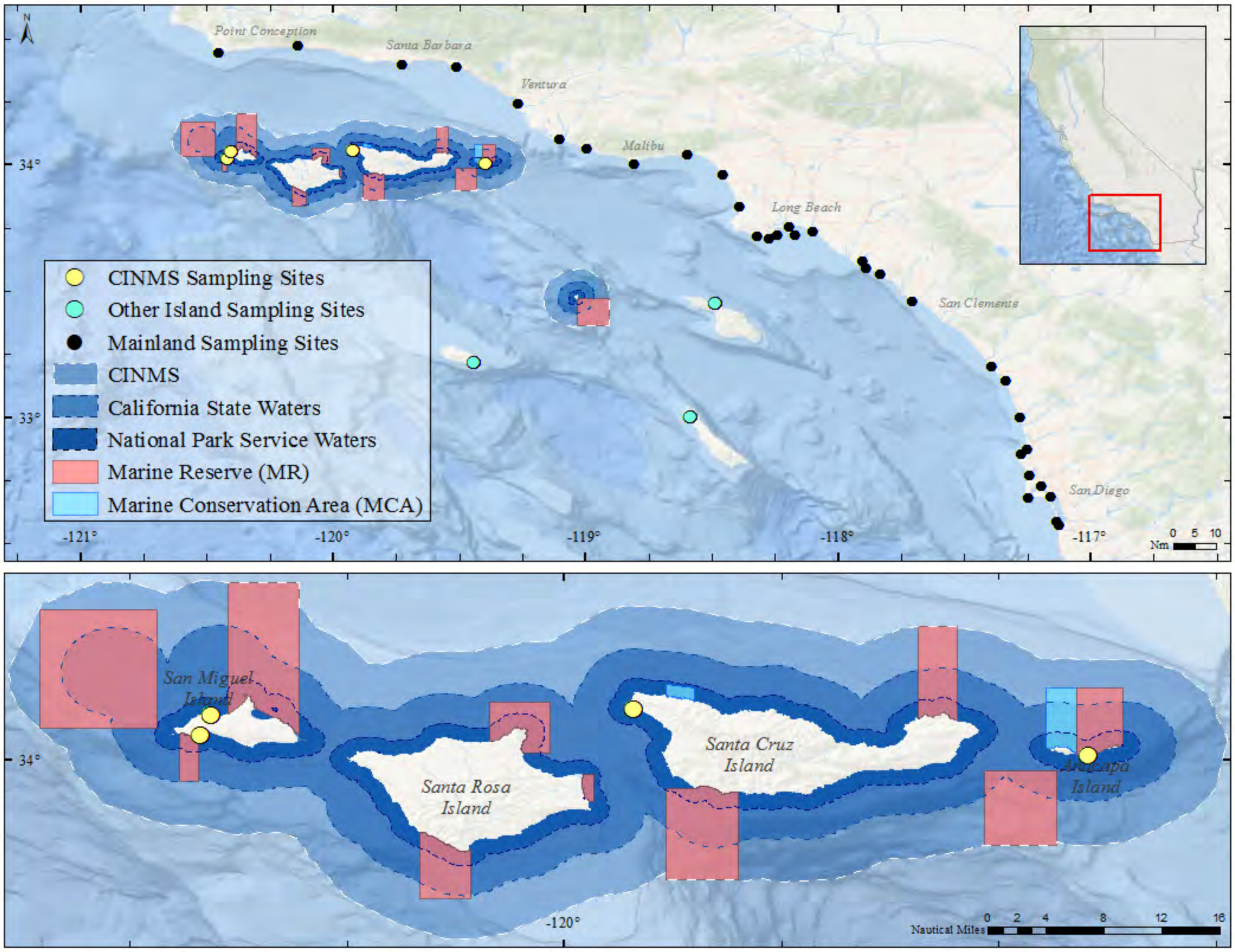


Figure App.E.11.1. Mussel tissue contaminant monitoring sites from NOAA's Mussel Watch Program are shown in southern California (top) and around CINMS (bottom). Only one site within CINMS has been monitored consistently over time: Fraser Point, SCI (1986–2010), Other monitoring sites include: Anacapa (2008 only); Tyler Bight, south SMI (1988 only); and Otter Harbor, north SMI (2008-2010). Data source: D. Whitall/ NOS NCCOS Mussel Watch; Map: M. Cajandig/NOAA

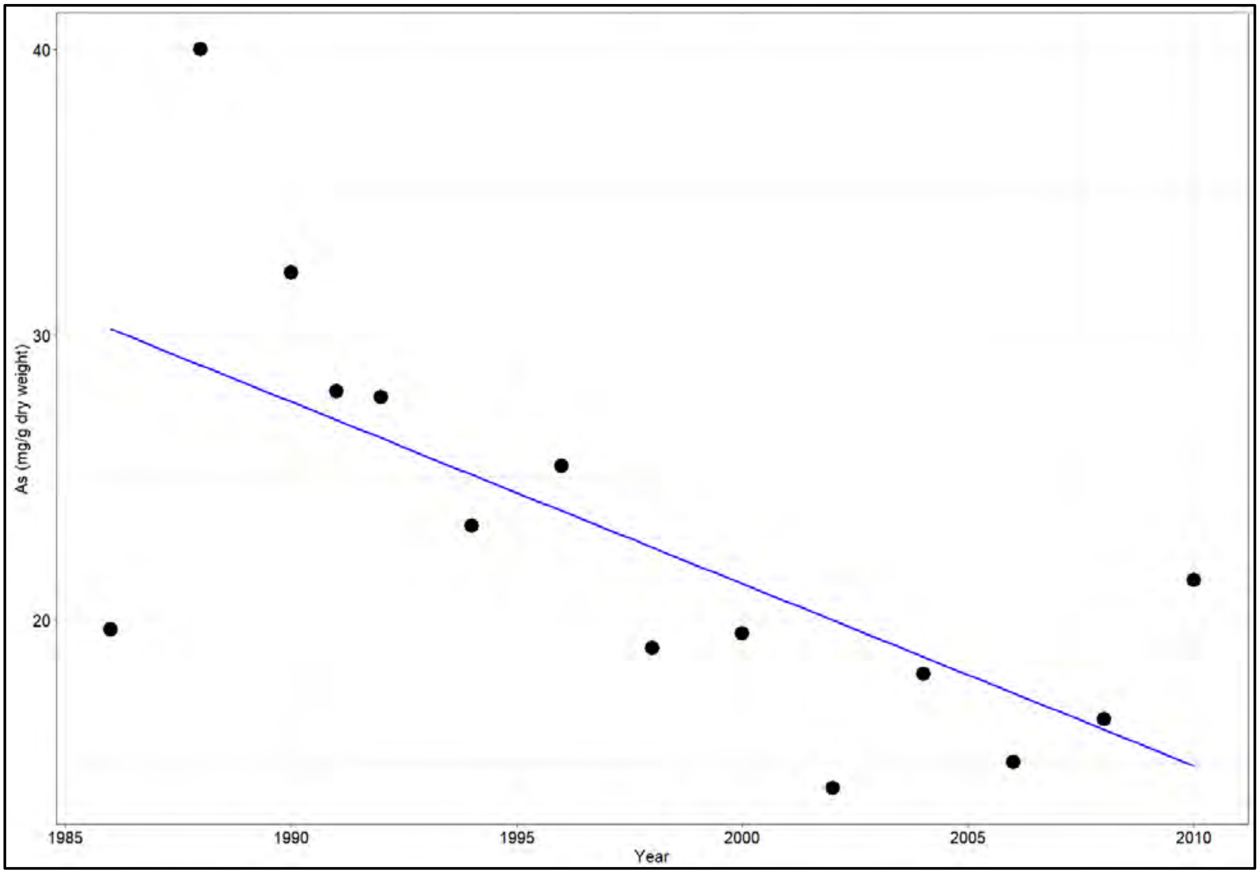


Figure App.E.11.2. Time series of arsenic (as µg/g dry weight) in *Mytilus* spp. at Fraser Point, Santa Cruz Island is shown above. Data is from NOAA's Mussel Watch Program (monitored 1986-2010). Arsenic values have been slowly declining in *Mytilus* spp tissue. Arsenic can impact a number of enzymes and has a widespread effects on a number of organ systems. There are multiple potential explanations for this finding, including limited spatial resolution, limited recent data, possible return to background levels consistent with the southern California mainland after remediation, or improved instrumentation and analytics that have been developed since data collection began. Due to this, more through research and data collection is required to confirm this trend. Figure: D. Whitall/NOAA, Mussel Watch

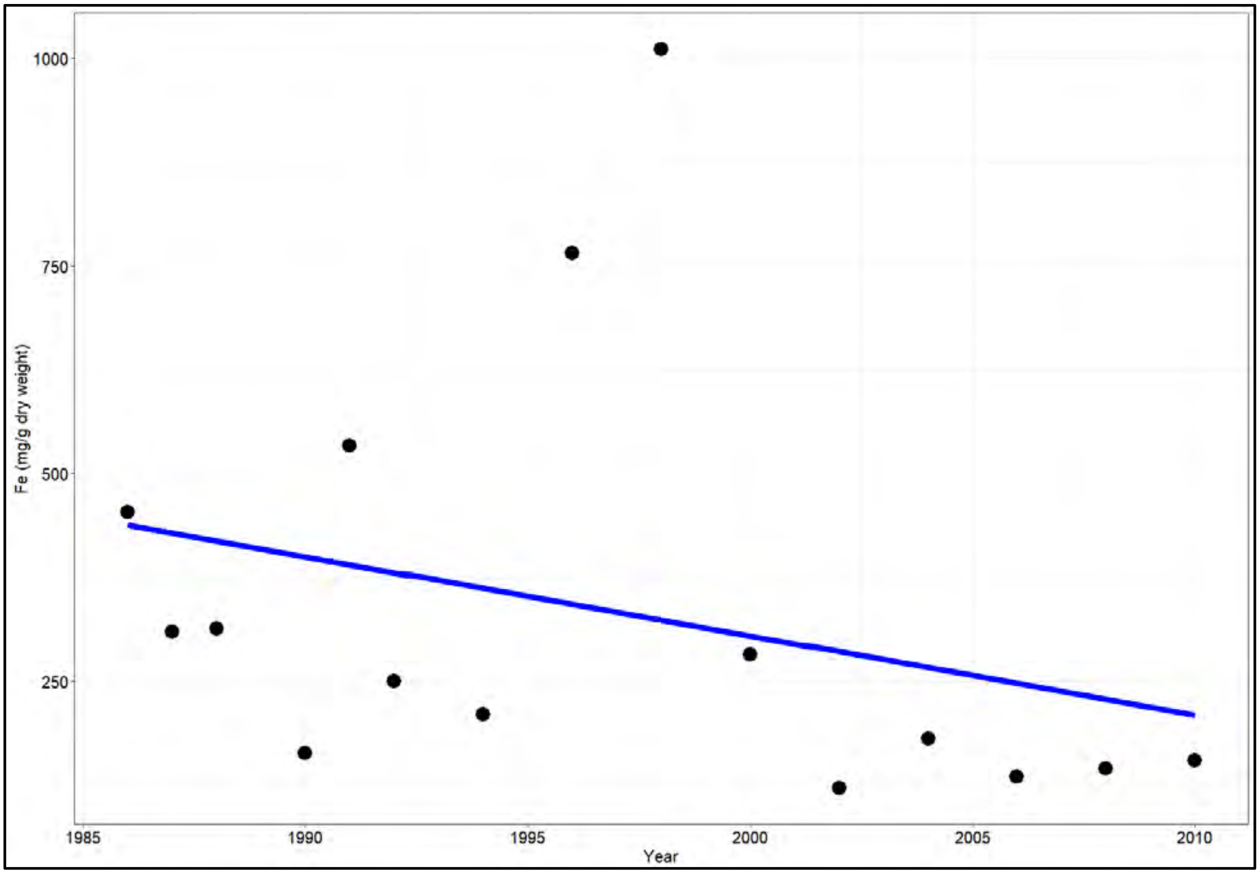


Figure App.E.11.3. Time series of iron (as µg/g dry weight) in *Mytilus* spp. at Fraser Point, Santa Cruz Island is shown above. Data is from NOAA's Mussel Watch Program (monitored 1986–2010). Iron values have been slowly declining in *Mytilus* spp. tissue. There are multiple potential explanations for this finding, including limited spatial resolution, limited recent data, possible return to background levels consistent with the southern California mainland after remediation, or improved instrumentation and analytics that have been developed since data collection began. Due to this, more through research and data collection is required to confirm this trend. Figure: D. Whitall/NOAA, Mussel Watch

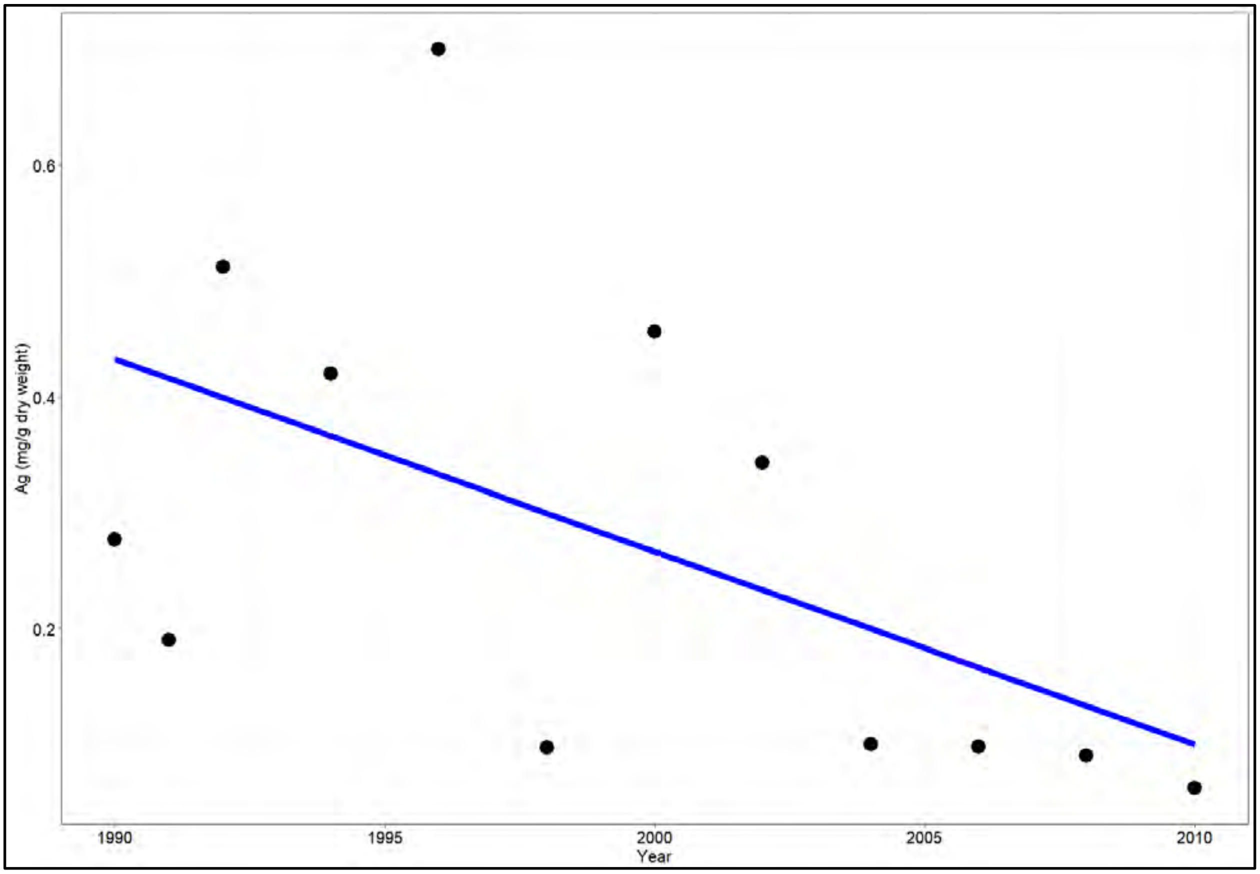


Figure App.E.11.4. Time series of silver (as µg/g dry weight) in *Mytilus* spp. at Fraser Point, Santa Cruz Island is shown above. Data is from NOAA's Mussel Watch Program (monitored 1986–2010). Silver values have been slowly declining in *Mytilus* spp. tissue. There are multiple potential explanations for this finding, including limited spatial resolution, limited recent data, possible return to background levels consistent with the southern California mainland after remediation, or improved instrumentation and analytics that have been developed since data collection began. Due to this, more through research and data collection is required to confirm this trend. Figure: D. Whitall/NOAA, Mussel Watch

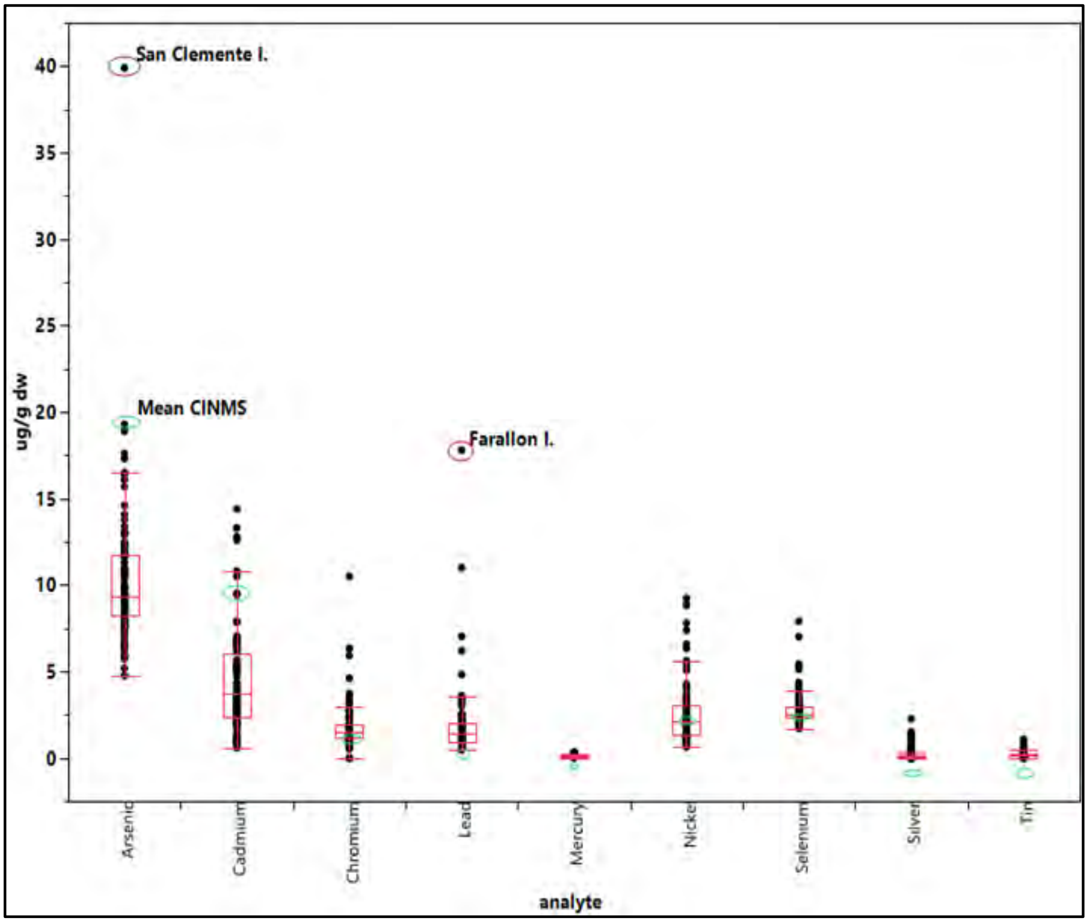


Figure App.E.11.5. This graph is California coastwide comparison of total extractables (TE) from *Mytilus* spp. tissue for heavy metals. Data is from NOAA's Mussel Watch Program (monitored 1986–2010). The horizontal lines of the red box illustrate the 25th, median, and 75th percentiles, while the top and bottom whiskers represent the 10th and 90th percentiles. Black dots are data points from collection sites and the green ellipsoids represent mean concentration values for metals from sites within CINMS (n = 3). There are multiple potential explanations for this finding, including limited spatial resolution, limited recent data, possible return to background levels consistent with the southern California mainland after remediation, or improved instrumentation and analytics that have been developed since data collection began. Due to this, more through research and data collection is required to confirm this trend. Figure: D. Apeti/NOAA, Mussel Watch

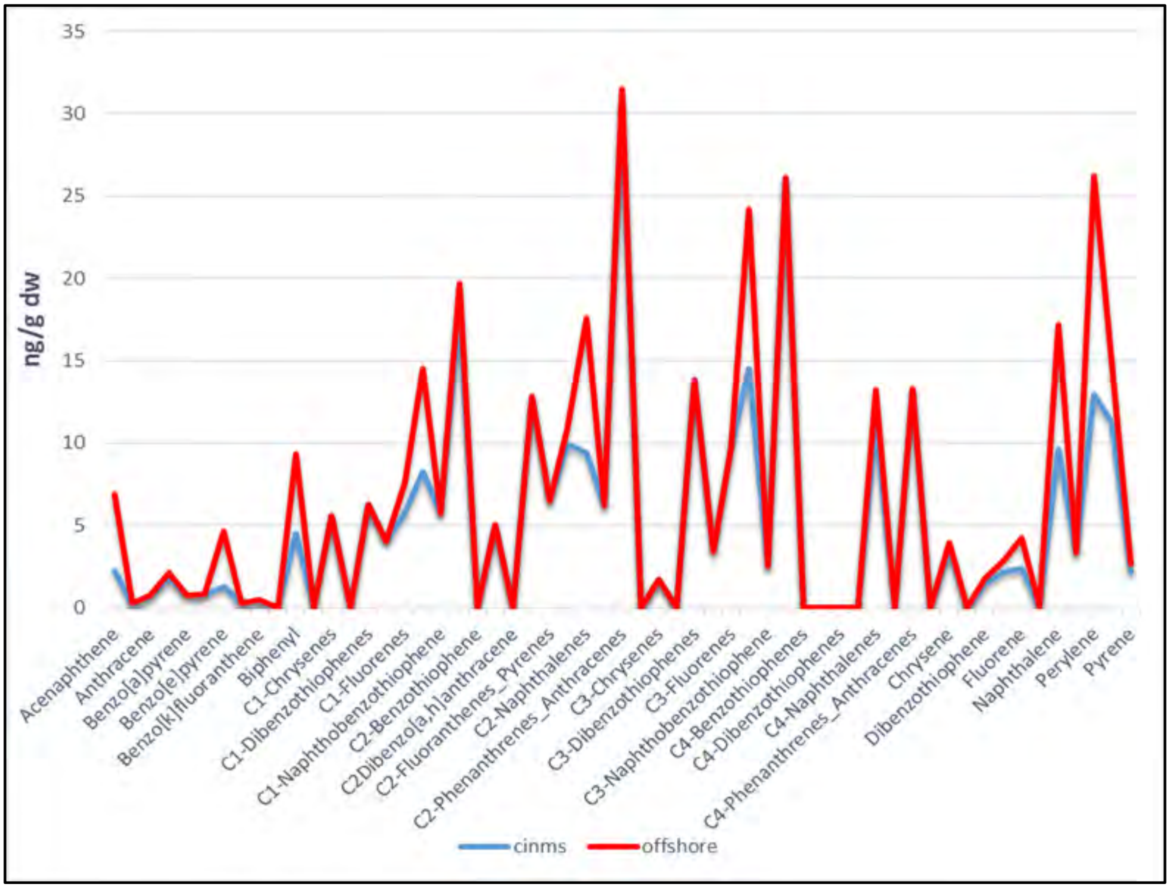


Figure App.E.11.6. Mean Total Extractables (TE) for individual Polycyclic Aromatic Hydrocarbons or PAHs are compared between Channel Islands (blue) and other offshore sites (red). PAHs are organic contaminants that are carcinogenic. Invertebrate species typically have limited ability to metabolize PAHs; however, they typically do not biomagnify because vertebrates can metabolize them more easily. Concentrations of PAHs are variable, but concentrations at CINMS are usually equivalent, if not lower than other offshore locations. There are multiple potential explanations for this finding, including limited spatial resolution, limited recent data, possible return to background levels consistent with the southern California mainland after remediation, or improved instrumentation and analytics that have been developed since data collection began. Due to this, more through research and data collection is required to confirm this trend. Figure: D. Apeti/NOAA, Mussel Watch

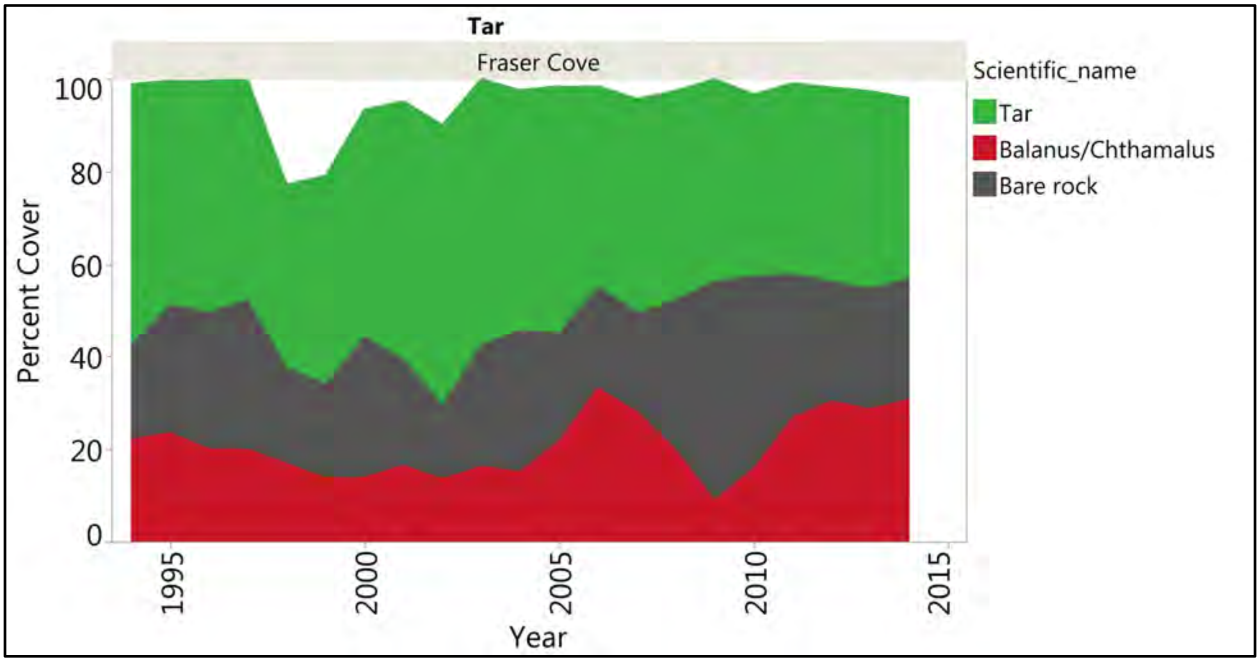


Figure App.E.11.7. Tar deposition percent cover (green) at Fraser Cove, Santa Cruz Island is compared to bare rock (red) and a barnacle complex (*Balanus/Chtamalus*, grey). The park only monitors tar at Fraser Cove and it is believed that tar at this location is from natural seeps. There was a slight decline (< 10 percent) in tar cover in 2014 from long-term mean, but tar still covered approximately 50 percent of plots. Figure: Channel Islands National Park

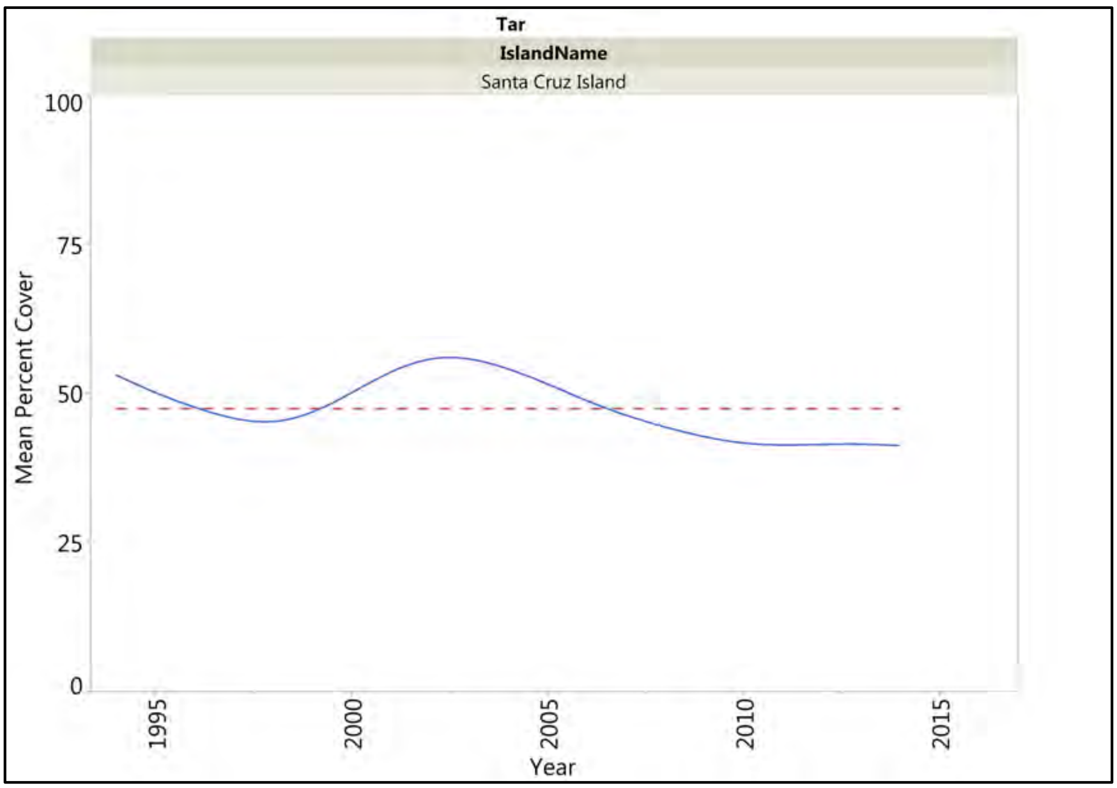


Figure App.E.11.8. Tar deposition percent cover at Fraser Cove, Santa Cruz Island. The park only monitors tar at Fraser Cove and it is believed that tar at this location is from natural seeps. The blue line represents the mean percent cover at a given year while the red dashed line represents the long-term mean. There was a slight decline (< 10 percent) in tar cover in 2014 from the long-term mean, but tar still covered approximately 50 percent of plots. Figure: Channel Islands National Park

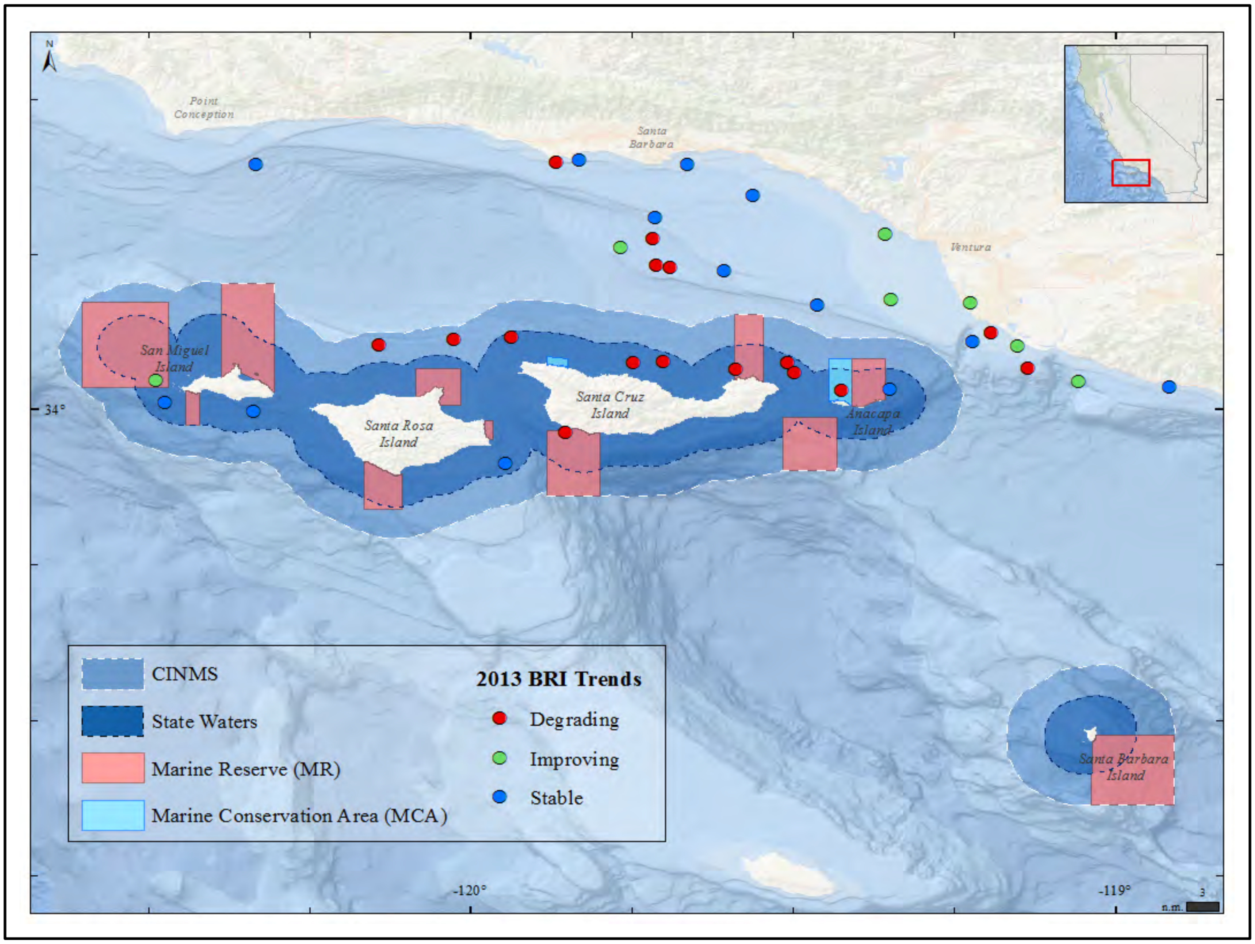


Figure App.E.11.9. The Southern California Water Research Project uses a diversity index of tolerant and sensitive infauna, also known as the Benthic Response Index (BRI), to gauge the ecosystem impact from anthropogenic contamination. The map above shows the 2013 locations of samples and the BRI trends at each location. Previously, island sites were all considered 100 percent pristine (reference), but now roughly 70 percent of samples are considered degraded from that status. Decline in BRI was particularly prevalent around Santa Cruz Island. This decline in BRI was not mirrored in other regions in southern California. The most recent samples, collected in 2013, found that ten of the 15 sites in Channel Island National Marine Sanctuary had infaunal community compositions that were shifting towards species more tolerant of degraded conditions (red) compared to the samples collected previously. Data Source: K. Schiff/ SCCWRP; Map: M. Cajandig/NOAA

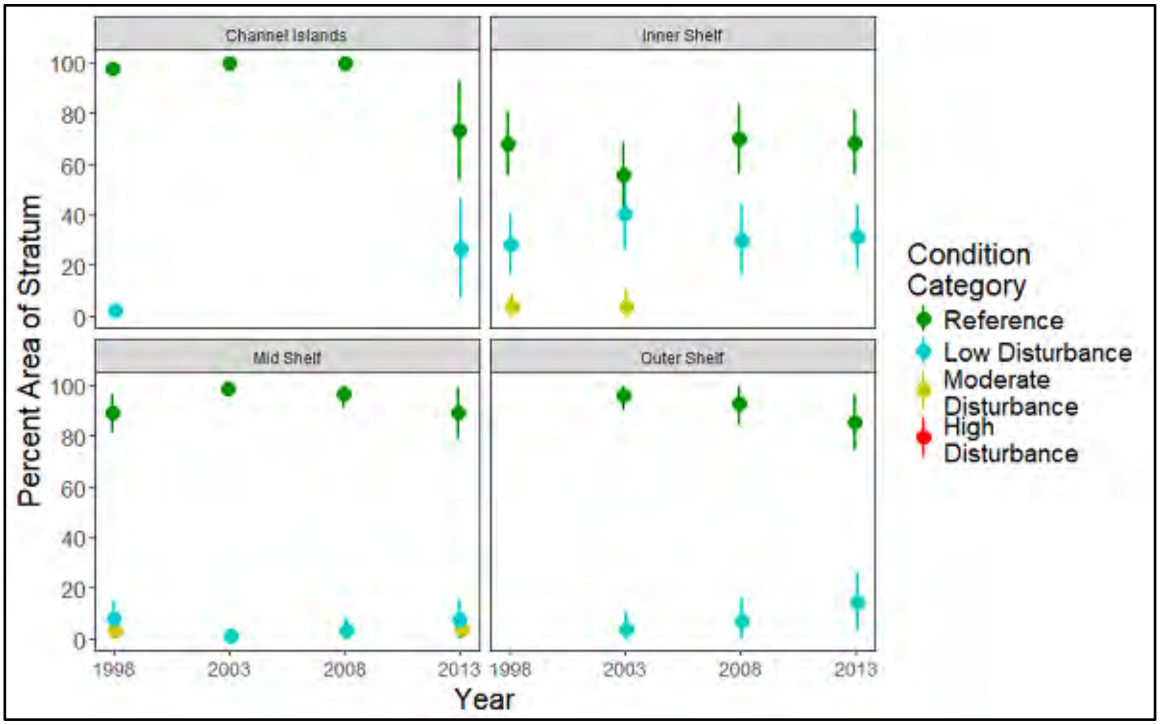


Figure App.E.11.10. Comparisons of the Benthic Response Index (BRI), a diversity index of contaminant tolerant and sensitive infauna, among different regions of the Southern California Bight is shown. Island shelf sites (upper right) had been at reference levels (highest ranking) until 2013, when approximately 30 percent of sites were reclassified as low impact. Other regions in the bight did not experience such a large BRI decline as the island shelf, which indicates potential new impacts to sediments around southern California Islands. Figure: K. Schiff/SCCWRP

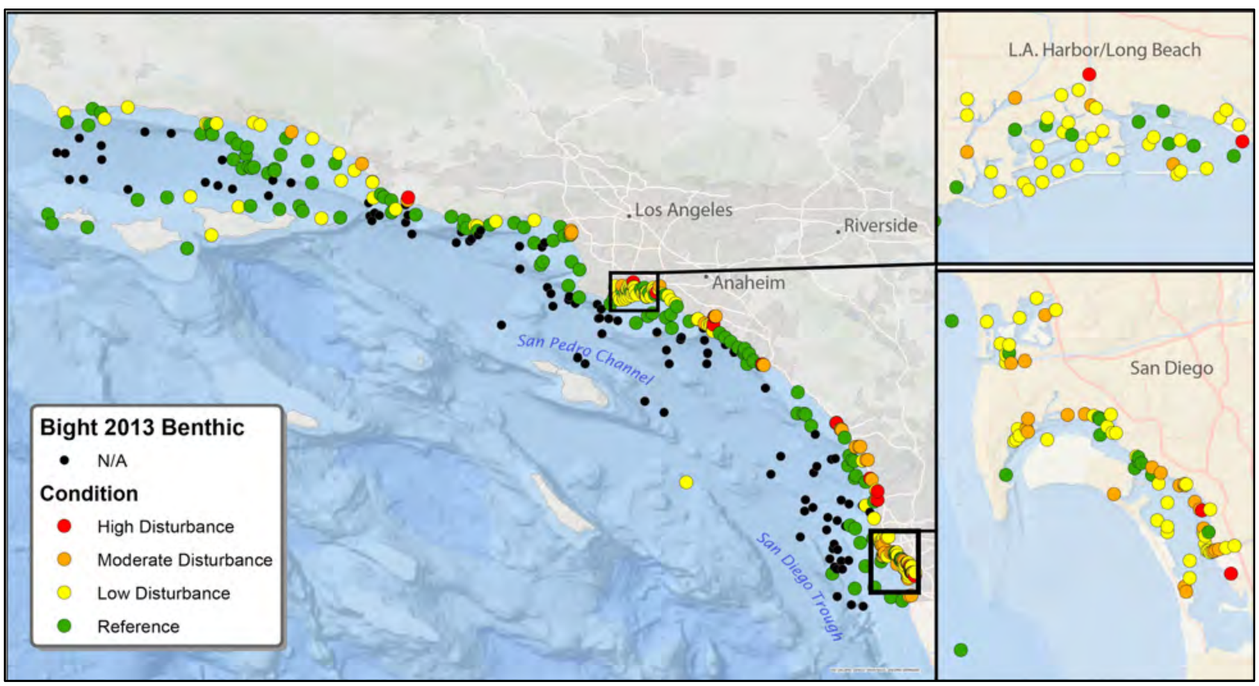


Figure App.E.11.11. SCCWRP sediment sample locations and their respective Benthic Response Index (BRI) from the 2013 bight-wide survey are shown in the map. In order to create the BRI, infaunal invertebrate communities are characterized based on the proportion of taxa present in a sample that are sensitive to as opposed to tolerant of contaminant levels. Using a composite score of the infauna community, SCCRWP labels sample sites as reference, low impact, moderate impact, or high impact. Figure: K. Schiff/SCCWRP

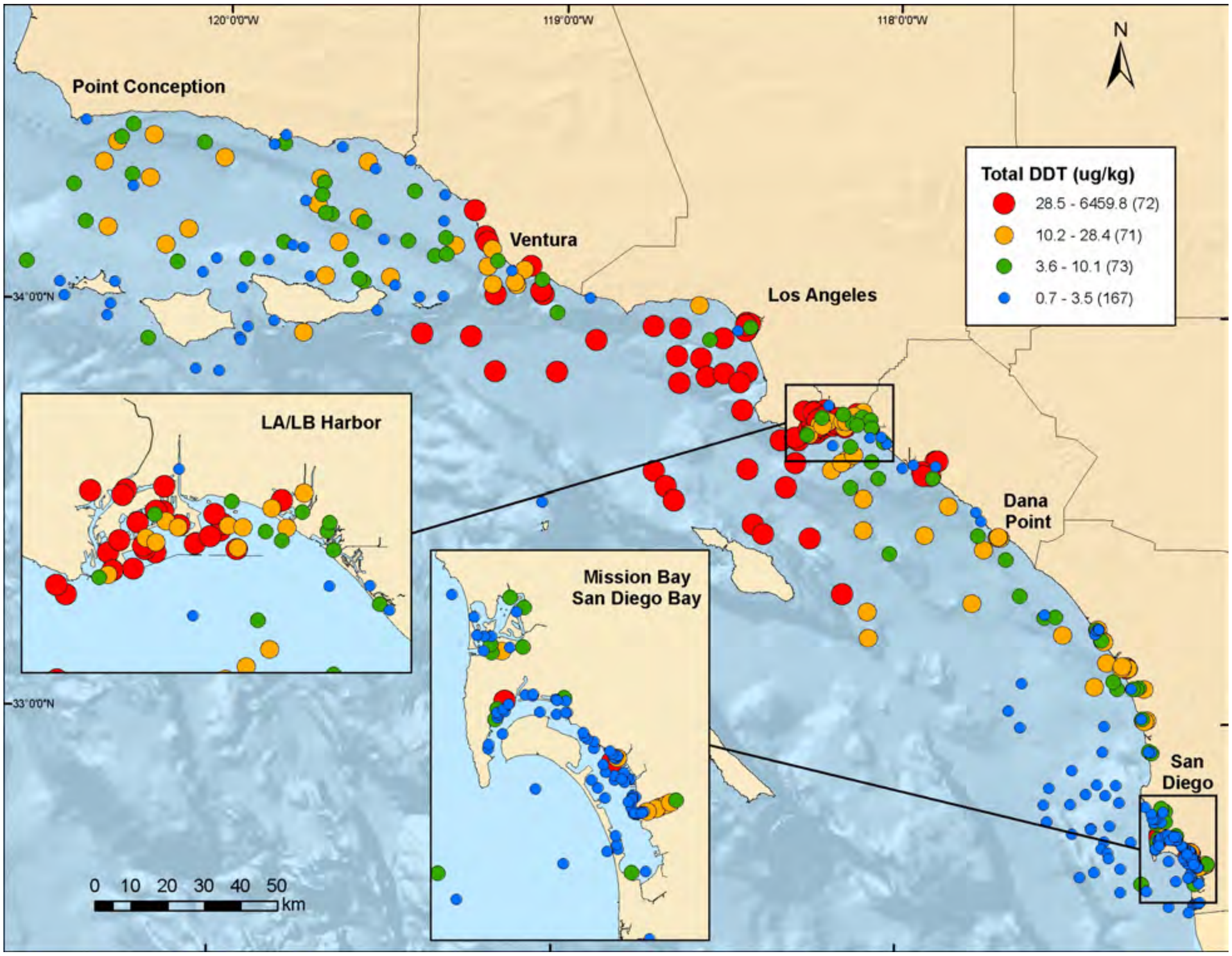


Figure App.E.11.12. Dichlorodiphenyltrichloroethane (DDT) contaminant levels in sediment sampling locations during SCCRWP's 2008 bight-wide survey are shown in the map. DDT is most prominent around the Ports of Long Beach, Los Angeles, and Santa Monica Bay. DDT is a legacy contaminant, which means it persists in the environment long after introduction. A large amount of DDT in the bight came from the dumping of the contaminant by the Montrose Chemical Company off Palos Verdes until the early 1980s, which is why the surrounding areas have high DDT levels. CINMS is relatively far from the spill site and thus, has limited DDT concentrations in sediments. Figure: Schiff et al. 2011

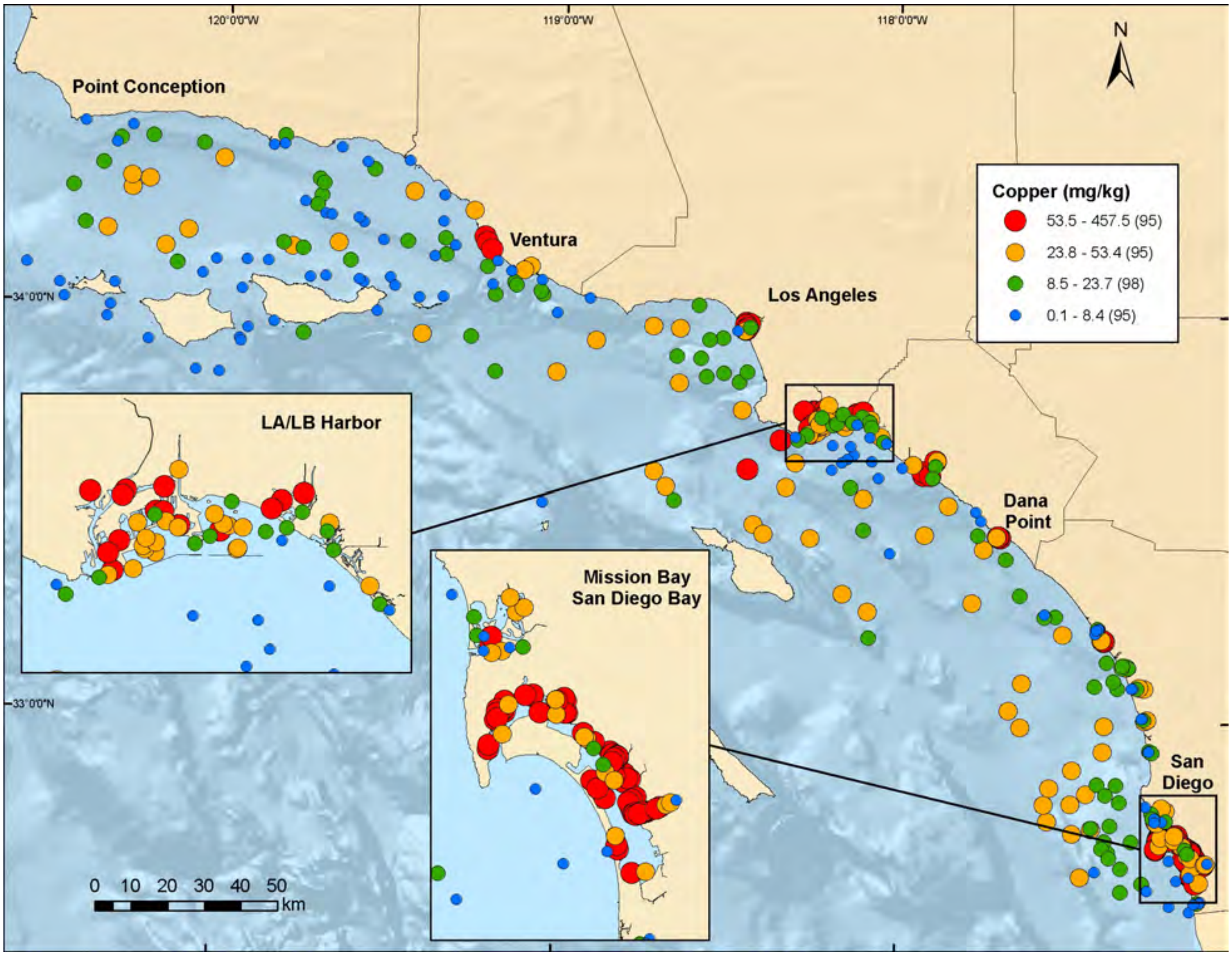


Figure E11.13. Copper contaminant levels at sediment sampling locations during SCCRWP's 2008 Bight wide survey are shown in the map. Copper is a heavy metal contaminant that in high concentrations can be toxic to living marine resources. Concentrations in CINMS are consistently low compared with other regions in the southern California Bight. Figure: Schiff et al. 2011.

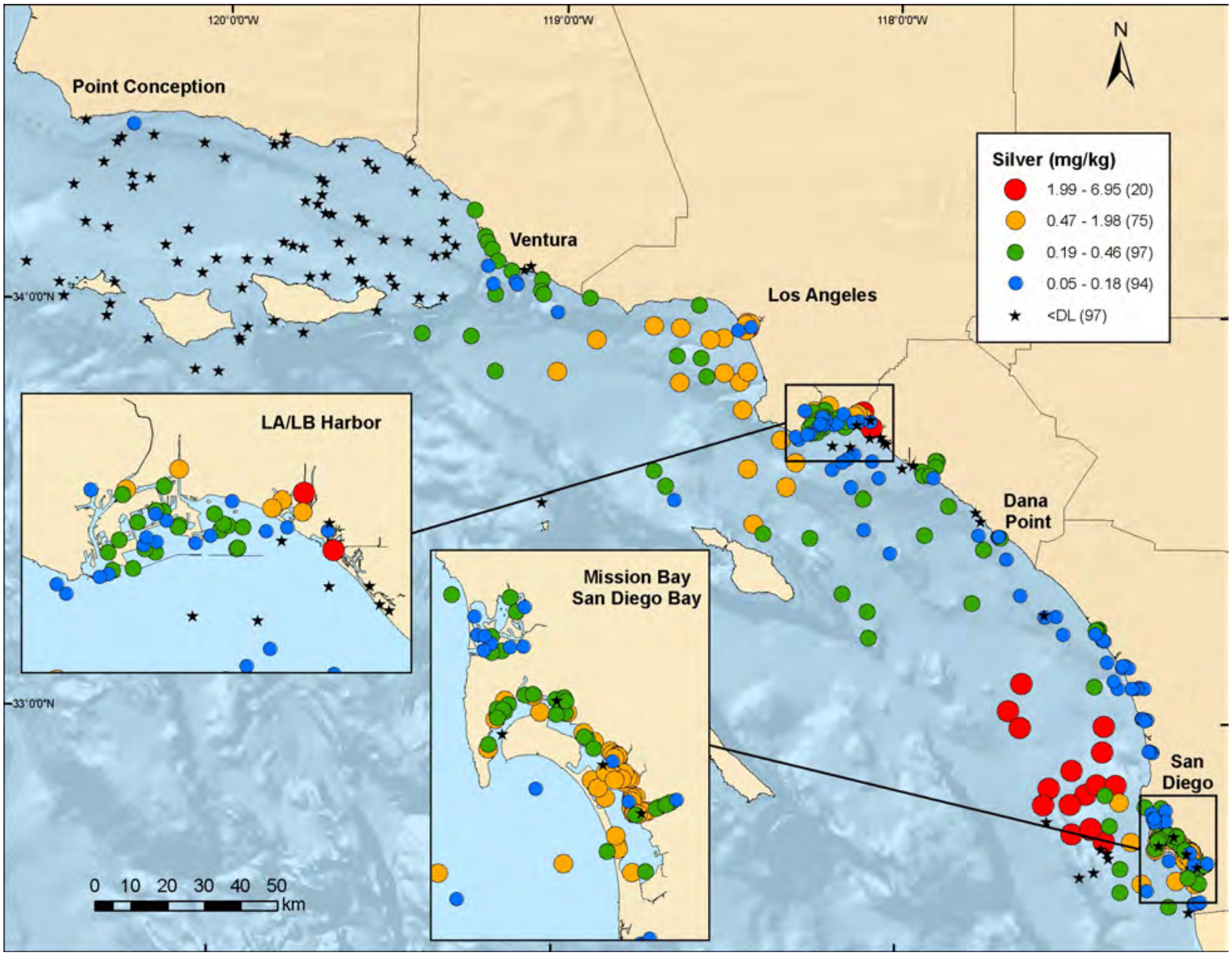


Figure App.E.11.14. Silver contaminant levels in sediment sampling locations during SCCRWP's 2008 bight-wide survey are shown in the map. Silver is a heavy metal contaminant that in high concentrations can be toxic to living marine resources. Concentrations in CINMS and the Santa Barbara Channel are consistently low compared other regions in the Southern California Bight. High concentrations of silver appear to be clustered off the two largest population centers: Los Angeles and San Diego. Figure: Schiff et al. 2011

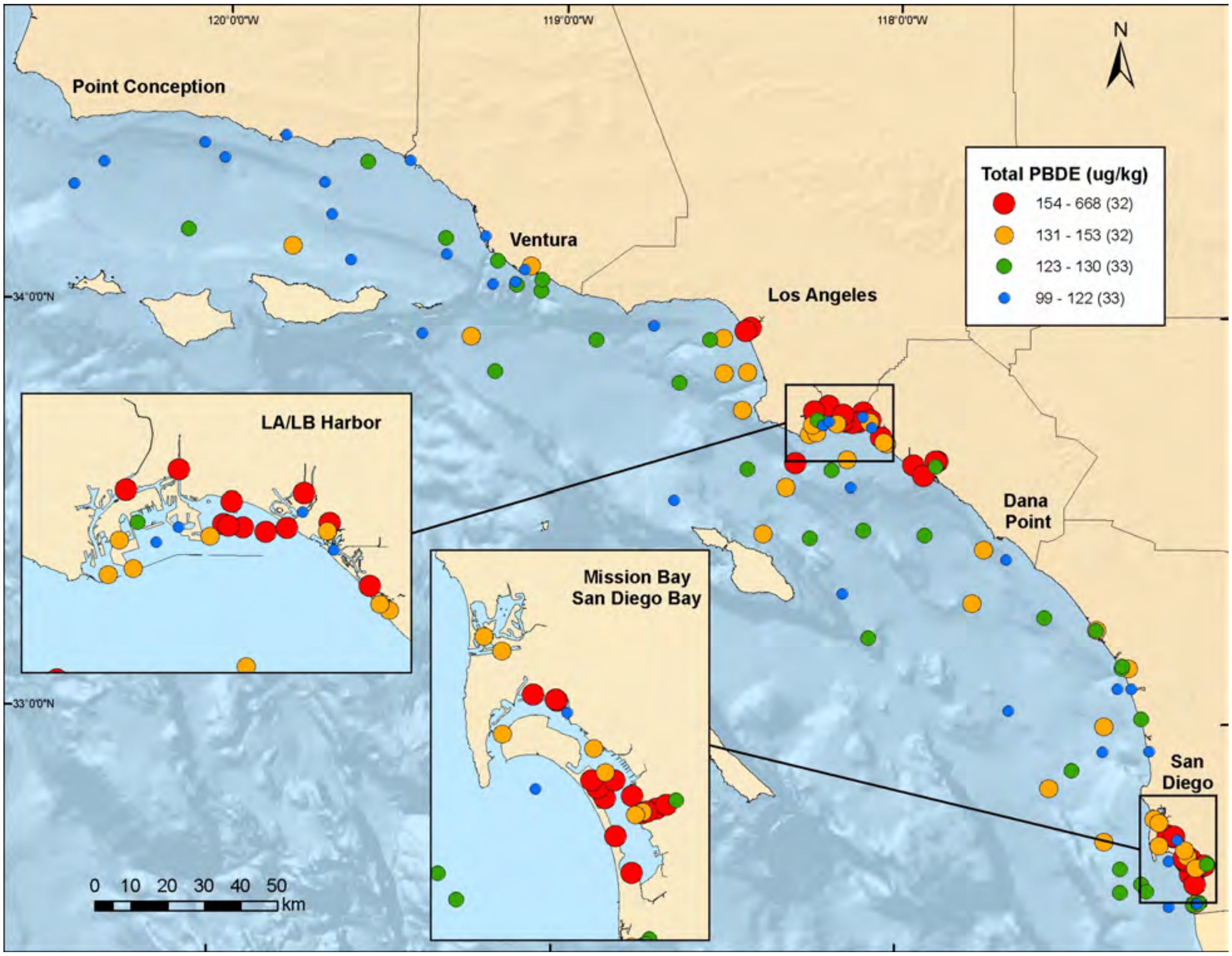


Figure E11.15. Sediment contaminant levels for Polybrominated diphenyl ethers (PBDEs) in the Southern California Bight are shown in the map above. These products are typically added to manufactured products as flame retardants. Concentrations of PBDEs are low at the islands compared to mainland areas. Figure: Schiff et al. 2011

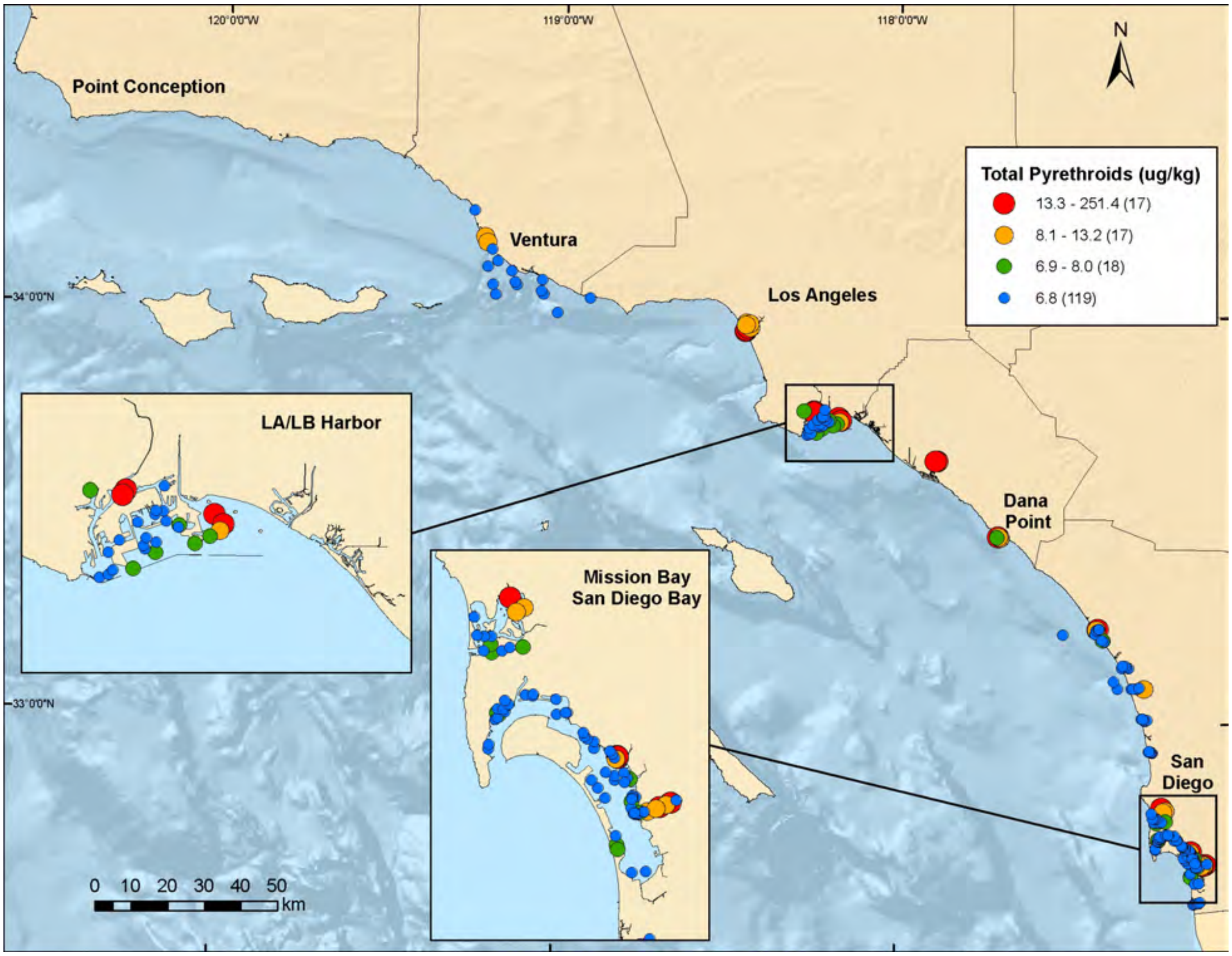


Figure App.E.11.16. Pyrethroids contaminant levels in sediment sampling locations during SCCRWP's 2008 bight-wide survey are shown in the map. Pyrethroids are typically pollutants coming from insecticide use. In recent years, there has been no agriculture on the islands and thus, pyrethroids are absent from CINMS sediments. Sediments adjacent to CINMS off Ventura have low levels of pyrethroids likely due to agriculture in that area. Figure: Schiff et al. 2011

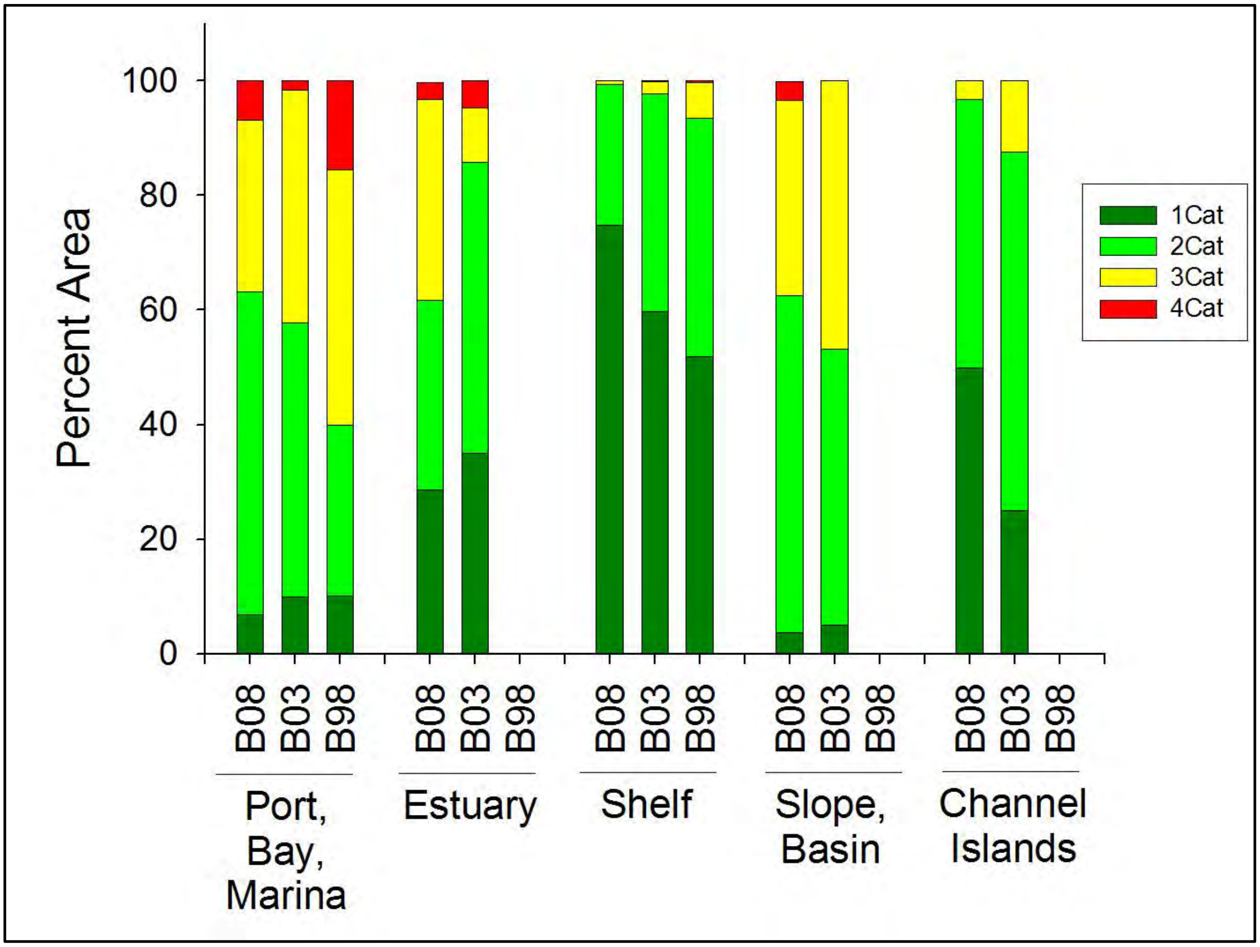


Figure App.E.11.17. Percent area of impacted sediments by stratum and survey year in varying categories of exposure to sediment contamination are shown in the bar plot. Category 1 is minimal exposure; Category 2 is low exposure; Category 3 is moderate exposure; and Category 4 is high exposure. Categories are determined by two prominent chemistry indices determined by analyzing a suite of chemical concentrations present in sediment samples. Missing bars represent no data. In minimal exposure, sediment-associated contamination may be present, but exposure is unlikely to result in effects. In low exposure, small increase in contaminant exposure may be associated with increased effects, but magnitude or frequency of occurrence of biological impacts is low. In moderate exposure, there is clear evidence of sediment contaminant exposure at concentrations that are likely to result in biological effects. For high exposure, contaminant exposure is highly likely to result in substantial biological effects. The Channel Islands have no sediments in Category 4 and the large majority of sediments are in Category 1 or 2, thus indicating limited contamination impact in sanctuary sediments. At this time, the suites of chemical indices have not yet been completed for the 2008 bight-wide survey. Figure: Schiff et al. 2011

APPENDIX F:
Living Resources Tables and Graphs

12. What is the status of keystone and foundation species and how is it changing?

Table App.F12.1. Data presented to living resources experts at the workshop on June 1, 2016 to update status and trends assessments for Channel Islands National Marine Sanctuary (CINMS).
**Denotes graphs that were received after the expert workshops and were not available for experts to view during the status and trend workshop; however, a representative from the monitoring program discussed this data during the meeting.

Indicator	Source	Figure #	Data Summary
Rocky Intertidal Habitat			
Ocher star *Pisaster ochraceus* abundance and size structure	CINP; MARINe	App.F.12.2, App.F.12.3	*Status:* 2014 very low abundance at most sites *Trend:* Drastic declines in 2013–2014.
Beach Habitat			
Sand crab *Emerita analoga* abundance	CINP	App.F.12.4	*Status and Trend:* High variability among sites (at Santa Rosa Island) and years. No clear trend in abundance from 1994 to 2015.
Kelp Forest and Shallow Reef Habitat (< 30 meters)			
Red and purple sea urchin abundance	PISCO	App.F.12.5	*Status:* Purple urchins are not harvested; red urchins are harvested and currently below unfished levels. *Trend:* 2014–2016 density of both species declined at eastern islands and increased at western islands.
Red and purple sea urchin abundance	SBC LTER	App.F.12.6	*Status:* Reds are harvested and currently below unfished levels. *Trend:* Fairly stable at island sites from 2004 to 2015.
Sea star (*Pisaster* and *Pycnopodia*) abundance	PISCO	App.F.12.7	*Status:* Very low abundance at all sites from 2014 to 2016. *Trend:* Drastic declines in all three species from 2013 to 2014.
Sea star (*Pisaster* and *Pycnopodia*) abundance	CINP	App.F.12.8**	*Status:* Reduced abundance from 2014 to 2016 at all islands. *Trend:* Drastic declines from 2013 to 2014 at all islands.
Sea star (*Pisaster* and *Pycnopodia*) abundance	SBC LTER	App.F.12.9	*Status:* Reduced abundance from 2014 to 2015 at island and mainland sites. *Trend:* Drastic declines from 2013 to 2014.
Spiny lobster *Panulirus interruptus* abundance	PISCO	App.F.12.10	*Status:* Harvested; well below unfished levels and low density. *Trend:* Possible recent, gradual increase at Anacapa and Santa Cruz islands.

Spiny lobster *P. interruptus* abundance	CINP	App.F.12.11 **	*Status:* Harvested; well below unfished levels and low density. *Trend:* Recent, gradual increase at Anacapa, Santa Cruz, and Santa Barbara islands, no clear trend at San Miguel and Santa Rosa islands.
California sheephead *Semicossyphus pulcher* abundance	PISCO	App.F.12.12	*Status:* Harvested; well below unfished levels. *Trend:* Density fluctuates over time, but no clear trend across islands.
California sheephead *S. pulcher* abundance	CINP	App.F.12.13 **	*Status:* Harvested; well below unfished levels. *Trend:* Recent increase in average density observed at all islands except San Miguel.
California sheephead *S. pulcher* abundance	SBC LTER	App.F.12.14	*Status:* Harvested; well below unfished levels. *Trend:* Abundance appears to be increasing at the island sites compared to the mainland sites.
Sandy Seafloor Habitat (< 30 meters) (Long-term monitoring data for indicators in this habitat were not available.)			
Deep Seafloor (> 30 meters)			
Sea star *P. helianthoides* abundance	MARE	App.F.12.15	*Status:* Drastic reduction in abundance along all transects sampled in 2014 compared to 2008. *Trend:* Drastic decline.
California sheephead *S. pulcher* abundance	MARE	App.F.12.16 **	*Status:* Currently reduced from pre-harvest levels. *Trend:* Average density has increased recently, mostly inside marine reserve.
Pelagic Habitat			
Small plankton volume	CalCOFI; CCIEA	App.F.12.18	*Status:* Abundance within range expected from full-time series. *Trend:* Stable or slightly decreasing.
Abundance of key forage fish (sardine, anchovy, myctophids, hake, rockfish spp., sanddabs)	CalCOFI; CCIEA	App.F.12.19	*Status:* Recent very low abundance of sardine and anchovy; average to high abundance of myctophids, rockfish, and sanddab. *Trend:* Mixed trend, species dependant.
Market squid *Doryteuthis opalescens* abundance	CalCOFI; CCIEA	App.F.12.20	*Status:* Average to reduced abundance. *Trend:* Declining trend.

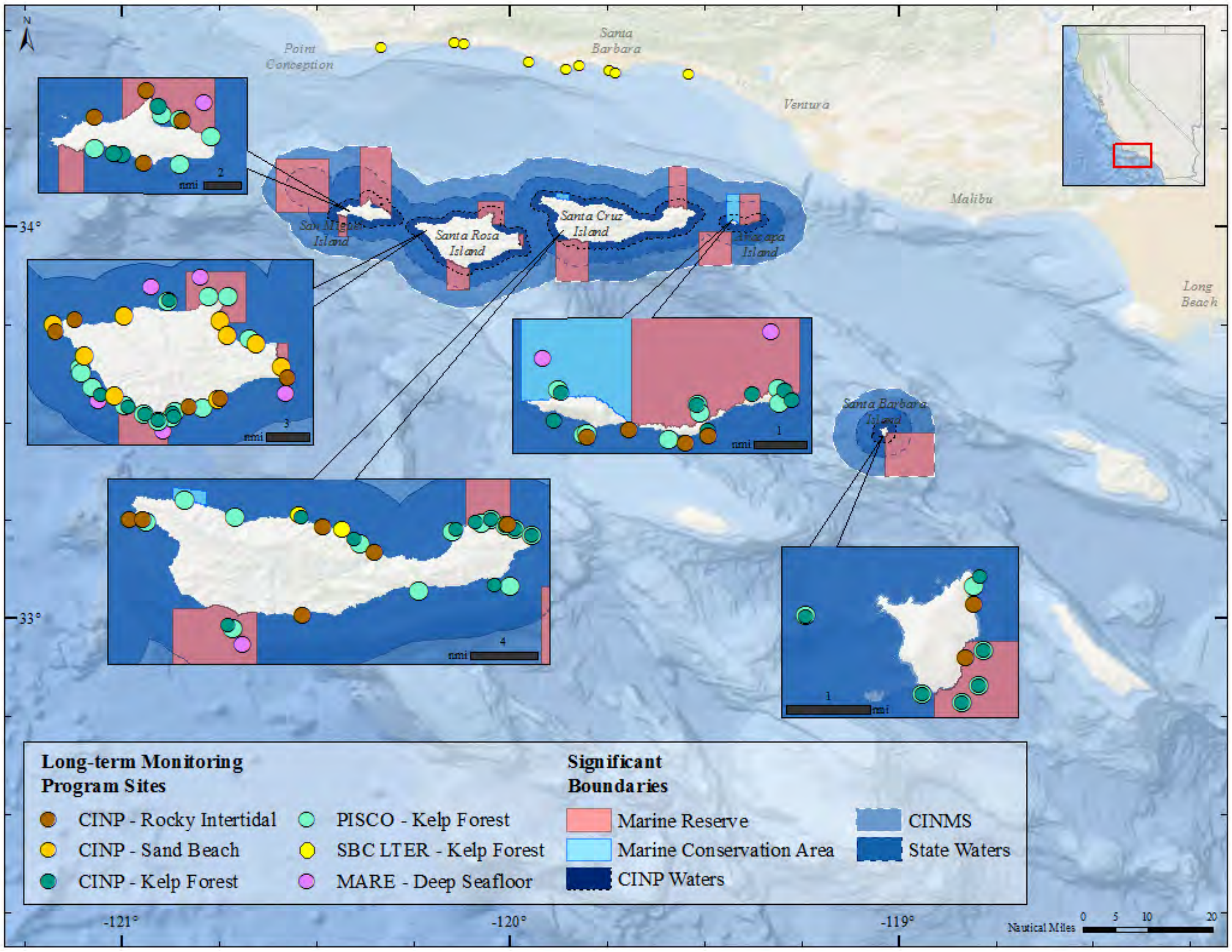


Figure App.F.12.1. Location of sites in Channel Islands National Marine Sanctuary for the following long-term monitoring programs: Channel Islands National Park (CINP) rocky intertidal[49] (brown), sand beach[50] (orange), and kelp forest[51] (dark green); Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) kelp forest[52] (turquoise); Santa Barbara Coastal Long-term Ecological Research (SBC LTER) kelp forest[53] (yellow); and Marine Applied Research and Exploration (MARE) deep seafloor[54] (pink). SBC LTER monitoring sites on the mainland are shown because the graphs using SBC LTER data compare abundances at island and mainland sites. Map: M. Cajandig/NOAA

[49] Channel Islands National Park Rocky Intertidal Monitoring protocol: https://irma.nps.gov/DataStore/Reference/Profile/2224305.

[50] Channel Islands National Park Beach Monitoring protocol: https://irma.nps.gov/DataStore/Reference/Profile/2224486.

[51] Channel Islands National Park Kelp Forest Monitoring protocol: https://irma.nps.gov/DataStore/Reference/Profile/2203207.

[52] PISCO Kelp Forest Survey sampling protocol: http://www.piscoweb.org/kelp-forest-sampling-protocols.

[53] Santa Barbara Coastal Long-term Ecological Research kelp forest monitoring protocol: http://sbc.lternet.edu//sites/sampling/index.html

[54] Marine Applied Research and Exploration deep seafloor monitoring protocol described in Rosen and Lauermann (2016).

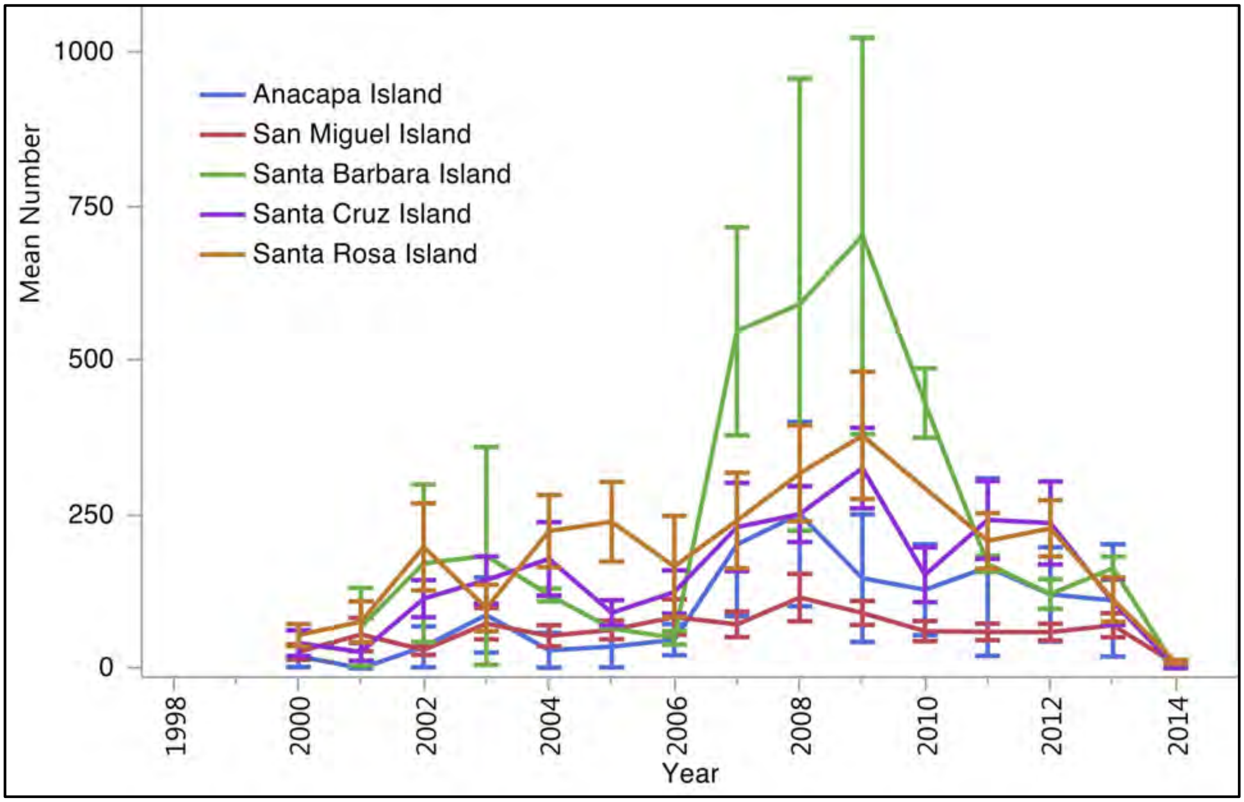


Figure App.F.12.2. Mean number (+/- standard error) of ochre stars *Pisaster ochraceus* observed during 30-minute searches pooled across all sites at each of the five islands in Channel Islands National Marine Sanctuary from 1999–2014. In the past decade, most locations had more than 100 sea stars counted during 30-minute searches. In 2014, abundances ranged from 0–23 individuals per site with the majority of sites having less than ten. Figure: Channel Islands National Park

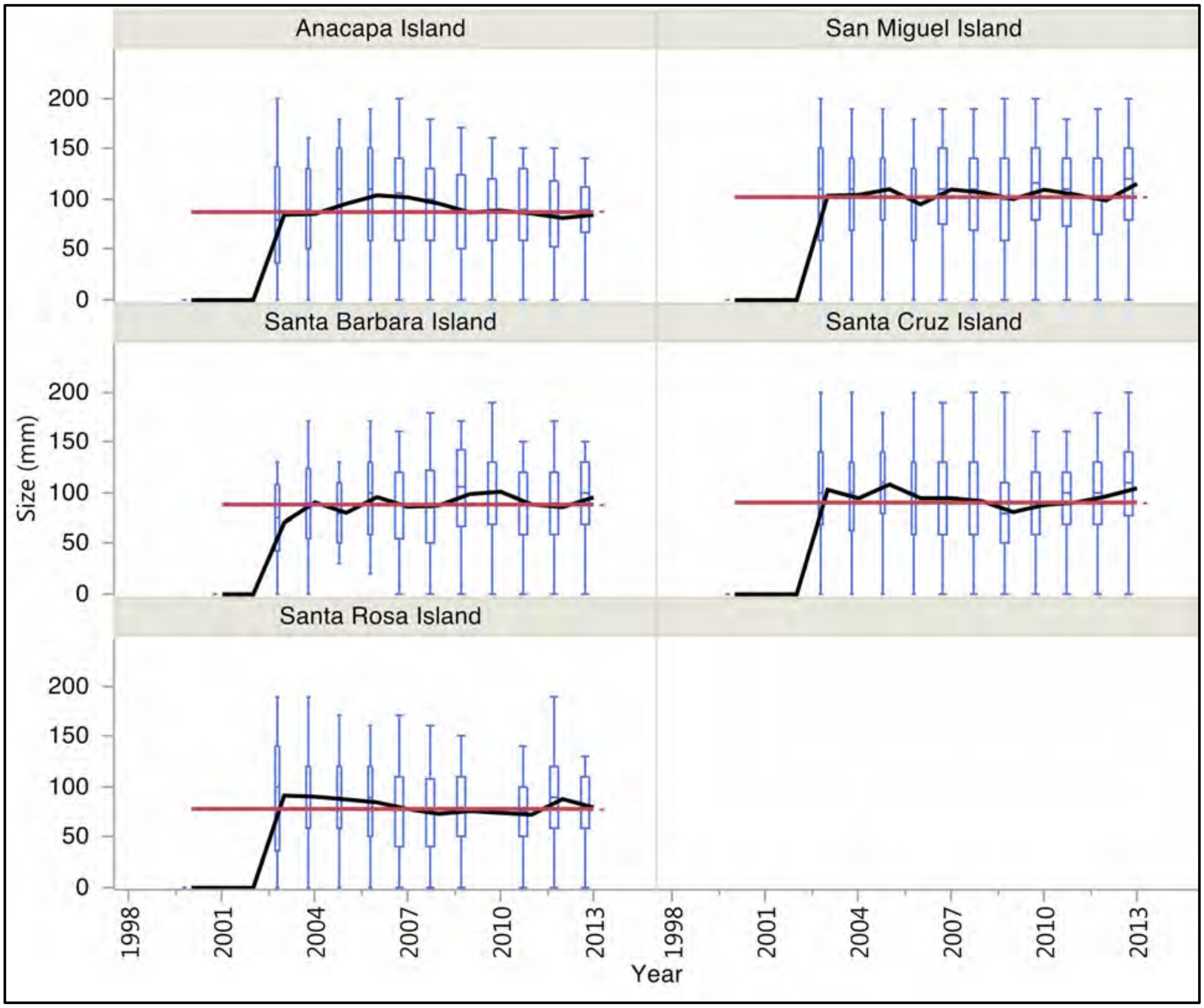


Figure App.F.12.3. Box plots for annual size frequency distributions of ochre star *P. ochraceus* at each island. Black lines represent mean sizes of ochre stars at each island pooled across sites. Red lines represent the mean of all years. Note that data for 2014 are not presented due to insufficient numbers of ochre stars encountered to estimate population size frequency. Figure: Channel Islands National Park

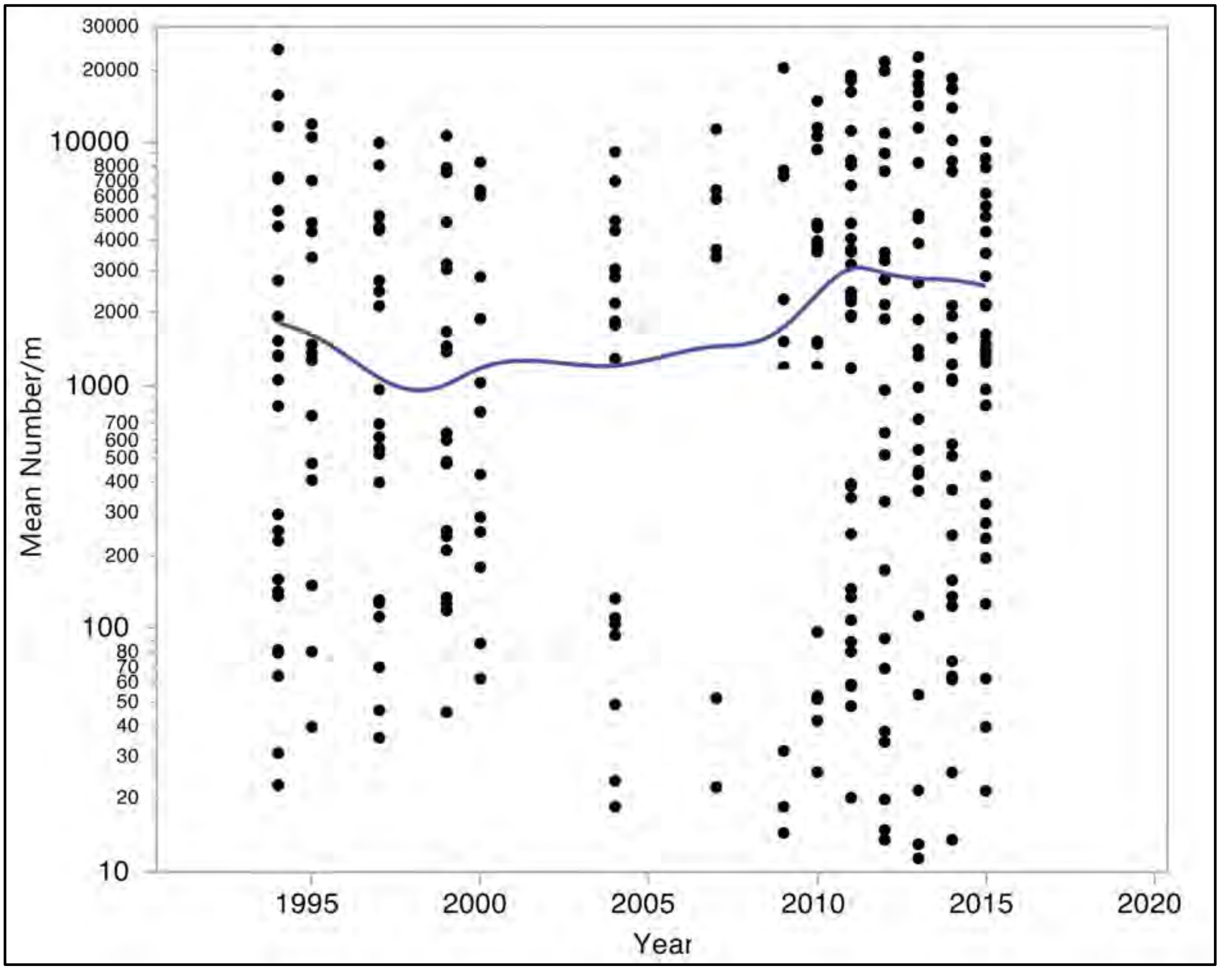


Figure App.F.12.4. Mean density of sand crabs *Emerita analoga* from surveys of eight beaches on Santa Rosa Island from 1994–2015. Curved blue line represents the statistically smoothed mean. Figure: Channel Islands National Park

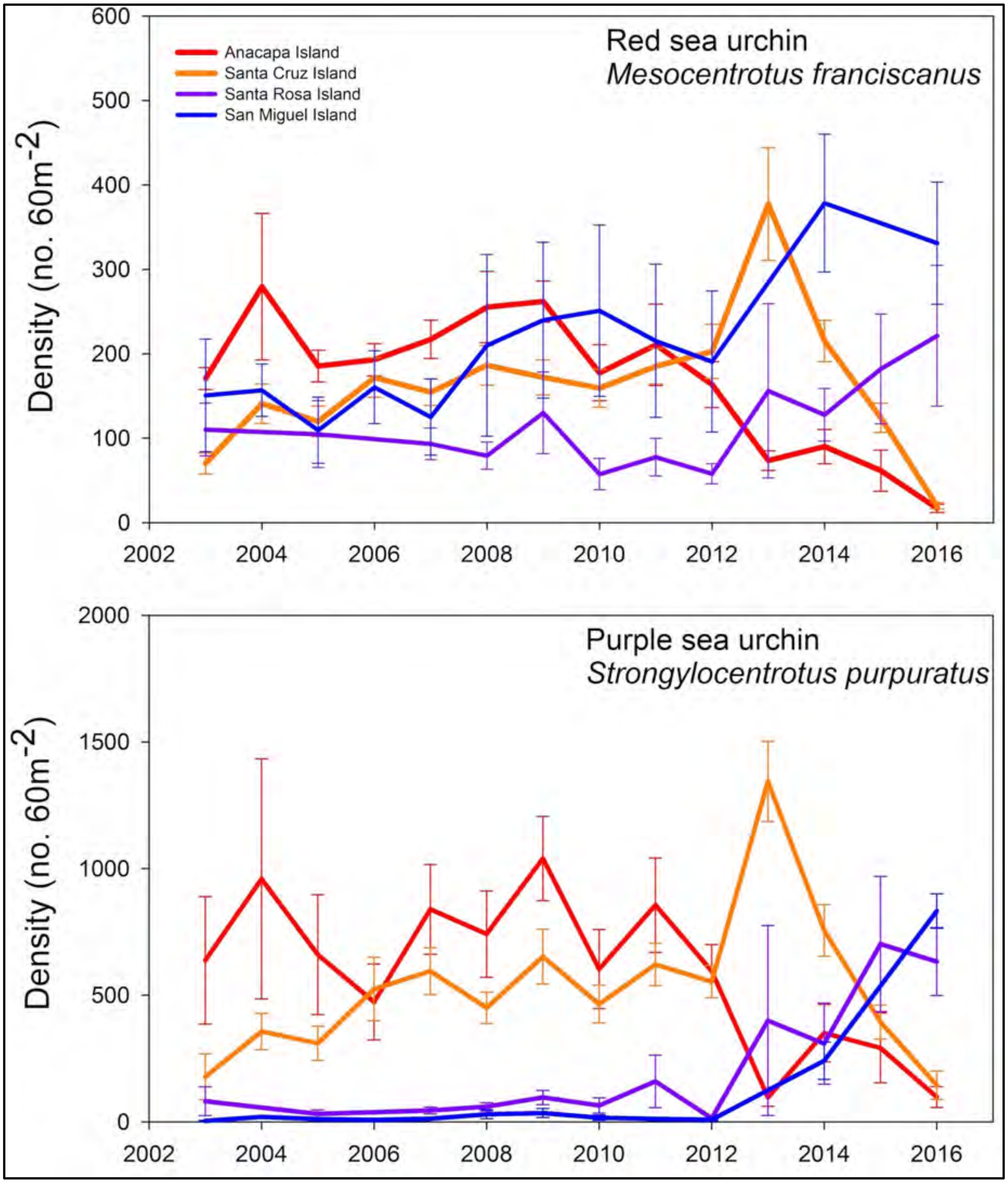


Figure App.F.12.5. Mean density (+/- standard error) of red sea urchin *Mesocentrotus franciscanus* (top) and purple sea urchin *Strongylocentrotus purpuratus* (bottom) at 14 sites across four islands in Channel Islands National Marine Sanctuary monitored by the PISCO kelp forest monitoring program from 2003–2016. Recently, density of both species has declined at eastern islands (Anacapa and Santa Cruz) and increased at western islands (Santa Rosa and San Miguel). Sea urchins are counted by SCUBA divers swimming along transect lines. Sea urchin density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, sea urchin density is responding differently inside and outside of some marine protected areas (MPAs) in CINMS. A discussion of MPA effects in CINMS is available in *MPA Effects*. Data source: PISCO; Figure: R. Freedman/NOAA.
Note: This is variant of a similar figure shown during the expert workshop.

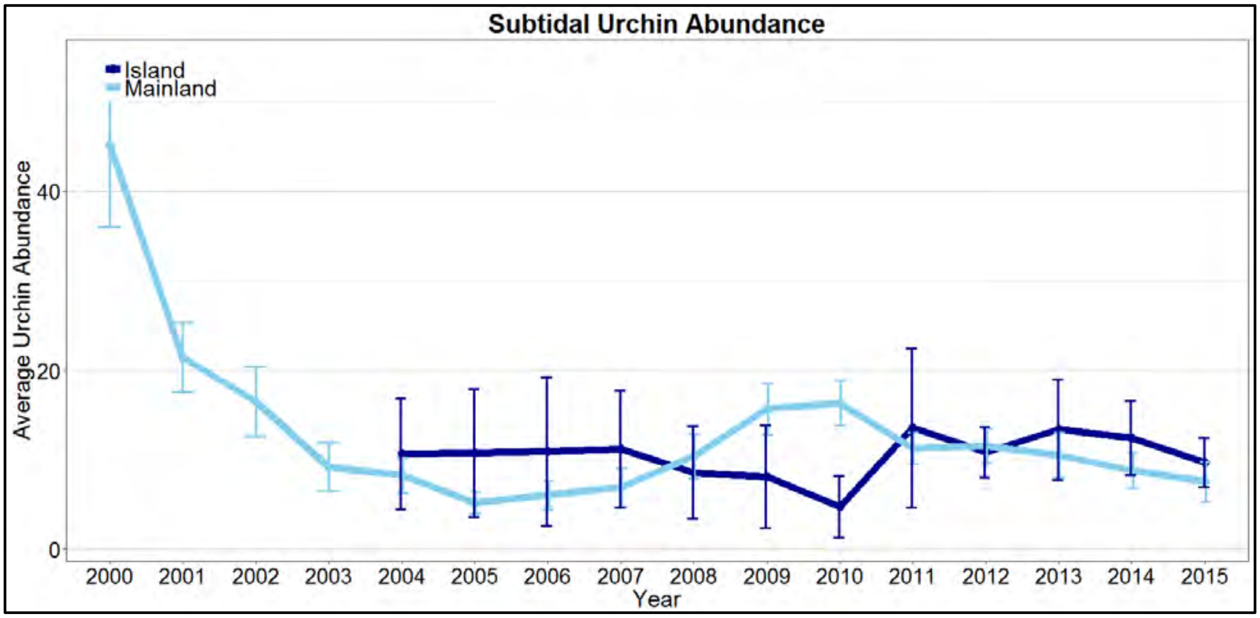


Figure App.F.12.6. Average abundance (+/- standard error) of sea urchins (red sea urchin *Mesocentrotus franciscanus* and purple sea urchin *Strongylocentrotus purpuratus* combined) at two island (dark blue) and nine mainland (light blue) kelp forest sites monitored by the Santa Barbara Channel Long-term Ecological Research (SBC LTER) program. Overall abundance of sea urchins appears stable at island sites over the available time series. Data source: SBC LTER; Figure: R. Freedman/NOAA

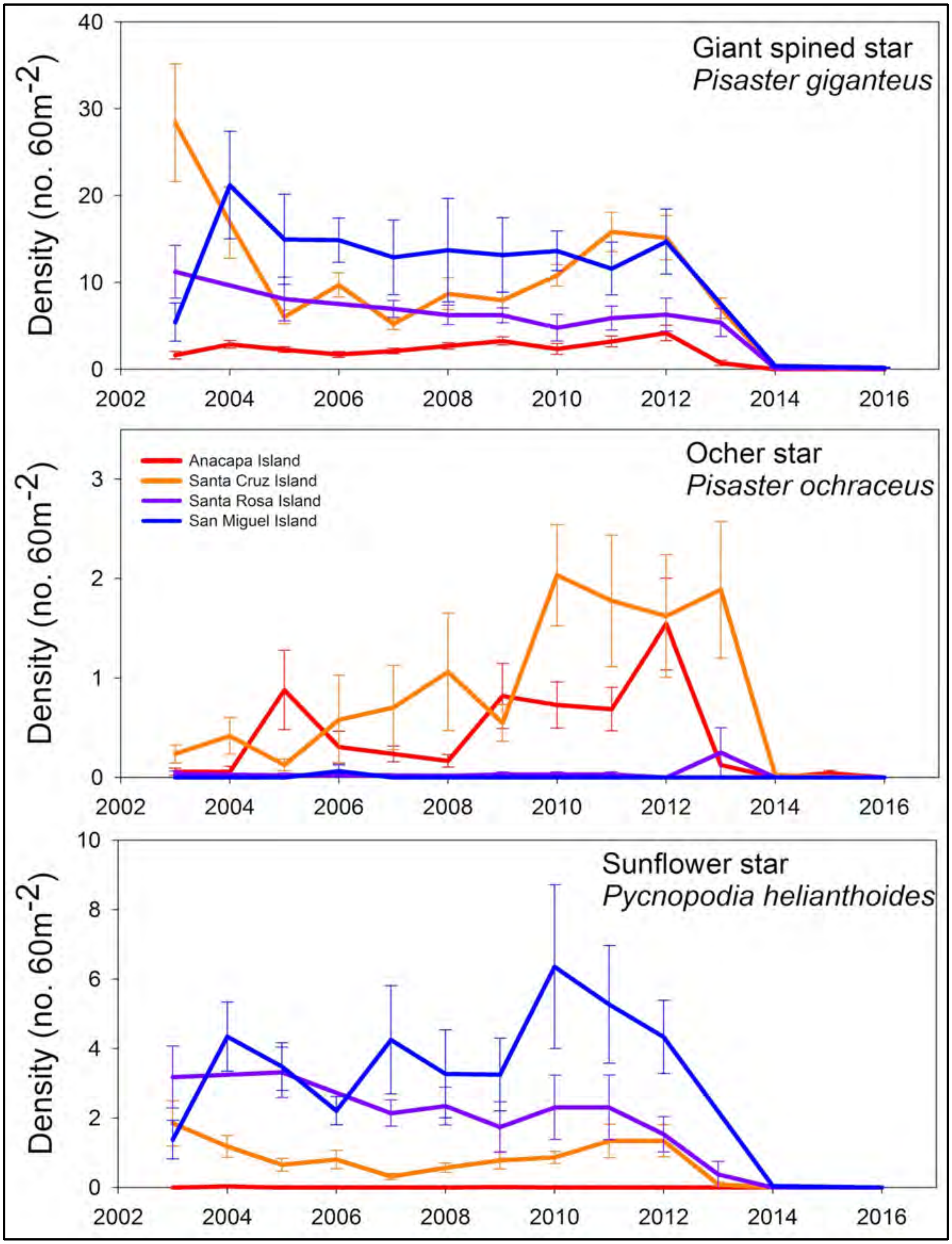


Figure App.F.12.7. Average density (+/- standard error) of giant spined star *Pisaster giganteus* (top), ochre star *P. ochraceus* (middle) and sunflower star *Pycnopodia helianthoides* (bottom) at 14 sites across four islands in Channel Islands National Marine Sanctuary monitored by the PISCO kelp forest monitoring program from 2003–2016. Sea stars are counted by SCUBA divers swimming along transect lines. Sea star density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. Giant, ochre, and sunflower stars suffered severe declines from 2013 to 2014 at all four islands due to sea star wasting syndrome. Data source: PISCO; Figure: R. Freedman/NOAA
Note: This is variant of a similar figure shown during the expert workshop.

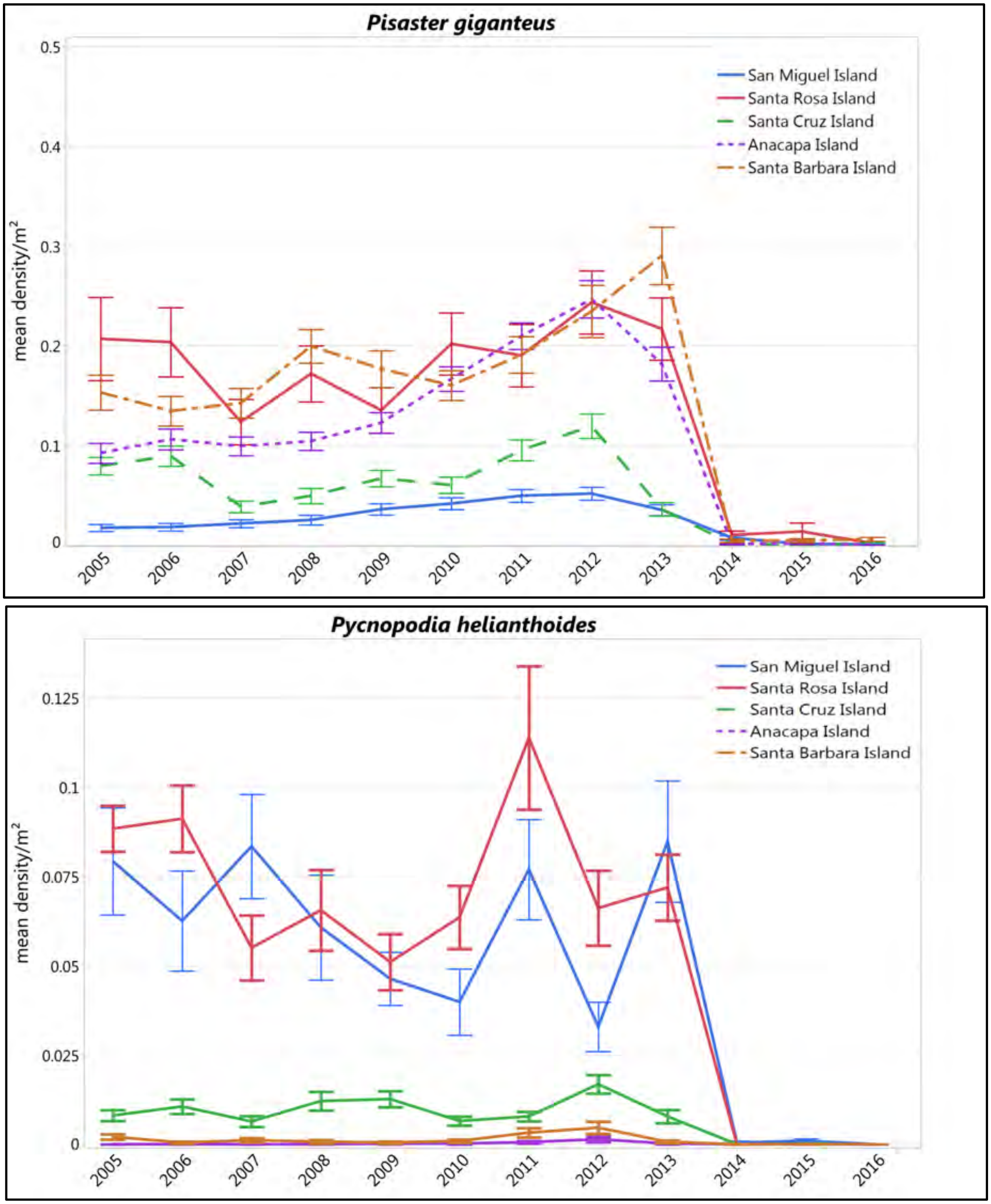


Figure App.F.12.8. Average density (+/- standard error) of the giant-spined star *Pisaster giganteus* (top) and sunflower star *Pycnopodia helianthoides* (bottom) at Channel Islands National Park kelp forest monitoring sites at the five islands in CINMS. Sea stars are counted by SCUBA divers. Sea star density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. Sea star abundance drastically declined at all islands prior to 2014 monitoring and have remained very low through 2016. Figure: Channel Islands National Park.
Note: This figure was not available to be shown at the expert workshop.

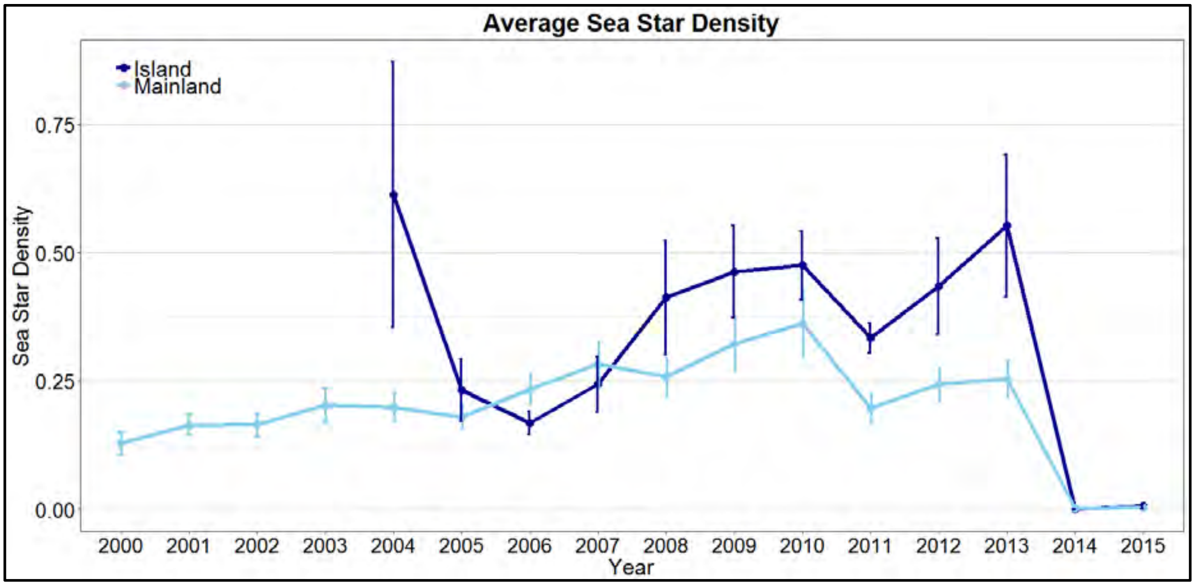


Figure App.F.12.9. Average density (+/- standard error) of sea stars (*Pisaster* and *Pycnopodia* combined) at two island (dark blue) and nine mainland (light blue) kelp forest sites monitored by the Santa Barbara Channel Long-term Ecological Research (SBC LTER) program. Sea star density had drastically declined all sites prior to 2014 monitoring and remained very low through 2015. Data source: SBC LTER; Figure: R. Freedman/NOAA

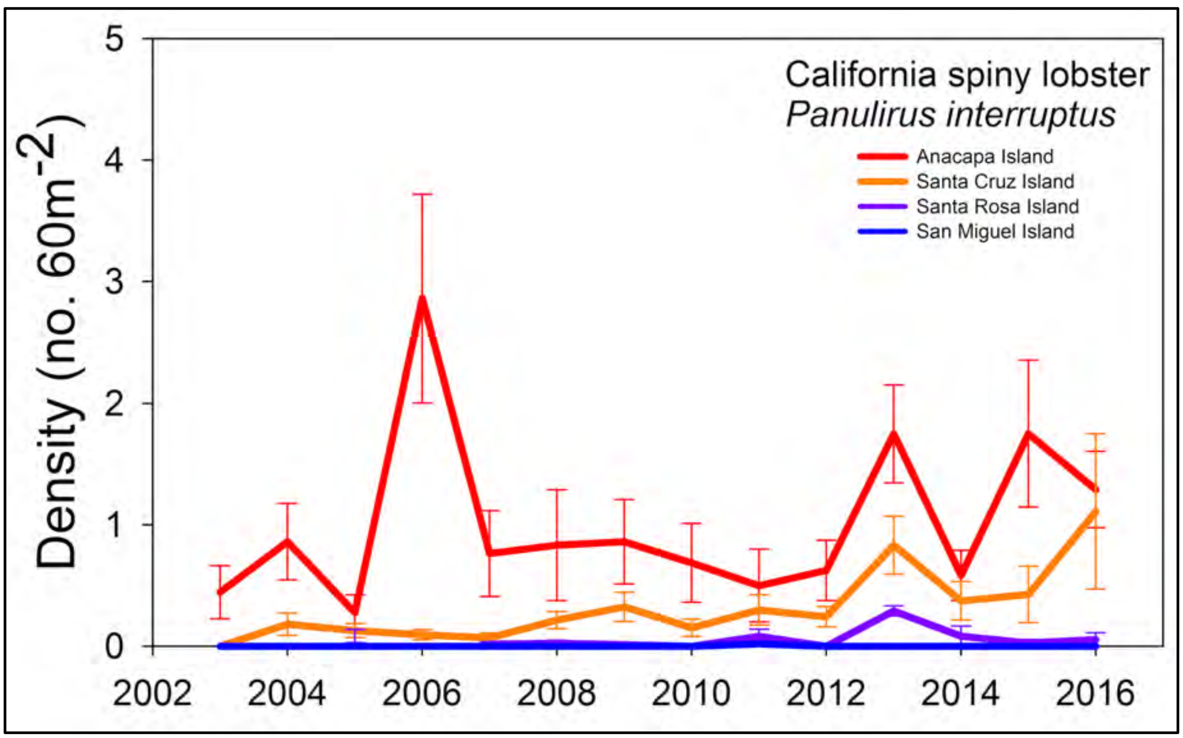


Figure App.F.12.10. Average density (+/- standard error) of California spiny lobster *Panulirus interruptus* at 14 sites across four islands in Channel Islands National Marine Sanctuary monitored by the PISCO kelp forest monitoring program from 2003–2016. Lobster abundance is low at San Miguel (blue) and Santa Rosa (purple) islands and appears to be slowly increasing recently at Anacapa (red) and Santa Cruz (orange) islands. Lobster are counted by SCUBA divers swimming along transect lines. Lobster density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, lobster density is responding differently inside and outside of some marine protected areas (MPAs) in CINMS. A discussion of MPA effects in CINMS is available in *MPA Effects*. Data source: PISCO; Figure: R. Freedman/NOAA

Note: This is variant of a similar figure shown during the expert workshop.

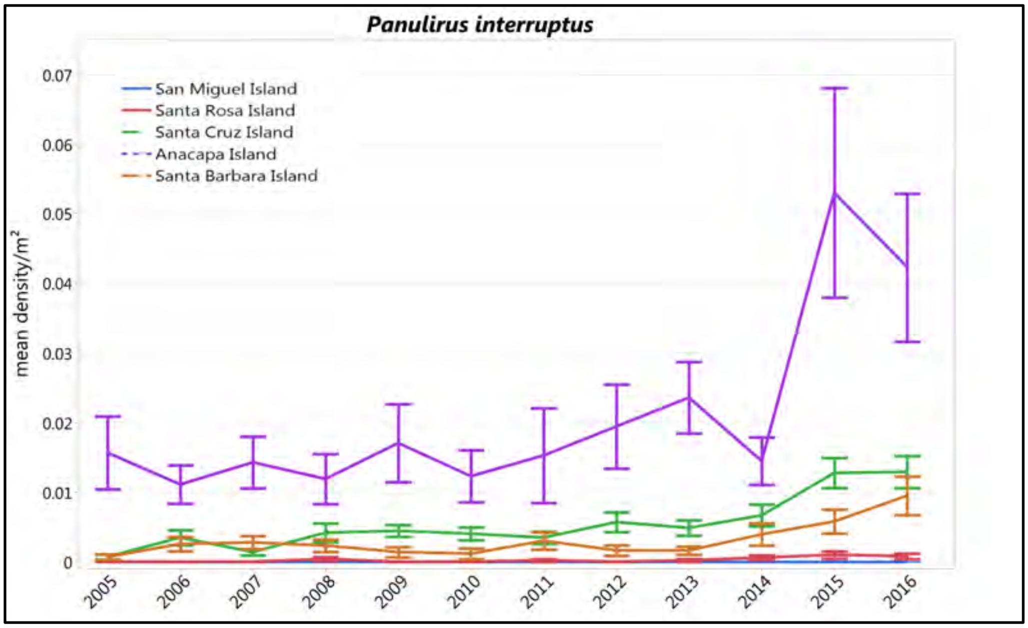


Figure App.F.12.11. Average density (+/- standard error) of California spiny lobster *Panulirus interruptus* at Channel Islands National Park kelp forest monitoring sites at the five islands in CINMS. Recent increases in average density of lobster were observed at Anacapa (purple), Santa Cruz (green), and Santa Barbara (orange) islands. Lobster are counted by SCUBA divers. Lobster density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, lobster density is responding differently inside and outside of some marine protected areas (MPAs) in CINMS. A discussion of MPA effects in CINMS is available in [MPA Effects](). Figure: Channel Islands National Park.
Note: This figure was not available to be shown at the expert workshop.

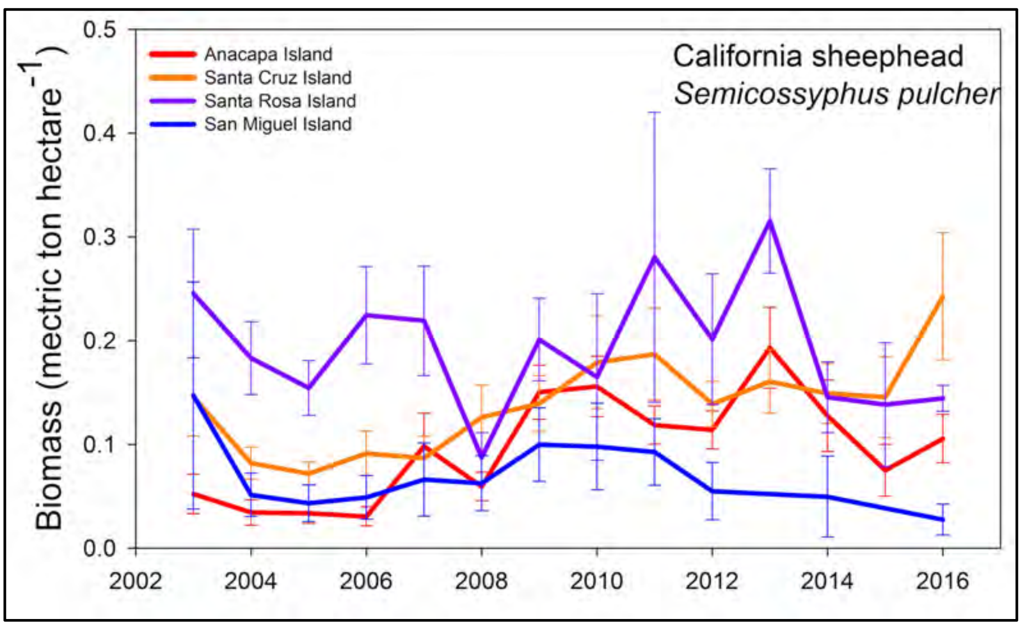


Figure App.F.12.12. Average density (+/- standard error) of California sheephead *Semicossyphus pulcher* at 14 sites across four islands in Channel Islands National Marine Sanctuary monitored by the PISCO kelp forest monitoring program from 2003 to 2016. Sheephead are counted by SCUBA divers swimming along transect lines. Observed density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, sheephead density is responding differently inside and outside of some marine protected areas (MPAs) in CINMS. A discussion of MPA effects in CINMS is available in [MPA Effects](). Data source: PISCO; Figure: R. Freedman/NOAA
Note: This is variant of a similar figure shown during the expert workshop.

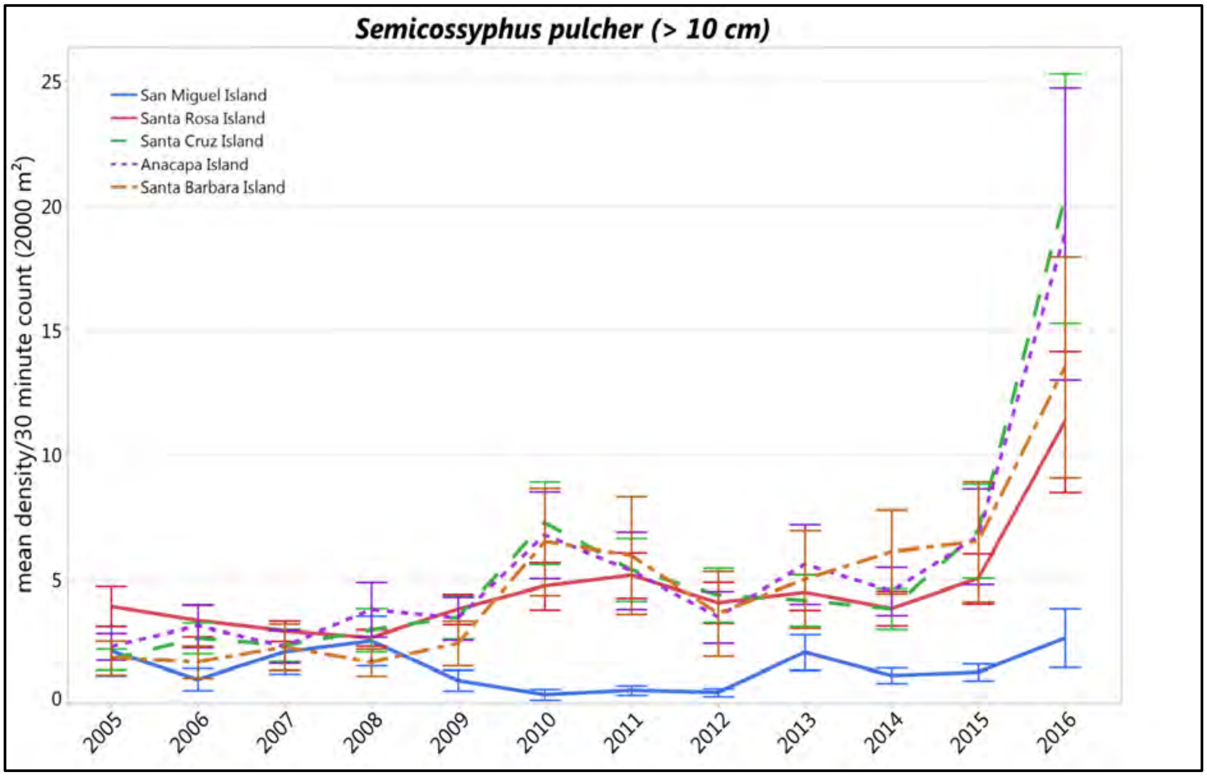


Figure App.F.12.13. Average density (+/- standard error) of California sheephead *Semicossyphus pulcher* at Channel Islands National Park kelp forest monitoring sites at the five islands in CINMS. Recent increases in average density of sheephead were observed at every island except for San Miguel (blue). Sheephead density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, sheephead density is responding differently inside and outside of some marine protected areas (MPAs) in CINMS. A discussion of MPA effects in CINMS is available in *MPA Effects*. Note that juveniles (< 10 centimeters) were excluded from analysis. Figure: Channel Islands National Park.
Note: This figure was not available to be shown at the expert workshop.

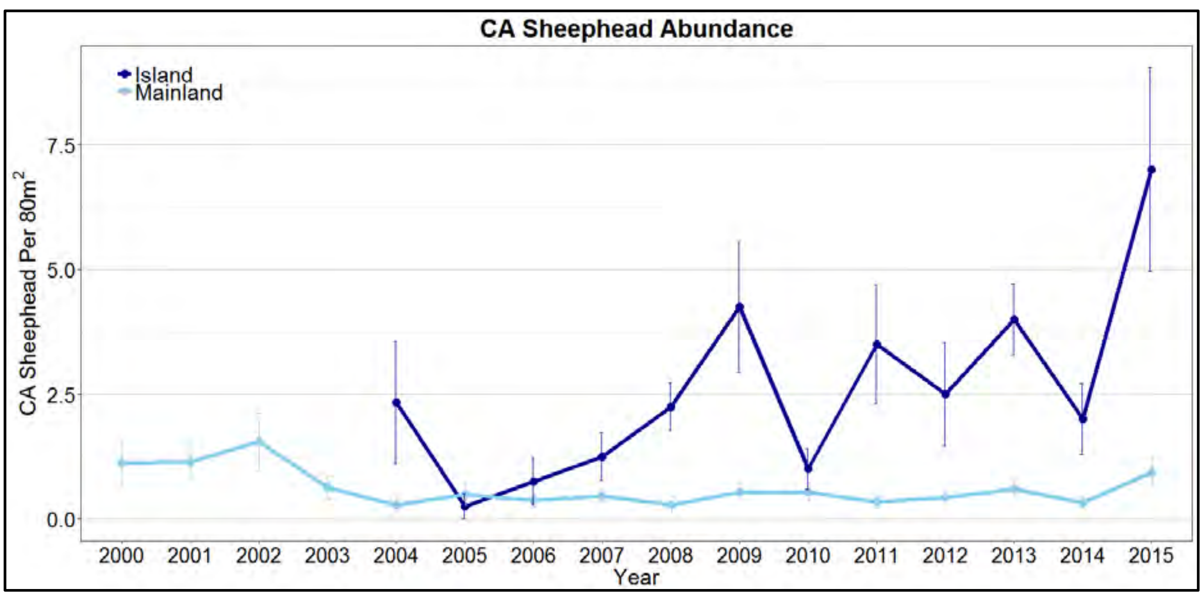


Figure App.F.12.14. Average number (+/- standard error) of California sheephead *Semicossyphus pulcher* at two island (dark blue) and nine mainland (light blue) sites monitored by the Santa Barbara Channel Long-term Ecological Research (SBC LTER) program. Abundance appears to be increasing at the island sites compared to the mainland sites. Data source: SBC LTER; Figure: R. Freedman/NOAA

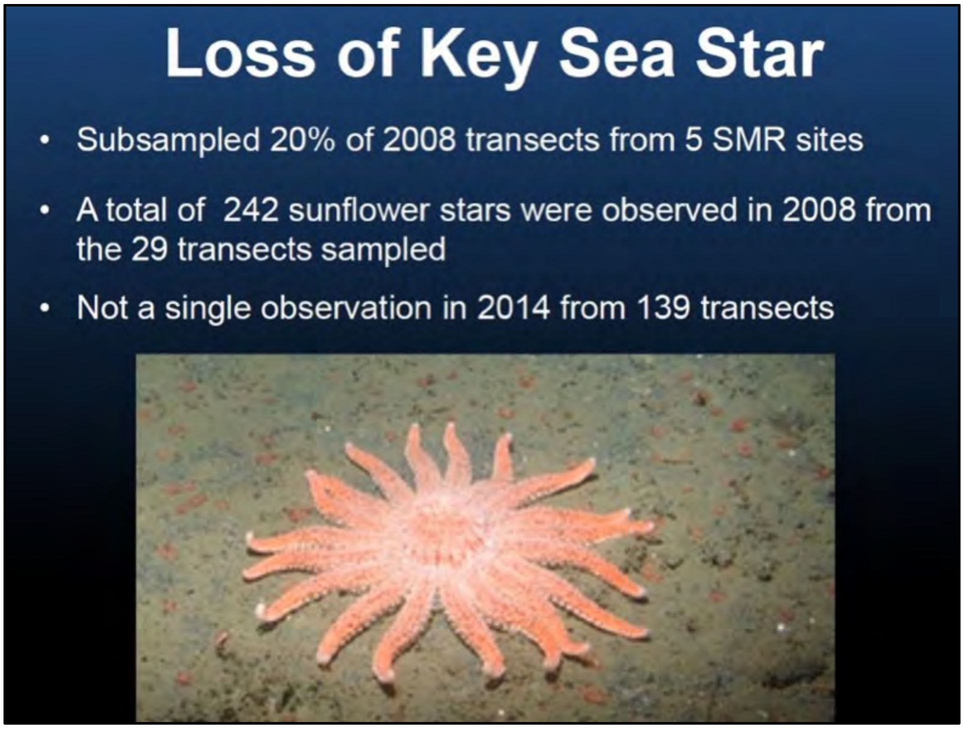


Figure App.F.12.15. Marine Applied Research and Exploration (MARE) data on abundance of sunflower star *Pycnopodia helianthoides* along seafloor transects. Source: MARE

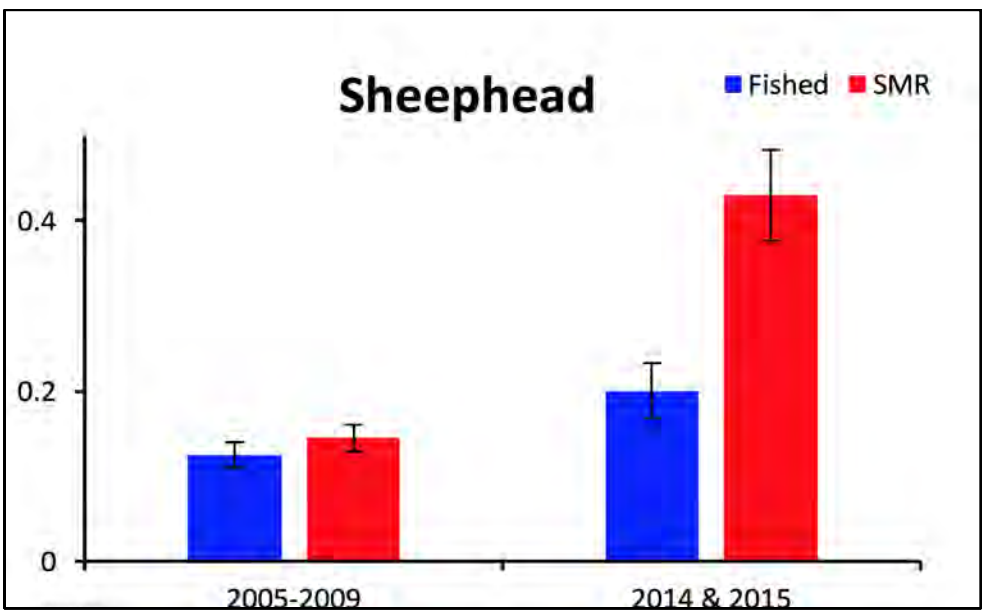


Figure App.F.12.16. Average density (per 100 m^2 +/- SE) of California sheephead (*Semicossyphus pulcher*) at fished (blue) and unfished marine reserves (red) surveyed annually in two time periods 2005–2009 and 2014–2015. Density has increased since the baseline period, and the increase was more pronounced inside reserves as compared to fished sites. Figure: MARE.
Note: This figure was not available to be shown at the expert workshop.

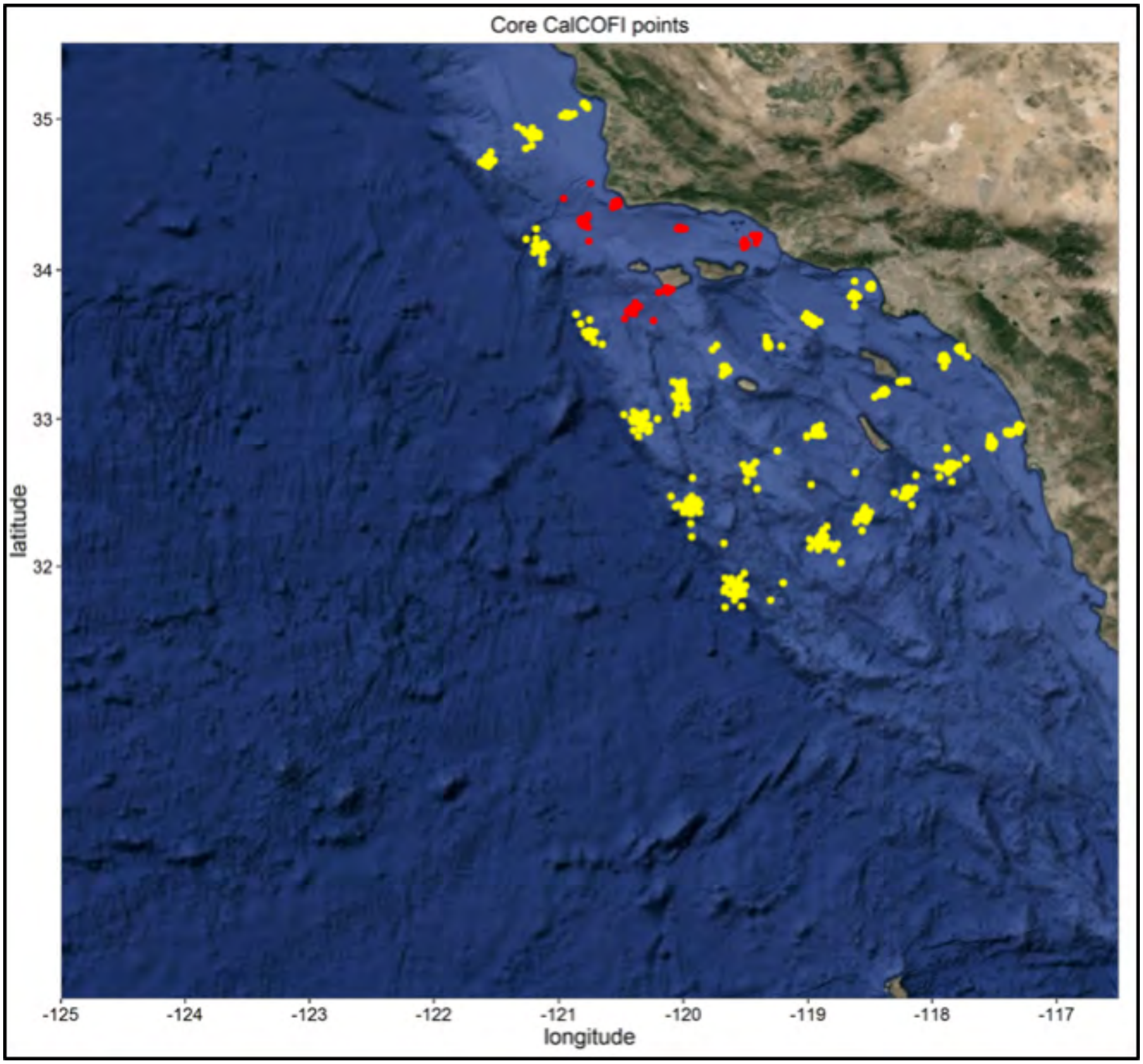
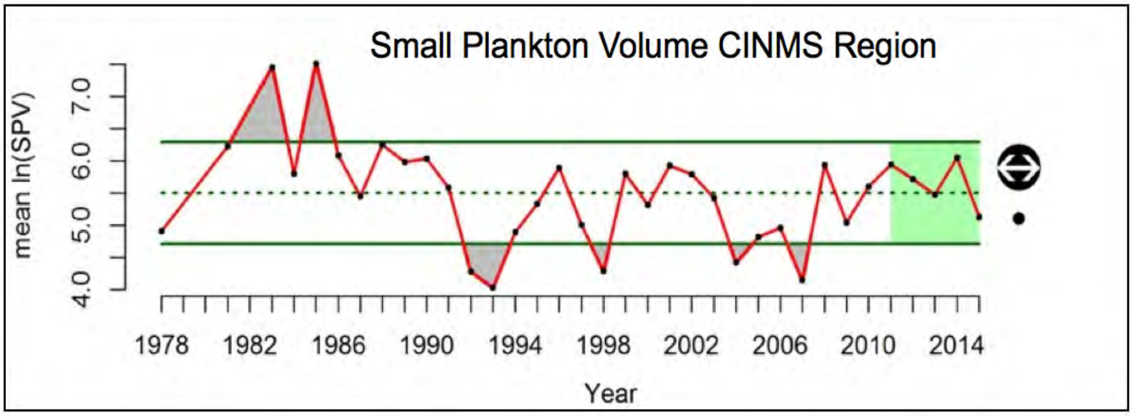


Figure App.F.12.17. Location of spring season net samples by the California Cooperative Oceanic Fisheries Investigations (CalCOFI) used in analyses of abundance and trends in pelagic resources in two regions: Channel Islands National Marine Sanctuary region (red) includes CalCOFI stations inside and adjacent to CINMS; and Southern California Shelf (yellow) includes all CalCOFI stations over the shelf. Figure: A. Thompson/NOAA



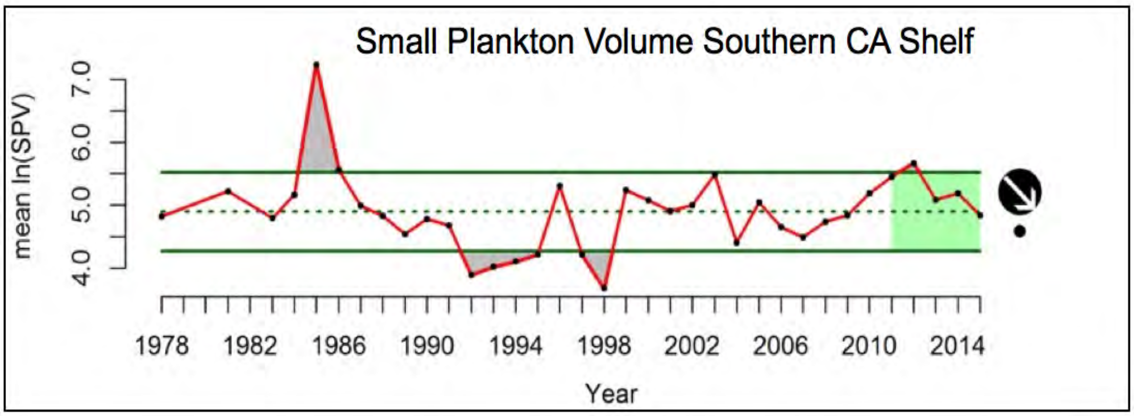


Figure App.F.12.18. Mean volume of small plankton collected in net samples during CalCOFI cruises at only sites in the Channel Islands National Marine Sanctuary region (top) and all sites over the Southern California Shelf (bottom) from 1978 to 2015 (sampling locations shown in Figure App.F.12.17). Horizontal lines show the mean (dashed line) ± 1.0 standard deviation (solid lines) over the full time series. Symbol at upper right indicates whether data over the last five years (green shaded areas) had a positive trend (↗), a negative trend (↘), or no trend (↔). Symbol at lower right indicates whether the mean over the past five years was greater than (+), less than (–), or within 1 standard deviation (●) of the mean of the full time series. Data source: CalCOFI; Figure: A. Thompson/NOAA

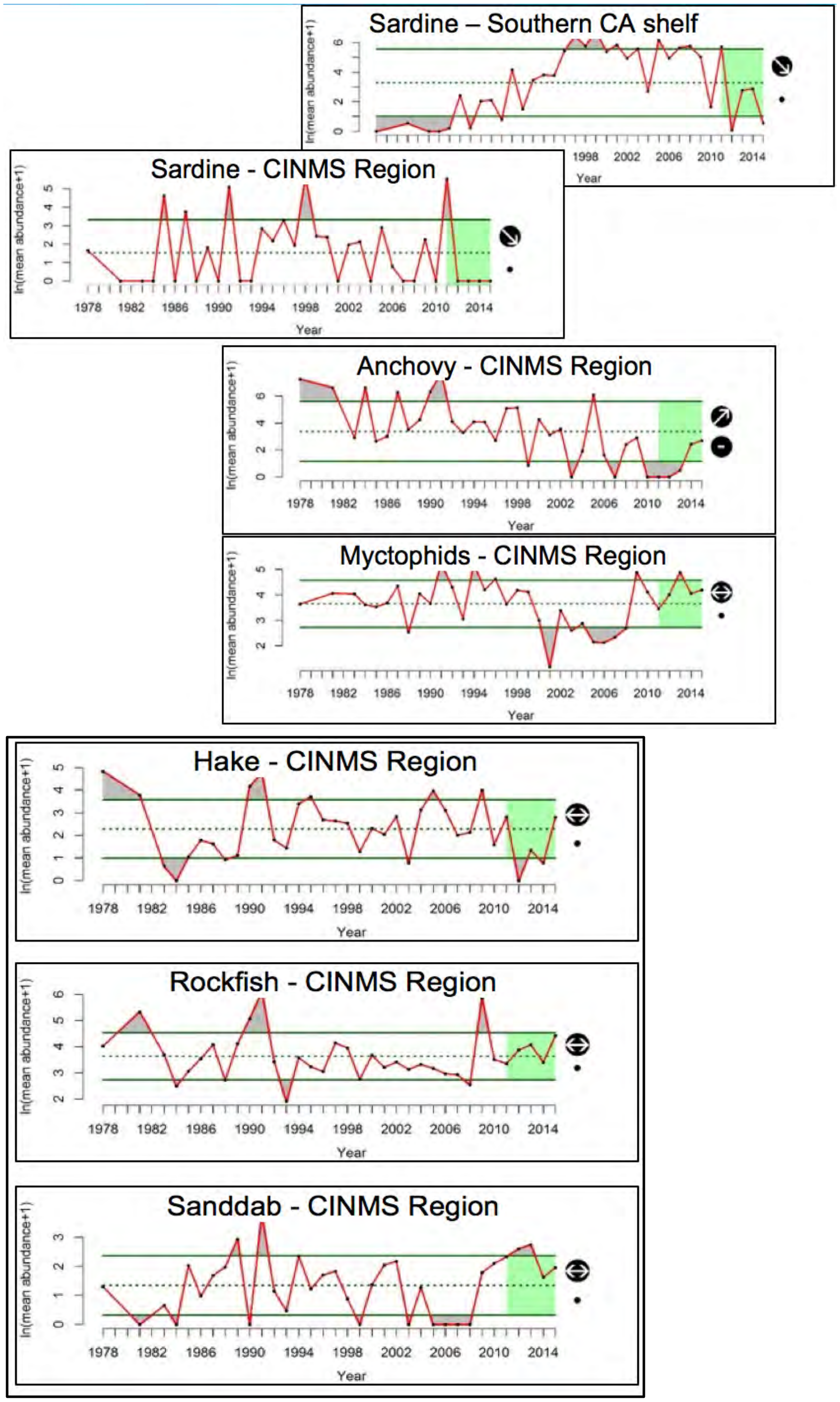


Figure App.F.12.19. Relative abundance of key forage groups collected in net samples during spring CalCOFI cruises at sites in the Channel Islands National Marine Sanctuary (CINMS) region from 1978 to 2015. Forage is grouped by high (left panel) and medium (right panel) energy density. High energy taxa are Pacific sardines, northern anchovies, and and Myctophids. Medium-energy taxa are Pacific hake, shortbelly rockfish, and sanddabs. Although sardine were completely absent in net samples from 2011 to 2014 in the CINMS region, comparison with samples collected in the larger Southern California Shelf region reveal that sardine were at very low abundance but not completely absent from the region (sampling locations shown in Figure App.F12.17). Symbols on graph explained in the caption of Figure App.F12.18. Data source: CalCOFI; Figure: A. Thompson/NOAA

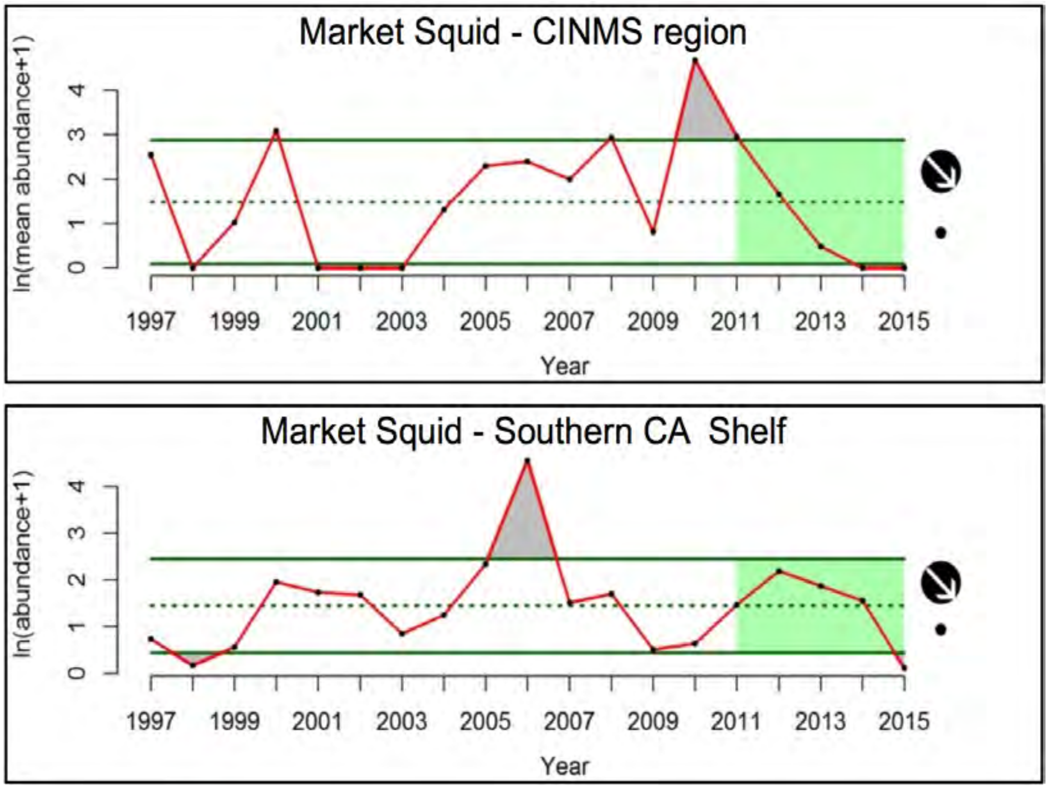


Figure App.F.12.20. Mean abundance of market squid (*Doryteuthis opalescens*) collected in net samples during CalCOFI cruises at only sites in the Channel Islands National Marine Sanctuary region (top) and all sites over the Southern California Shelf (bottom) from 1997 to 2015 (sampling locations shown in Figure App.F12.17). Symbols on graph explained in the caption of Figure App.F12.18. Data source: CalCOFI; Figure: A. Thompson/NOAA

13. What is the status of other focal species and how is it changing?

Table App.F.13.1. Data presented to the living resources experts at the workshop on June 1, 2016 to update status and trends assessments for Channel Islands National Marine Sanctuary (CINMS).
**Denotes graphs that were received after the expert workshops and were not available for experts to view during the status and trend workshop; however, a representative from the monitoring program discussed this data set during the meeting.

Indicator	Source	Figure #	Data Summary
Rocky Intertidal Habitat			
Black abalone *Haliotis cracherodii* abundance and size structure	CINP; MARINe	App.F.13.1–F.13.2	*Status:* Very low abundance compared to historic levels. *Trend:* Stable or slowly increasing.
Owl limpet *Lottia gigantea* abundance and size structure	CINP; MARINe	App.F.13.3	*Status:* 2009–2013 mean abundance below long-term mean at three of four islands, but 2014 mean abundance similar to long-term mean for three of four islands. *Trend:* increases in 2014 at San Miguel and Santa Rosa islands.
Black oystercatcher *Haematopus bachmani* abundance	Weinstein et al. 2014; CINP; CBC	App.F.13.4–App.F.13.6	*Status:* Estimated island population in 2011 was 779–854. *Trend:* CINP and CBC counts are variable, but no clear signs of significant declines.
Beach Habitat			
Western snowy plover *Charadrius nivosus nivosus* abundance	CINP	App.F.13.7	*Status and Trend:* Santa Rosa Island breeding: abundance lower than pre–2000; stable since 2006; chicks observed recently; winter: stable or slight decrease over last ten years.
Upper beach macrofauna abundance	CINP	App.F.13.8	*Status and Trend: Megalorchestia californiana* and *Alloniscus perconvexus:* both highly variable among sites and years at Santa Rosa Island. No clear trend in abundance.
Kelp Forest and Reef Habitat (< 30 meters)			
Red abalone (*Haliotis rufescens*) abundance	PISCO	App.F.13.9	*Status:* All species at very low abundance compared to historic levels. Higher densities observed at San Miguel Island. *Trend:* No trend.
Red and pink abalone (*Haliotis* spp.) abundance	CINP	App.F.13.10 **	*Status:* Both species at very low abundance compared to historic levels. *Trend:* No increase, except red abalone at San Miguel and Santa Rosa Islands.
Abalone (*Haliotis* spp.) abundance	SBC LTER	App.F.13.11	*Status:* Very low abundance compared to historic levels. *Trend:* No trend.
Warty sea cucumber *Parastichopus parvimensis* abundance	CINP	App.F.13.12 **	*Status:* Below unfished levels due to harvest. *Trend:* Stable at San Miguel and Santa Rosa islands and declining at Anacapa, Santa Cruz, and Santa Barbara islands.

Sea cucumber (*Parastichopus* spp.) abundance	SBC LTER	App.F.13.13	*Status:* Below unfished levels due to harvest. *Trend:* No clear trend (but limited data in CINMS).
Giant sea bass *Stereolepis gigas* abundance	PISCO	App.F.13.14	*Status:* Below unfished levels due to harvest. *Trend:* Too few observations to determine trend, but this species has not be seen during surveys since 2011.
Kelp forest fish abundance	PISCO	App.F.13.15	*Status:* Harvested species below unfished levels; for some species, density varies among islands. *Trend:* Most are stable (within variability of time series), but recent increases for some species at a few islands.
Kelp forest fish abundance	CINP	App.F.13.16 **	*Status:* Harvested species below unfished levels; for some species, density varies among islands. *Trend:* Most are stable (within variability of time series), but recent increases for some species at a few islands.
Kelp forest fish abundance	SBC LTER	App.F.13.17	*Status:* Harvested species below unfished levels; higher density at islands for three species. *Trend:* All within variability of time series for island sites.
Sandy Seafloor Habitat (< 30 meters) (Long-term monitoring data for indicators in this habitat were not available.)			
Deep Seafloor Habitat (> 30 meters)			
Demersal fish abundance	MARE	App.F13.18 –F13.19**	*Status and Trend:* Demersal fish abundance has increased substantially in recent surveys (2014 and 2015) compared to 2005–2009 baseline.
Deep reef fish abundance	NMFS NWFSC	Table App.F13.2	*Trend:* Mixed short-term trends; 12 species stable or increasing; four species declining.
Demersal fish abundance	NMFS NWFSC	Table App.F13.3	*Trend:* The 11 species well sampled in CINMS appear to have a stable or increasing trend.
Pelagic Habitat			
At-sea seabird abundance	Sydeman et al. 2015; CalCOFI	App.F.13.22	*Status and Trend:* Long-term declining trend in seabirds density in southern California (1987–2011).
California sea lion *Zalophus californianus* pup count and growth	NMFS; CCIEA	App.F.13.23 – F13.24	*Status:* High compared to late-1970s. *Trend:* Long-term increasing trend, recent decline likely due to recent unusual mortality event.
Harbor seal *Phoca vitulina* count	Carretta et al. 2016	App.F.13.25	*Trend:* Channel Islands abundance stable since late 1980s.
Northern elephant seal *Mirounga angustirostris* births	Carretta et al. 2016	App.F.13.26	*Status:* Channel Islands abundance in 2010 is highest on record. *Trend:* Long-term increasing.
Northern fur seal *Callorhinus ursinus* pups	Carretta et al. 2016	App.F.13.27	*Status:* Abundance recovered from 1997-1998 El Nino.– *Trend:* Increasing from 1999–2014.

Cetacean density	Campbell et al. 2015	App.F.13.28	*Trend:* Two whales, two small cetaceans stable; fin whale increasing; Pacific white-sided dolphin decreasing off southern California from 2004–2013.

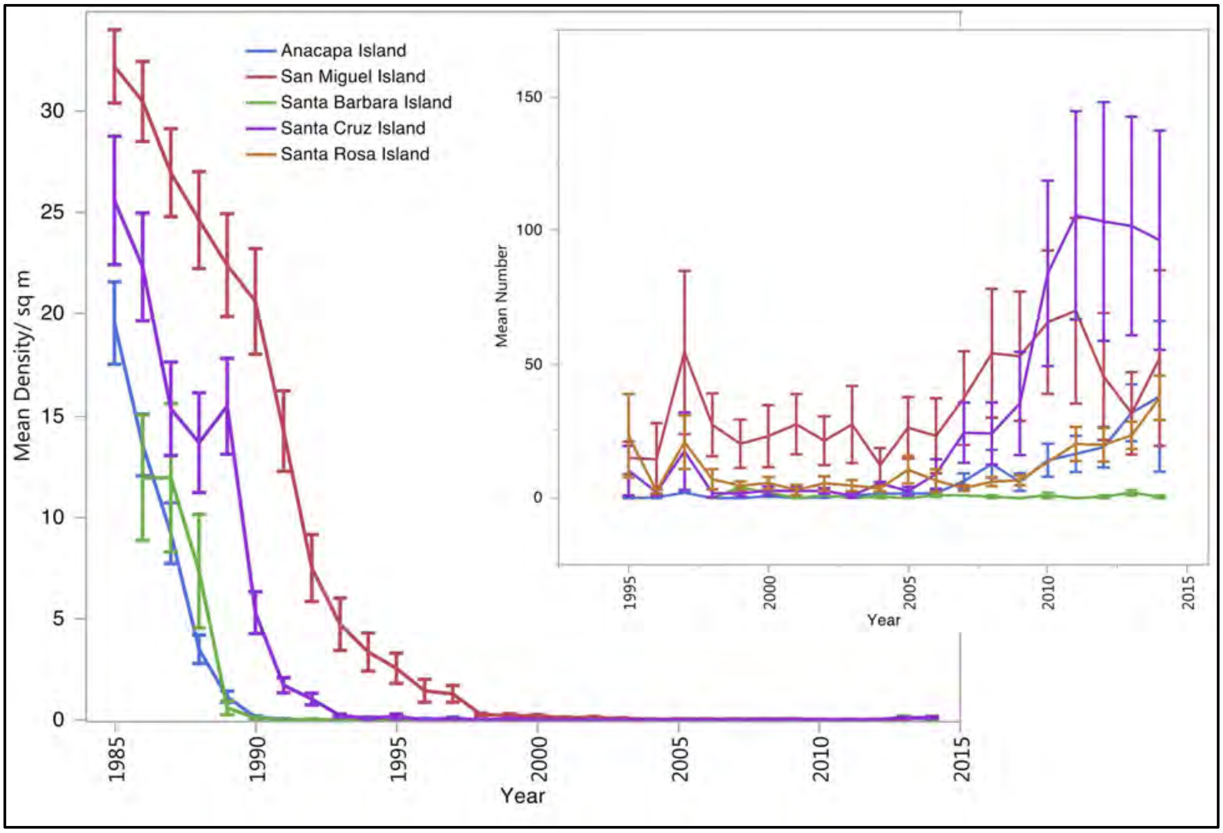


Figure App.F.13.1. Black abalone *Haliotis cracherodii* mean density from fixed plots from 1985–2014 (left) and mean counts from site-wide searches from 1995–2014 (inset) at four islands in Channel Islands National Marine Sanctuary. Site wide search counts began in 1995 due to the severe declines in abundance that occurred from 1985–1995. Generally, increasing abundances began approximately in the 2007–2009 timeframe. Error bars were constructed using one standard error from the mean. Figure: Channel Islands National Park

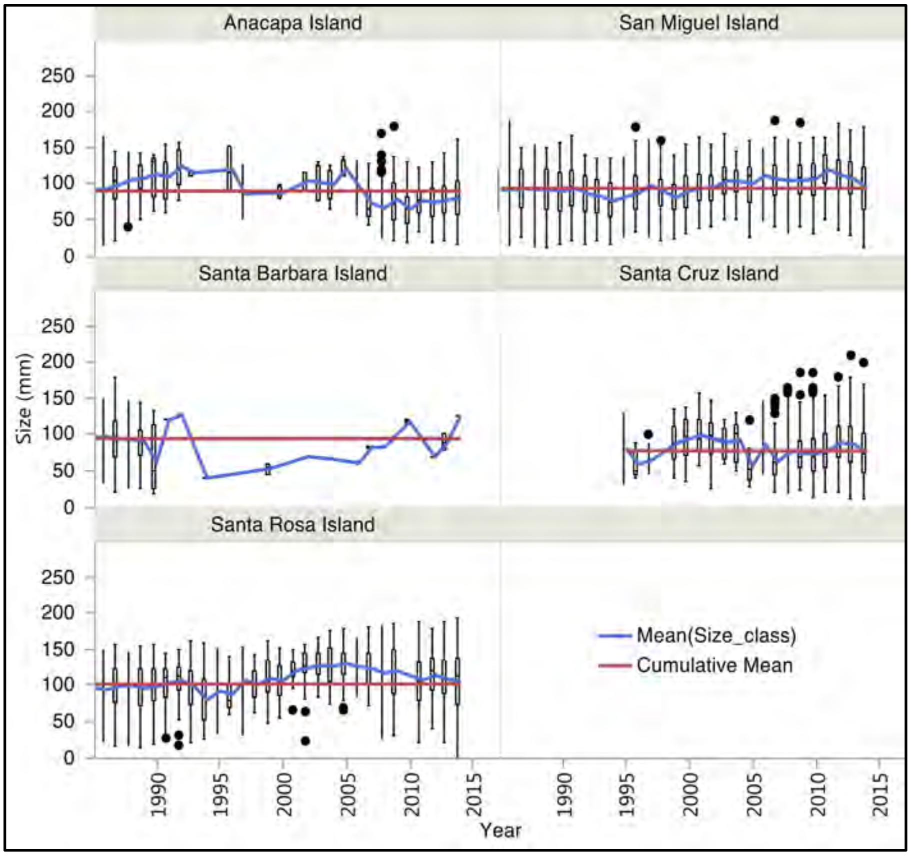


Figure App.F.13.2. Box plots for annual size frequency distributions of black abalone *Haliotis cracherodii* at each island. Blue lines represent mean sizes of *H. cracherodii* at each island pooled across and sites. Red lines represent the cumulative mean. Figure: Channel Islands National Park

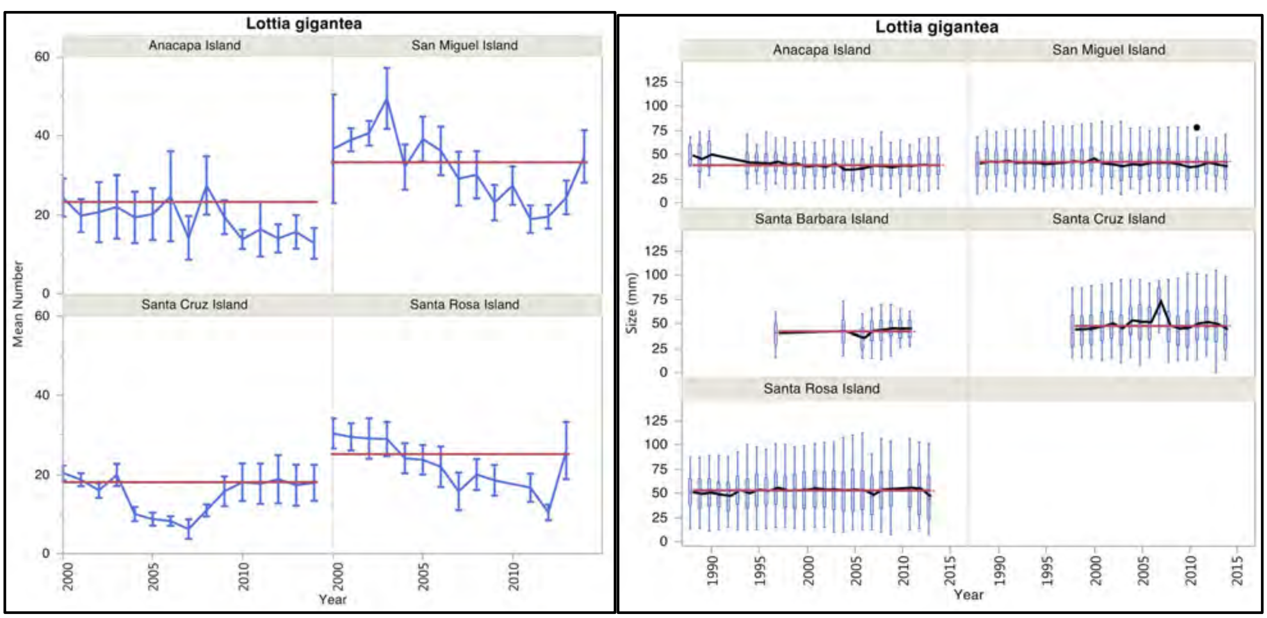


Figure App.F.13.3. (left) Mean number of owl limpets *Lottia gigantea* at each island from 2000–2014. Blue lines represent mean number at each island pooled across fixed plots and error bars were constructed using one standard error from the mean. (right) Box plots for annual size frequency distributions of *L. gigantea* at each island. Black lines represent mean sizes at each island pooled across fixed plots and sites. Red lines represent the cumulative mean. Figure: Channel Islands National Park

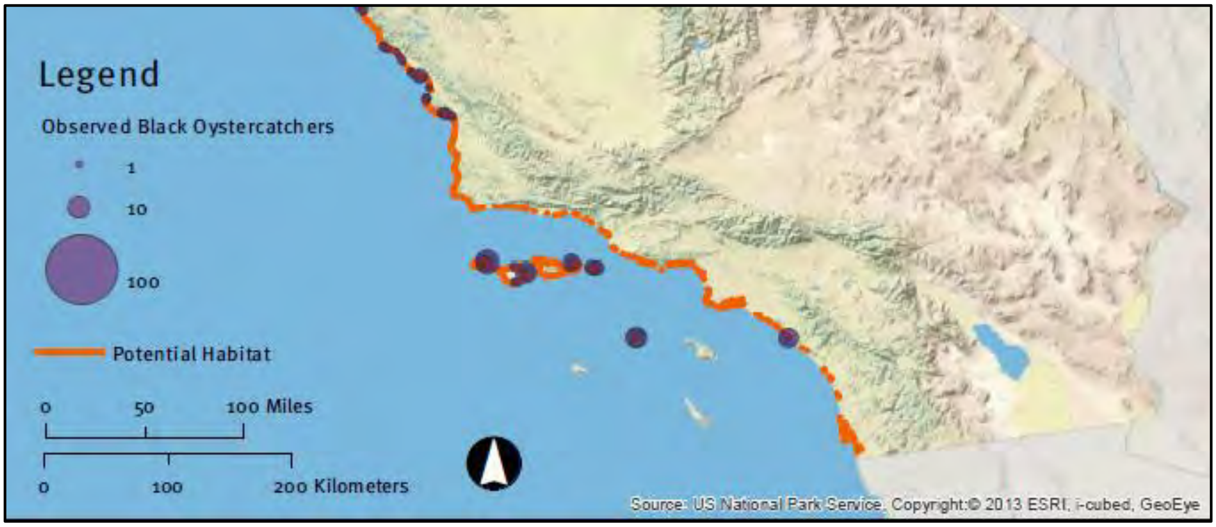


Figure App.F.13.4. In 2011, approximately 20 percent of the suitable habitat (orange) for black oystercatchers *Haematopus bachmani* was surveyed. A total of 176 adult or sub-adult black oystercatchers were detected at the five islands in Channel Islands National Marine Sanctuary. Density at different locations is shown by the diameter of the purple circles. The northern Channel Islands population was conservatively estimated to be between 779–854, which is 14 to 16 percent of the estimated total population in California. Figure: Modified from Weinstein et al. 2014

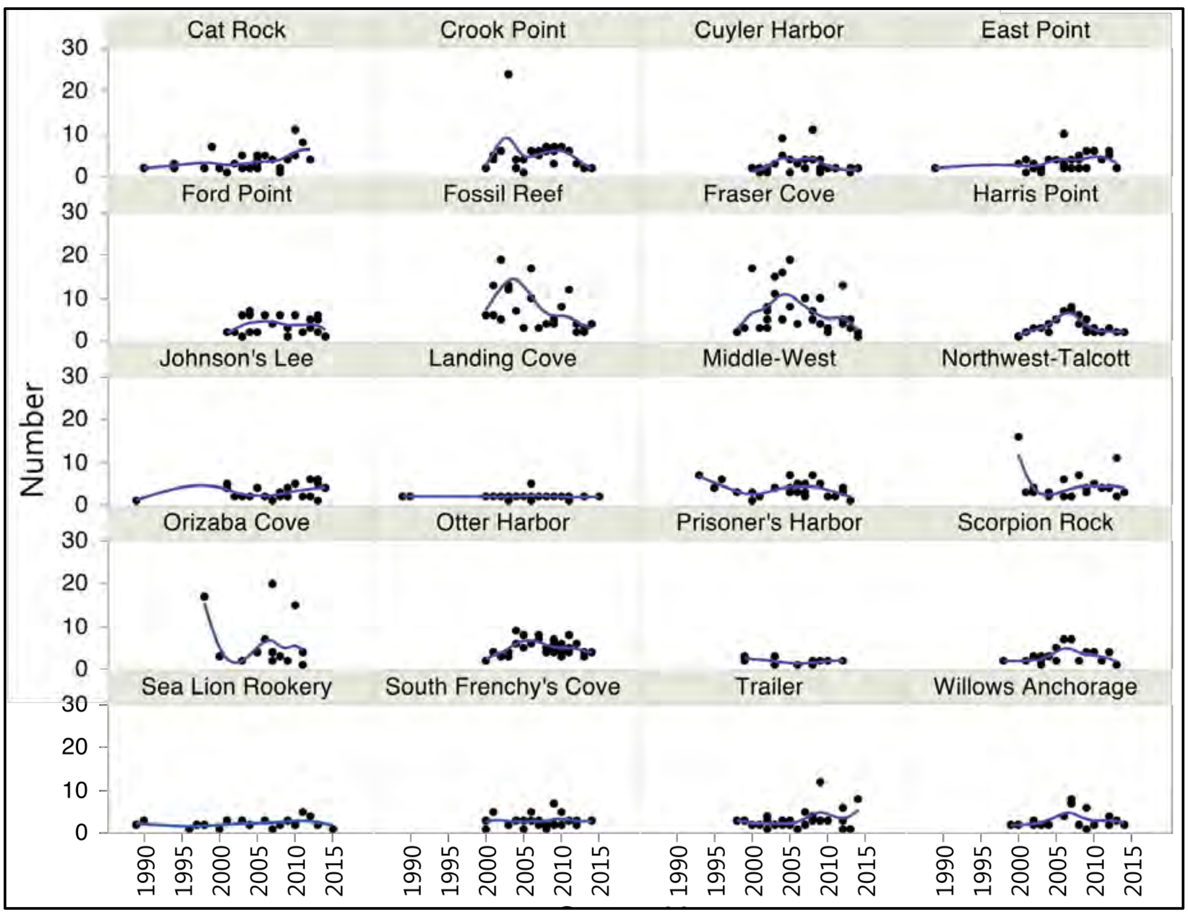


Figure App.F.13.5. Number of black oystercatchers *Haematopus bachmani* observed during surveys at 18 rocky shore sites by Channel Islands National Park. Data are collected opportunistically. Curved lines represent statistically smoothed means. Figure: Channel Islands National Park

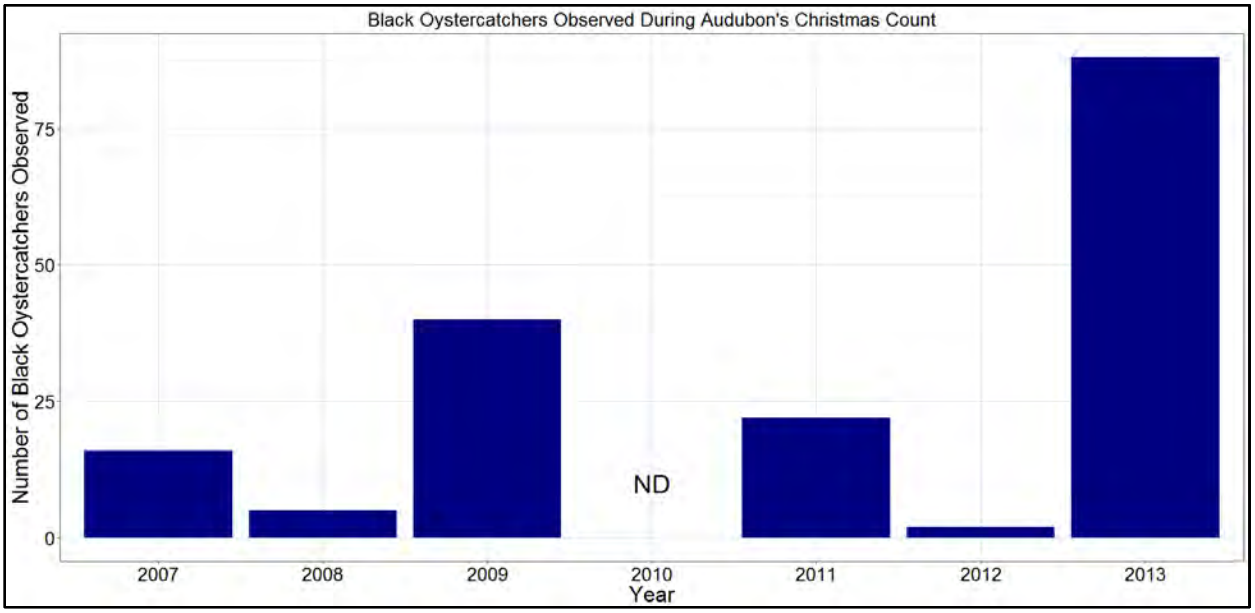


Figure App.F.13.6. Number of black oystercatchers *Haematopus bachmani* observed at Santa Cruz Island during the Audubon Christmas Bird Count from 2007 to 2013.; no data were available for 2010. Data source: Audubon Christmas Bird Count; Figure: R. Freedman/NOAA

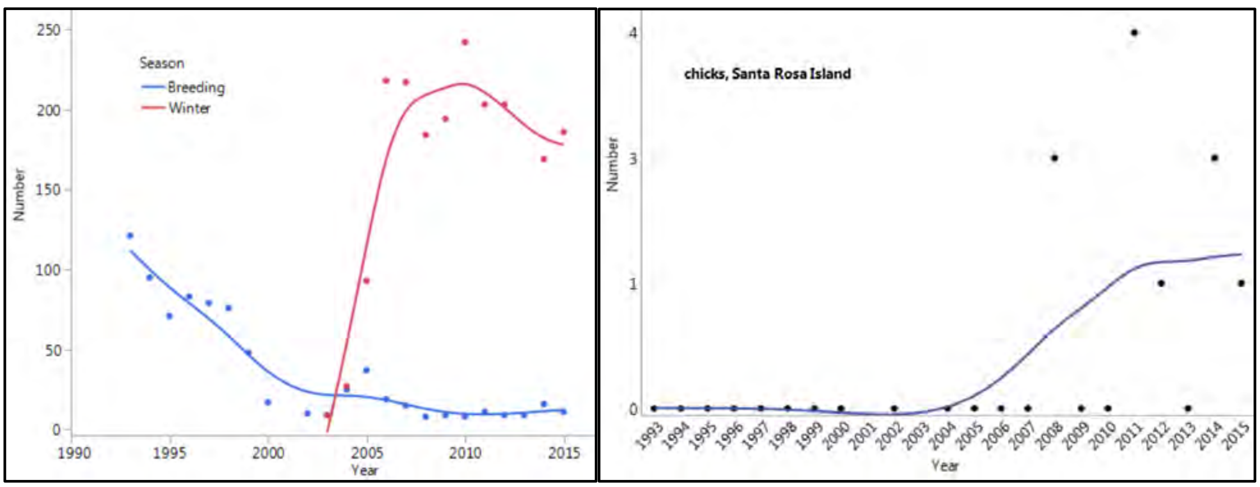


Figure App.F.13.7. (top) Counts of western snowy plover *Charadrius nivosus nivosus* at 11 beaches on Santa Rosa Island in winter (red) and summer breeding season (blue). Surveys are conducted as time and conditions allow. Winter and breeding surveys show relatively stable population sizes over the last decade. Curved lines represent statistically smoothed means. (bottom) Chicks were observed five of last eight years. Figure: Channel Islands National Park

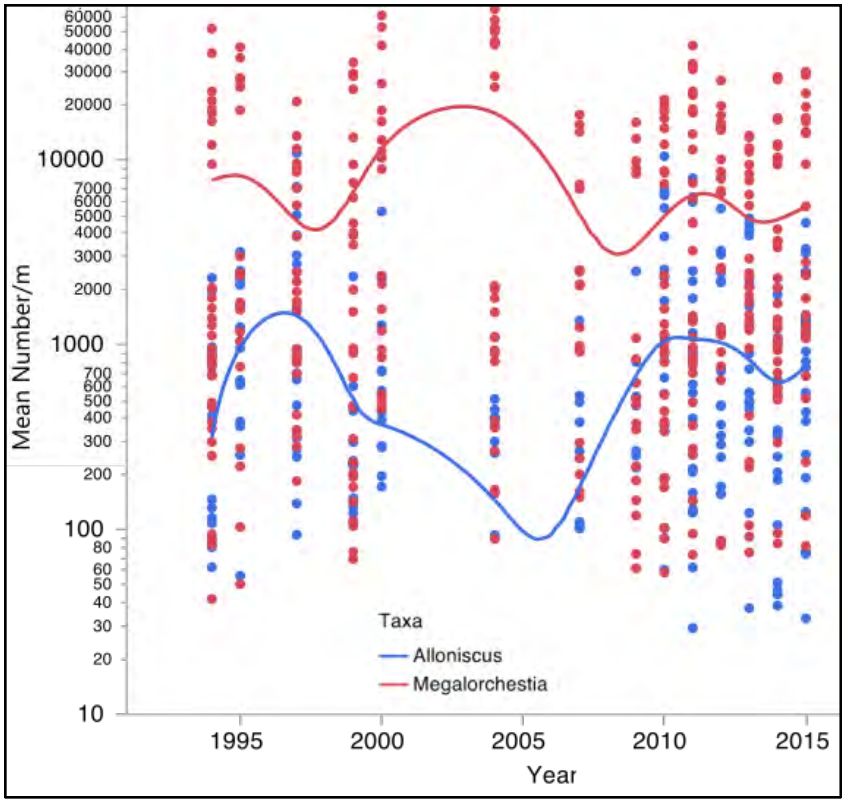


Figure App.F.13.8. Mean density of two important members of the upper beach macrofaunal community — California beach hopper *Megalorchestia californiana* (red) and *Alloniscus perconvexus* (blue)— from surveys of eight beaches on Santa Rosa Island from 1994–2015. Curved lines represent statistically smoothed means. Figure: Channel Islands National Park

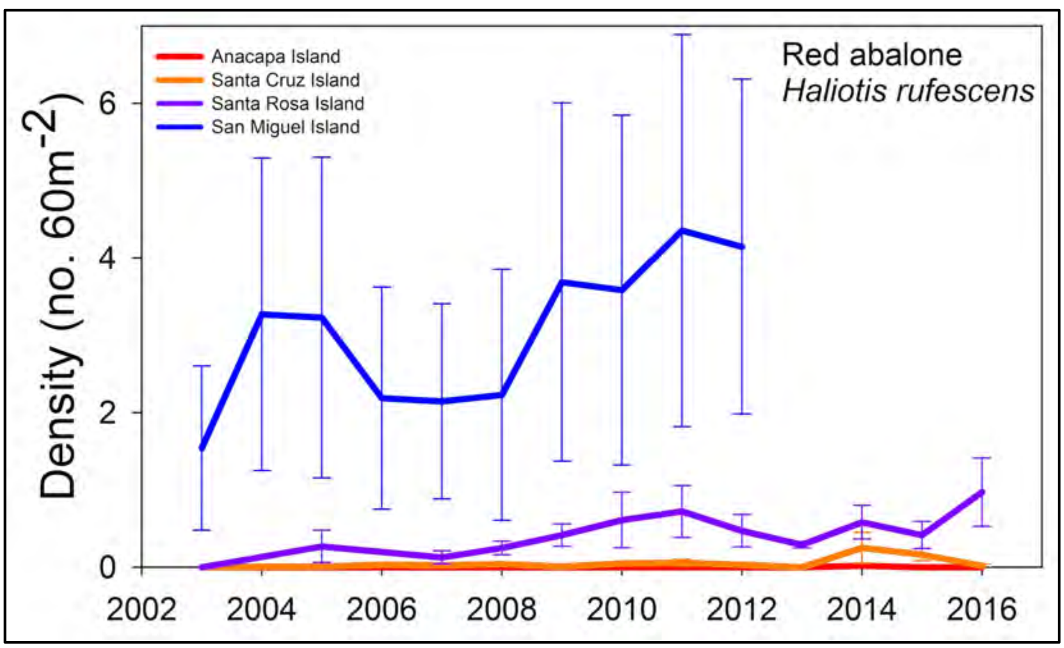


Figure App.F.13.9. Average density (+/- standard error) of red abalone *Haliotis rufescens* at 14 sites across four islands in Channel Islands National Marine Sanctuary monitored by the PISCO kelp forest monitoring program from 2003–2016. Abalone are counted by SCUBA divers swimming along transect lines. Observed density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. Observed density was higher at San Miguel Island (blue). Data source: PISCO; Figure: R. Freedman/NOAA
Note: This is variant of a similar figure shown during the expert workshop.

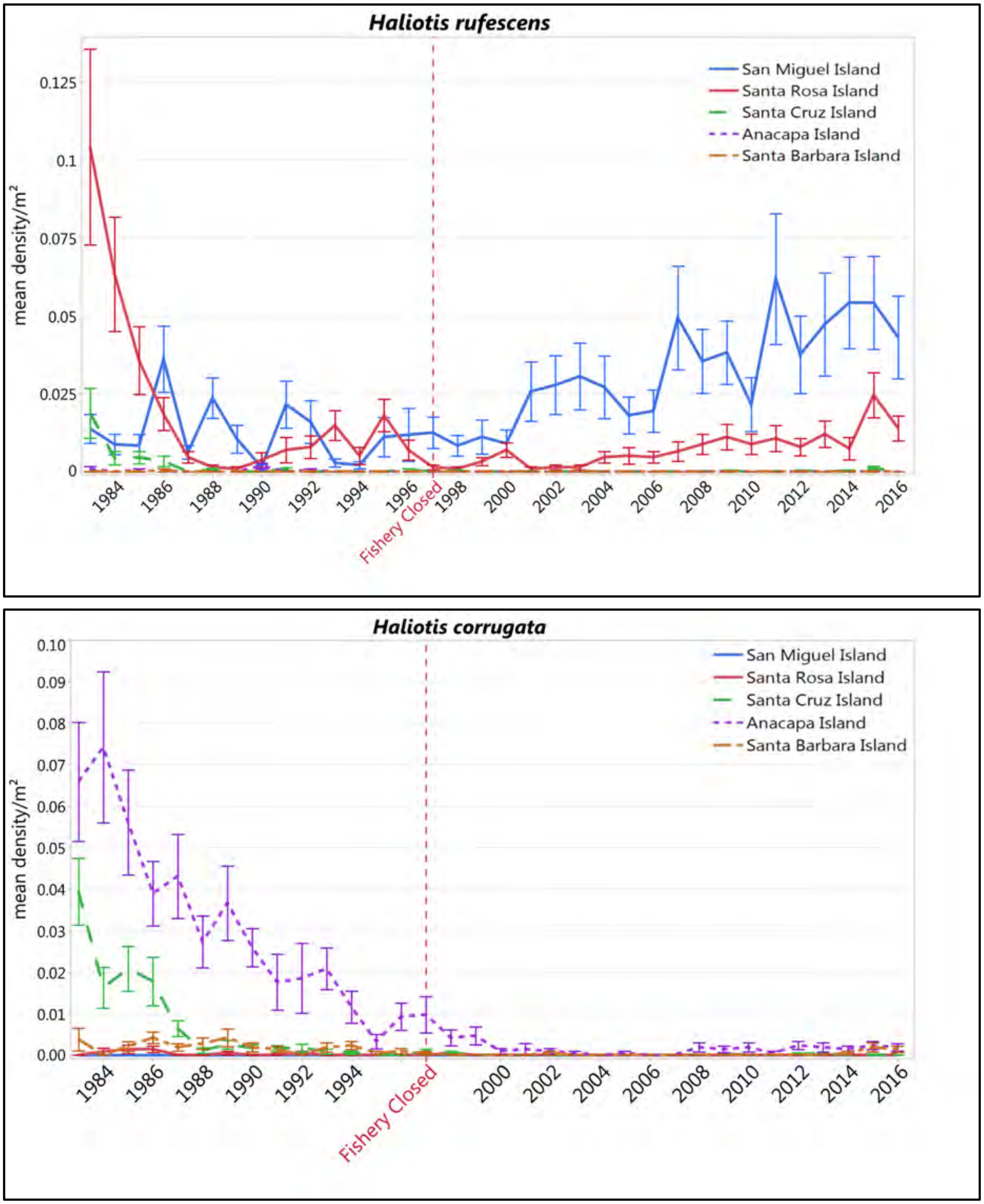


Figure App.F.13.10. Average density of red abalone *Haliotis rufescens* (top) and pink abalone *H. corrugata* (bottom) at Channel Islands National Park kelp forest monitoring sites at the five islands in Channel Islands National Marine Sanctuary. Abundance of both species was greatly reduced by harvest at all islands prior to the fishery closure in 1997. A gradual increasing trend in abundance of red abalone has been observed since the fishery closure at San Miguel (blue) and more recently at Santa Rosa (red) islands. Abalone are counted by SCUBA divers and observed density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. Figure: Channel Islands National Park.
Note: This figure was not available to be shown at the expert workshop.

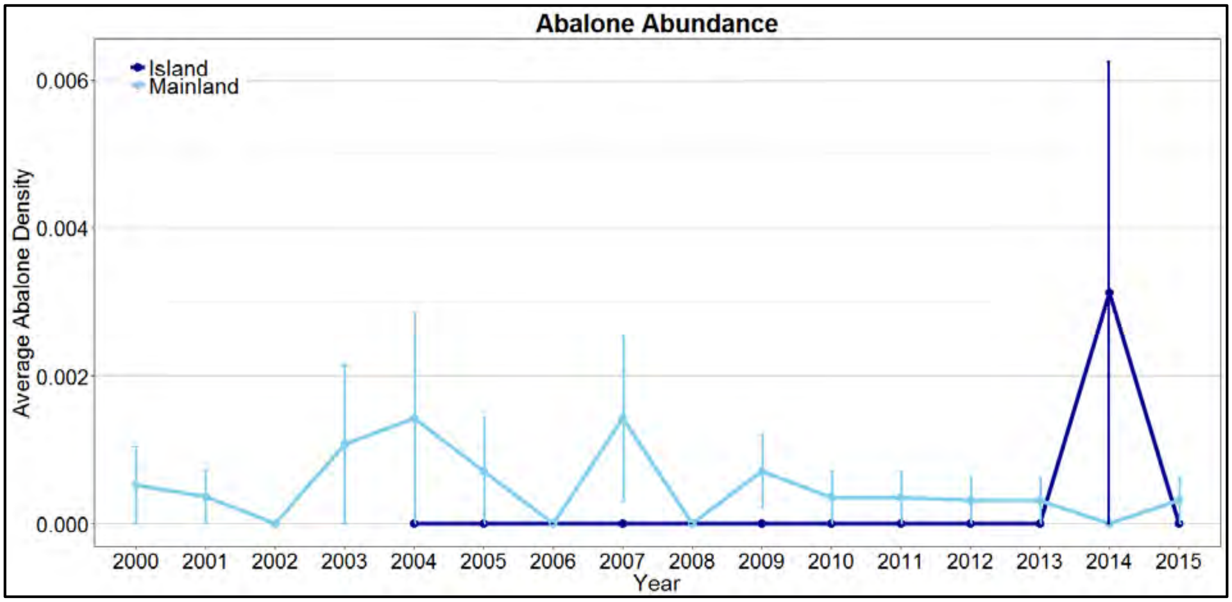


Figure App.F.13.11. Average density (+/- standard error) of abalone *Haliotis spp.*(all species combined) at two island (dark blue) and nine mainland (light blue) kelp forest sites monitored by the Santa Barbara Channel Long-term Ecological Research (SBC LTER) program. Data source: SBC LTER; Figure: R. Freedman/NOAA

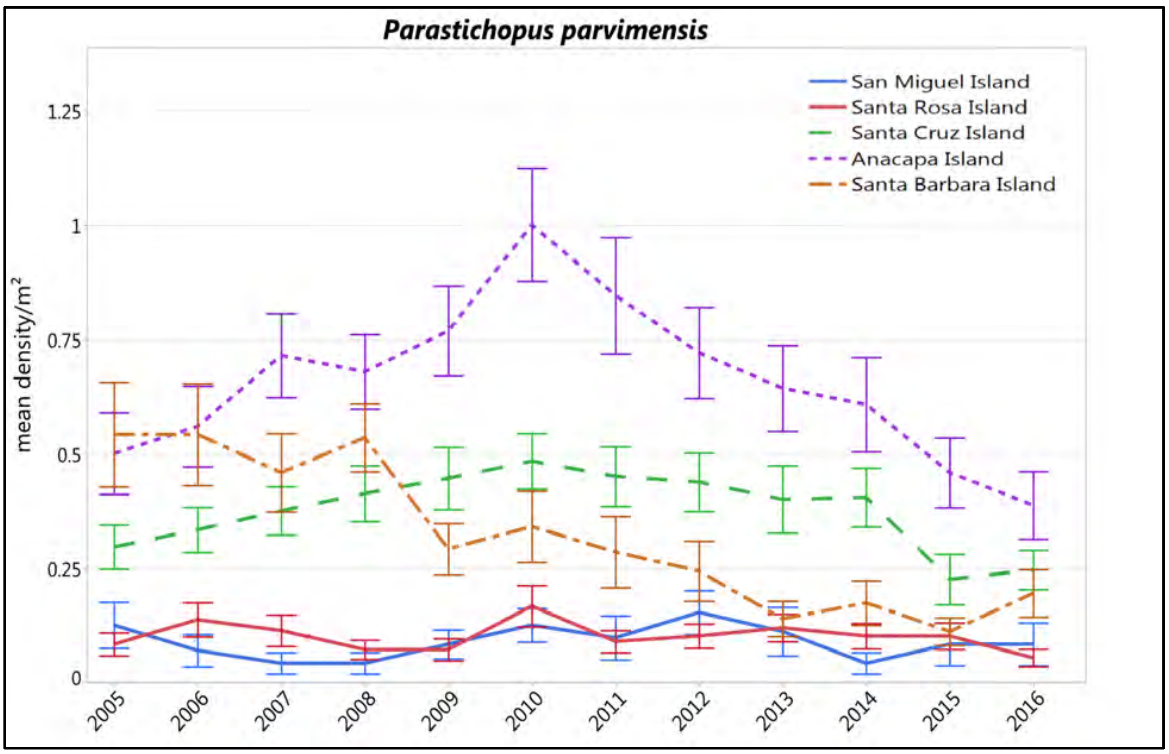


Figure App.F.13.12. Average density of warty sea cucumber *Parastichopus parvimensis* at Channel Islands National Park kelp forest monitoring sites at the five islands in Channel Islands National Marine Sanctuary. Densities are lower, but stable at San Miguel (blue) and Santa Rosa (red) islands, while densities have declined recently at the other islands. For this graph, sea cucumber density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, sea cucumber density is responding differently inside and outside of some marine protected areas (MPAs) in CINMS. A discussion of MPA effects in CINMS is available in MPA Effects. Figure: Channel Islands National Park.
Note: This figure was not available to be shown at the expert workshop.

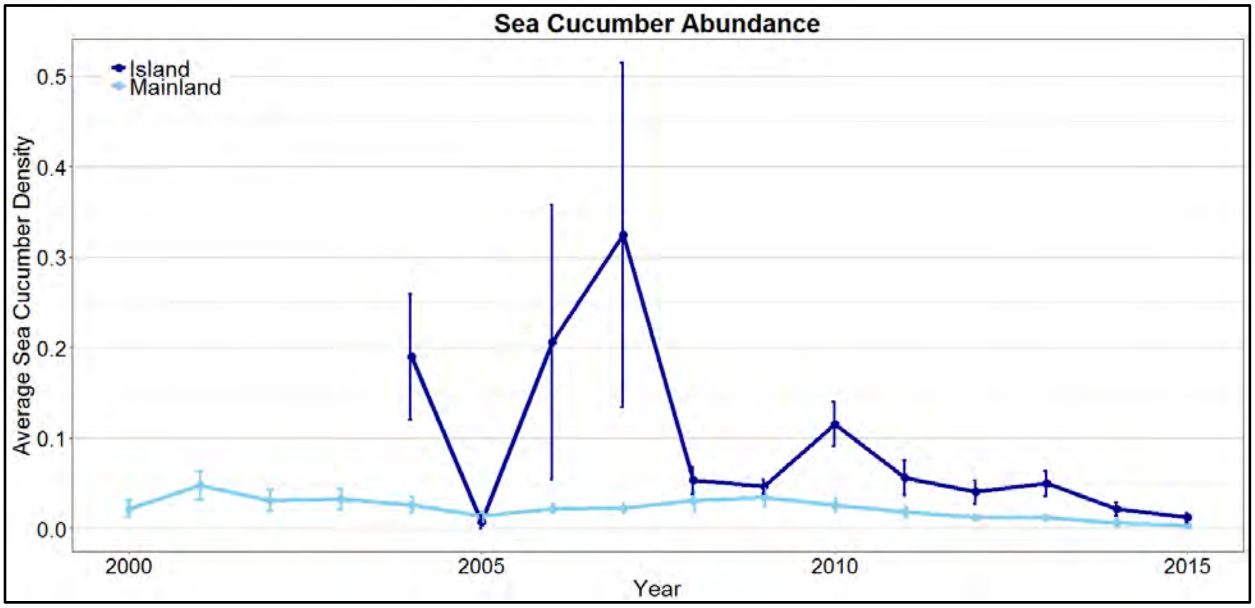


Figure App.F.13.13. Average density (+/- standard error) of sea cucumber (*Parastichopus* spp.) at 2 island (dark blue) and 9 mainland (light blue) kelp forest sites monitored by the Santa Barbara Channel Long-term Ecological Research (SBC LTER) program. Data source: SBC LTER; Figure: R. Freedman/NOAA

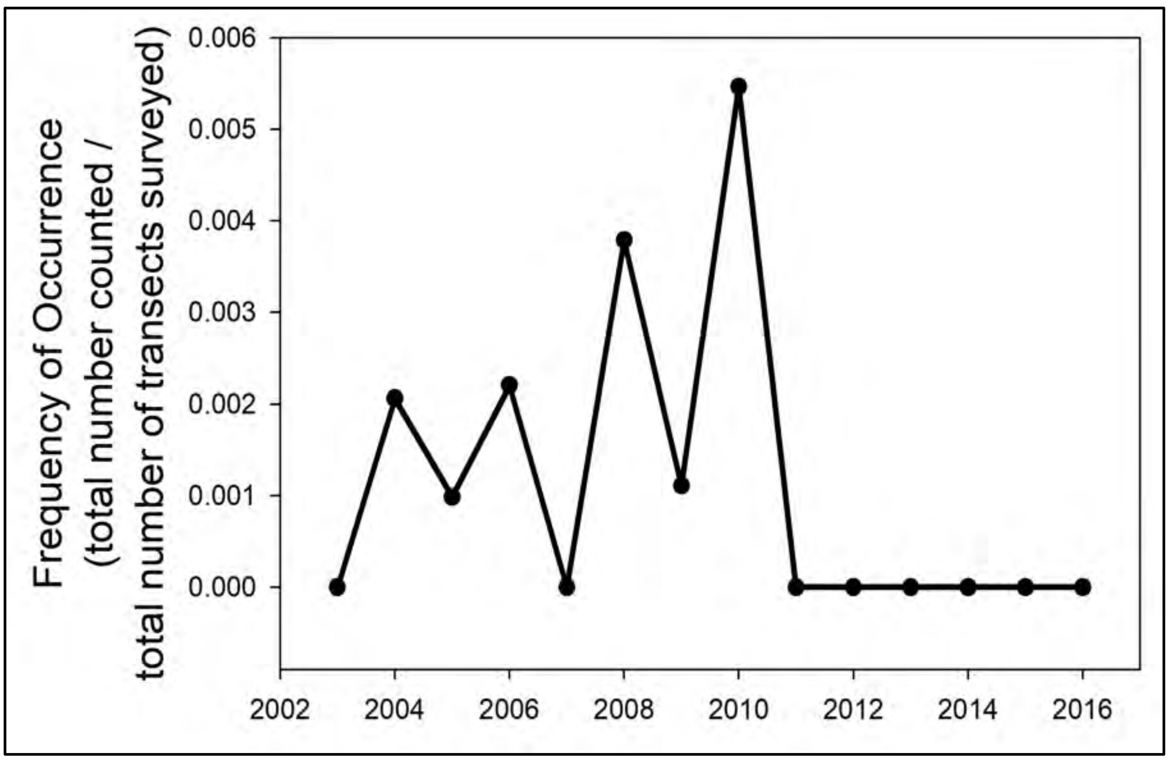


Figure App.F.13.14. Frequency of occurrence of giant sea bass *Stereolepis gigas* at 14 PISCO monitoring sites in Channel Islands National Marine Sanctuary from 2003—2016. Note that this species is so rare that there are too few observations to detect a trend, if one exists, but it is notable that this species has not been sighted during surveys since 2011. Data source: PISCO; Figure: R. Freedman/NOAA
Note: This figure was not available to be shown at the expert workshop.

Figure App.F.13.15. Average biomass of five kelp forest fish species at 14 PISCO monitoring sites across four islands in Channel Islands National Marine Sanctuary from 2003—2016. Fish are counted by SCUBA divers swimming along transect lines. Fish density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, fish density is responding differently inside and outside of some marine protected areas (MPAs) in CINMS. A discussion of MPA effects in CINMS is available in [MPA Effects](). Data source: PISCO; Figure: NOAA

Note: This is variant of a similar figure shown during the expert workshop.

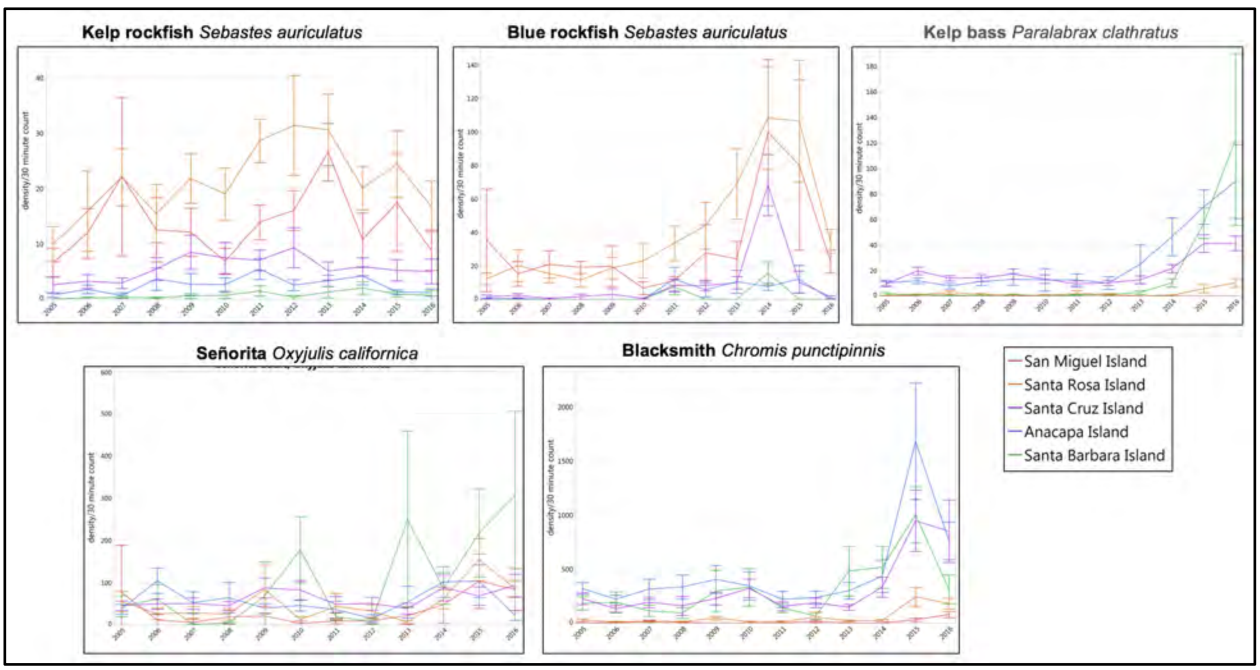


Figure App.F.13.16. Average density of five kelp forest fish species at Channel Islands National Park kelp forest monitoring sites at the five islands in Channel Islands National Marine Sanctuary. Fish density was averaged across all monitoring sites at each island, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends by island. At a finer scale, fish density is responding differently inside and outside of some marine protected areas (MPAs) in CINMS. A discussion of MPA effects in CINMS is available in [MPA Effects](). Figure: Channel Islands National Park.

Note: This figure was not available to be shown at the expert workshop.

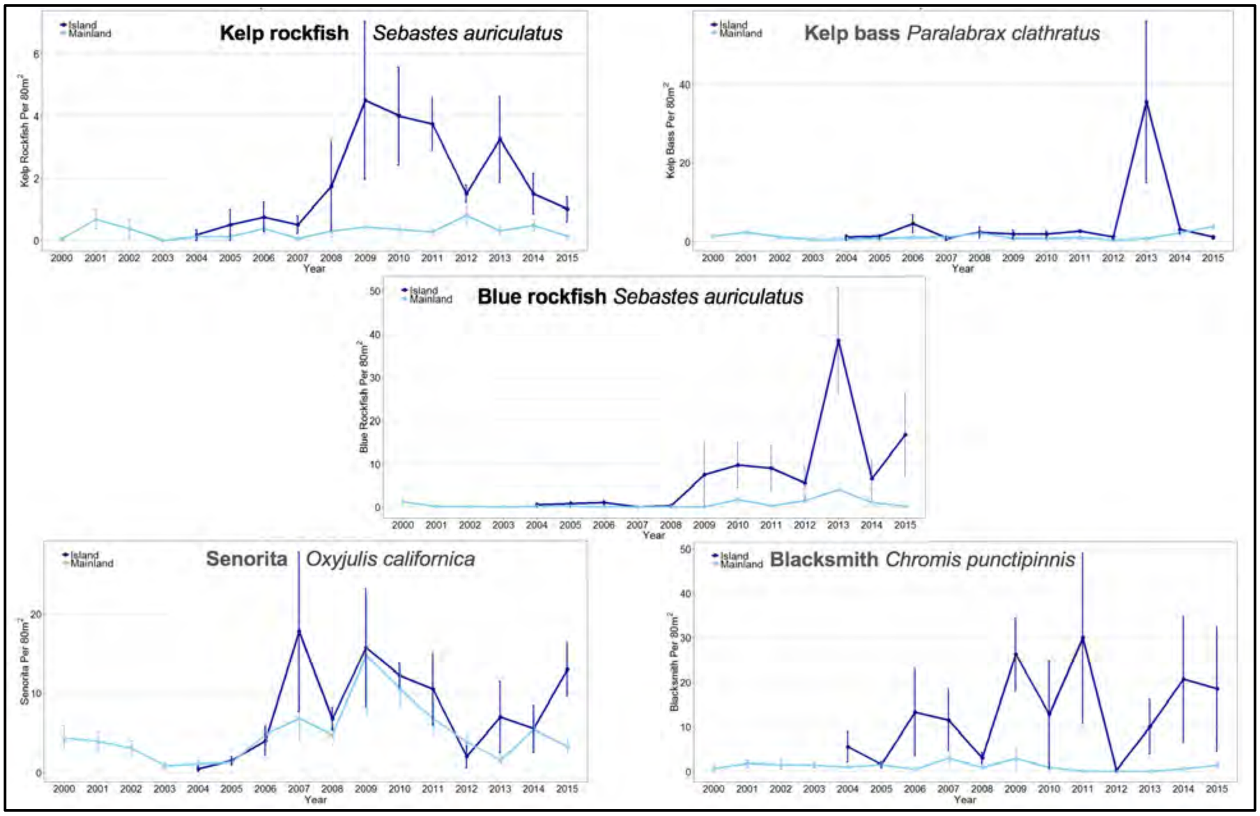


Figure App.F.13.17. Mean (+/- SE) density of five kelp forest fish species at two island (dark blue) and nine mainland (light blue) sites monitored by the Santa Barbara Channel Long-term Ecological Research (SBC LTER) program. Data source: SBC LTER; Figure: R. Freedman/NOAA

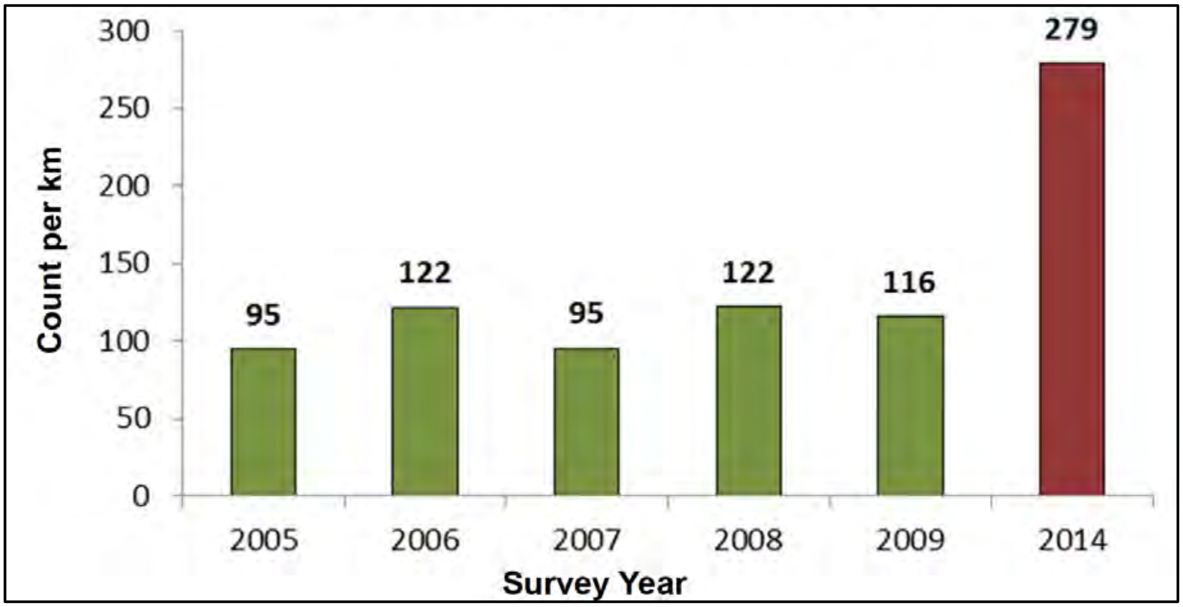


Figure App.F.13.18. Marine Applied Research and Exploration (MARE) data on abundance of demersal fishes along seafloor transects. Fish are counted using remotely operated vehicle (ROV) visual surveys of mid-depth (20 to 80 meters) rock and subtidal soft bottom in CINMS. Fish density was averaged across all monitoring sites, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends. From 2005—2009, fish greater in length than 10 centimeters averaged 110 total fish per kilometer of surveyed transect. In 2014, average total fish per kilometer was 279, an increase of 250 percent. At a finer scale, fish density may be responding differently inside and outside of some marine protected areas (MPAs) in CINMS. Figure: MARE

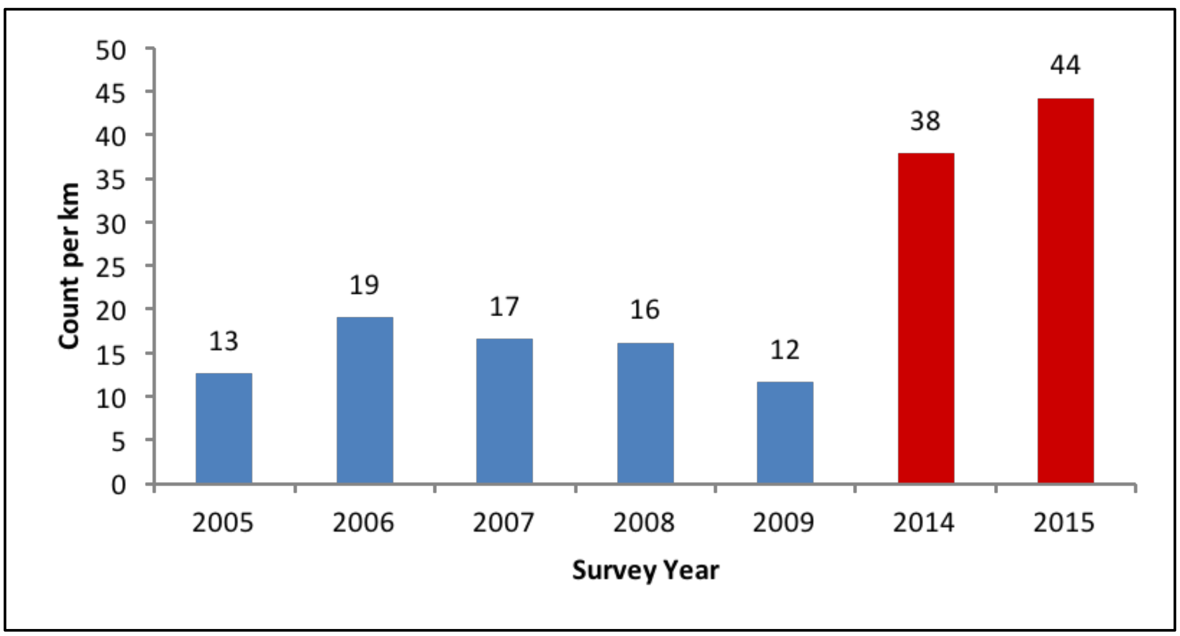


Figure App.F.13.19. Marine Applied Research and Exploration (MARE) data along seafloor transects on abundance of five species of demersal fish, lingcod, sheephead, gopher rockfish, copper rockfish, and vermillion rockfish. Fish density was averaged across all monitoring sites, including sites located inside and outside of marine reserves and conservation areas, to examine course-scale trends. From 2005–2009, the total counts for these five species combined annually averaged 15 total fish per kilometer of surveyed transect. In 2014–2015, average counts per transect rose to 38 and 44 fish, respectively. At a finer scale, fish density may be responding differently inside and outside of some marine protected areas (MPAs) in CINMS. Figure: MARE.
Note: This figure was not available to be shown at the expert workshop.

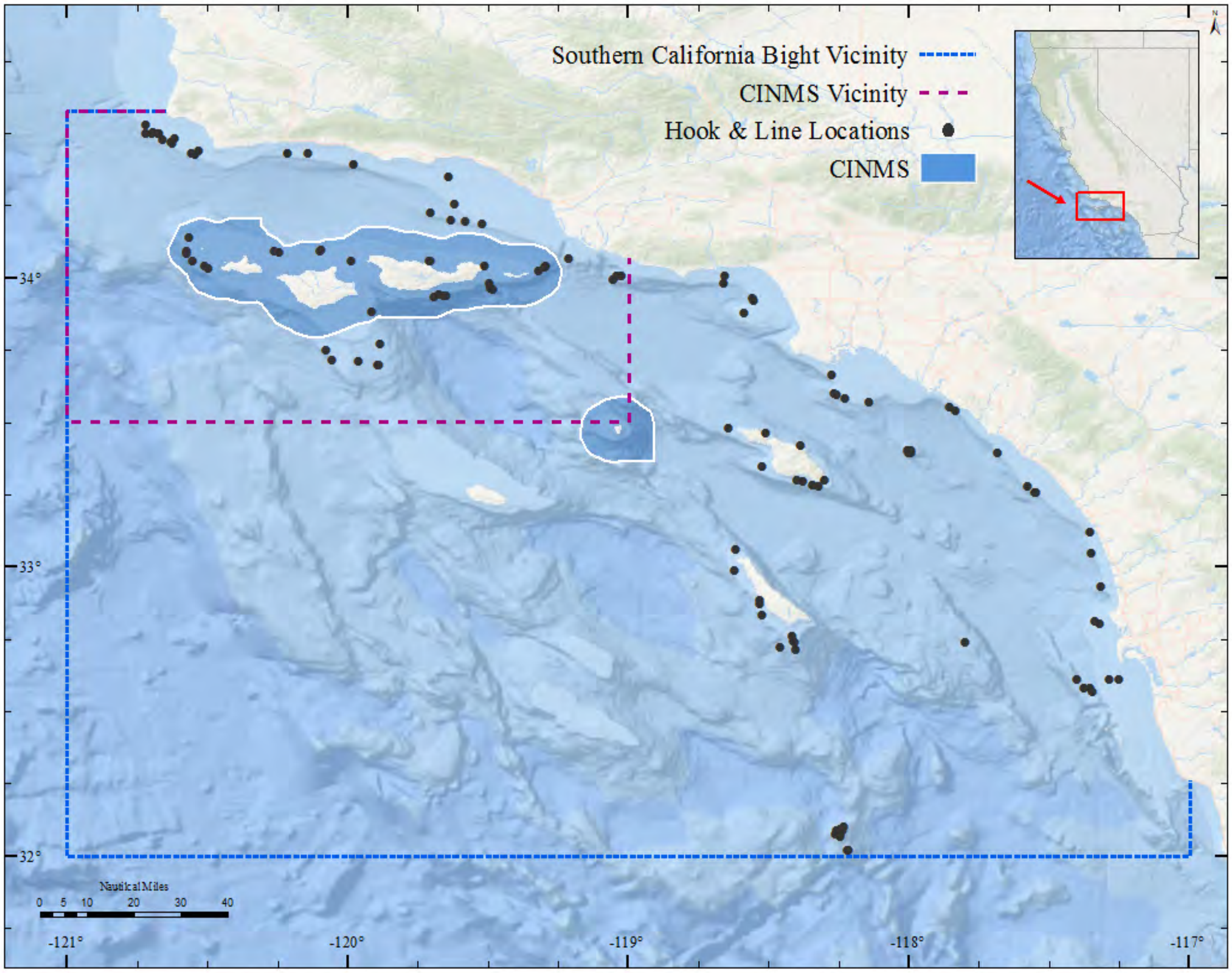


Figure App.F.13.20. Location of Southern California Shelf Rockfish Hook and Line Surveys. Annual surveys for reef-associated fish have occurred since 2004 in September and October using 75 hooks per site at depths ranging from 37 to 227 meters. Catch per unit effort (CPUE) per year was calculated for three spatial scales: CINMS included sites within the Channel Islands National Marine Sanctuary boundary (n = 26); CINMS region included sites inside the red box (n = 55); and Southern California Bight included all sites in the sampling program (n = 121). Data source: NMFS NWFSC; Map: M. Cajandig/NOAA

Table App.F.13.2. Common and scientific names of species selected for calculation of recent trends in CPUE from NMFS NWFSC Hook and Line surveys in the Southern California Bight. Of the more than 50 different species encountered in surveys from 2004—2015, the 15 species that were encountered most often (top 15 ranked species) were selected with the exception of sanddabs and squarespot rockfish, which are not well sampled by this survey method. The trend in annual CPUE was determined for the period 2009—2015 and is shown as increasing (↗), decreasing (↘), or no trend (↔) at the three spatial scales shown in Figure App.F.13.20. Three targeted or protected species were also included: cowcod, canary, and yelloweye rockfish (Note: These species were rarely encountered so observed trends may be misleading). Most strong regional trends (Southern California Bight and Channel Islands National Marine Sanctuary region) are reflected at the CINMS-level. Regional recovery or recruitment-driven population increases appears to be occurring for several species, including lingcod and bank rockfish. Trends were not strong for some rare species (e.g., cowcod and yelloweye). The CINMS trend was different than the larger sampling area for some species (e.g., bocaccio, chilipepper, and greenspotted rockfish) possibly influenced by depth segregation, effects of the Channel Islands network of MPAs, or regional/site level-effects amplified by low sample sizes.
Data source: NMFS NWFSC; Table: NOAA

Common Name	Scientific Name	Count	Rank	Recent Trend (2009-2016)		
				SoCA Bight	CINMS Region	CINMS
Vermilion (and Sunset) Rockfish	*Sebastes miniatus* (and *S. crocotulus*)	12,482	1	↔	↔	↔
Bocaccio	*Sebastes paucispinis*	9,384	2	↗	↗	↔
Greenspotted Rockfish	*Sebastes chlorostictus*	2,621	3	↔	↔	↗
Yellowtail Rockfish	*Sebastes flavidus*	1,303	4	↔	↔	↔
Speckled Rockfish	*Sebastes ovalis*	1,138	5	↗	↔	↔
Chilipepper	*Sebastes goodei*	942	6	↔	↔	↘
Starry Rockfish	*Sebastes constellatus*	790	7	↔	↘	↘
Copper Rockfish	*Sebastes caurinus*	730	8	↔	↔	↔
~~Sanddab Unidentified~~	*Citharichthys spp.*	721	9			
Widow Rockfish	*Sebastes entomelas*	583	10	↔	↔	↔
Swordspine Rockfish	*Sebastes ensifer*	573	11	↔	↘	↘
Bank Rockfish	*Sebastes rufus*	515	12	↗	↗	↗
Lingcod	*Ophiodon elongatus*	505	13	↗	↗	↗
~~Squarespot Rockfish~~	*Sebastes hopkinsi*	399	14			
Blue Rockfish	*Sebastes mystinus*	396	15	↔	↔	↔
Cowcod	*Sebastes levis*	293	19	↗	↔	↗
Canary Rockfish	*Sebastes pinniger*	197	21	↔	↔	↔
Yelloweye Rockfish	*Sebastes ruberrimus*	15	32	↘	↘	↘

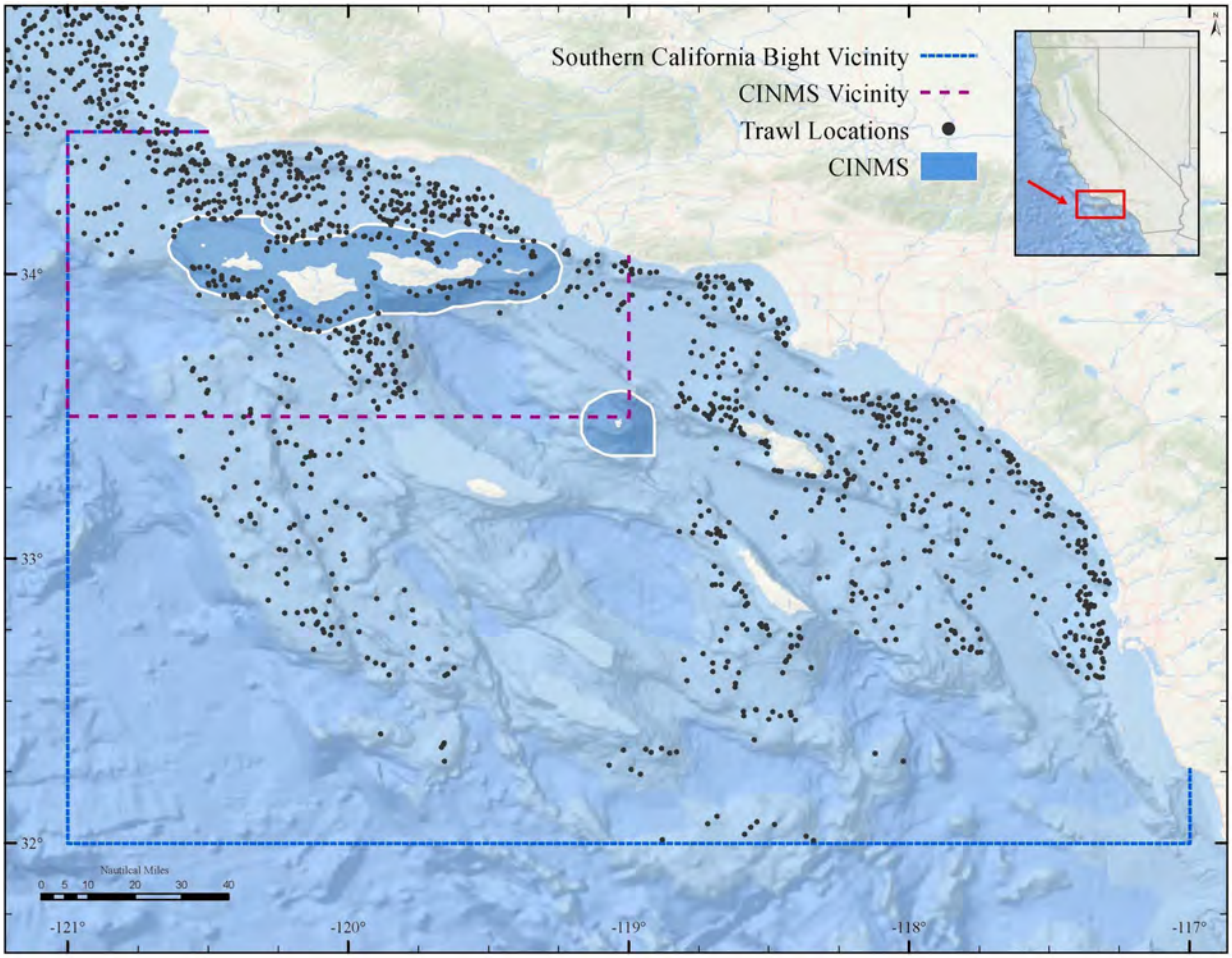


Figure App.F.13.21. Locations sampled by the West Coast Groundfish Bottom Trawl Surveys for demersal fish inhabiting trawlable habitat along the upper continental slope and shelf. Annual surveys have occurred along the entire U.S. West Coast from May to October each year at depths from 55 meters to 1,280 meters. Catch per unit effort (CPUE) per year was calculated for three spatial scales relative to Channel Islands National Marine Sanctuary: CINMS included sites within the CINMS boundary (light blue shading, n = 130, 2008–2014, 116 species); CINMS region includes sites inside the red box (n = 639, 2003-–2014, 192 species); Southern California Bight included sites inside the blue box (n = 1,353, 2003–2014, 247 species). Data source: NMFS NWFSC; Map: M. Cajandig/NOAA

Table App.F.13.3. Common and scientific names of species selected for calculation of recent trends in CPUE from NMFS NWFSC West Coast Groundfish Bottom Trawl Surveys in the Southern California Bight. Of the more than 247 different species encountered in surveys from 2003 to 2014, the 23 species that were encountered most often were selected. The trend in annual CPUE was determined for the period 2009–2014 and is shown as increasing (↗), decreasing (↘), or no trend (↔) at the three spatial scales shown in Figure App.F.13.21. Yellow highlights the 11 species that appear to be well sampled in trawls at the shallower depths most commonly surveyed inside Channel Islands National Marine Sanctuary (67 percent of sites in CINMS < 200 meters). These shallower species appear to be stable or increasing in CINMS and the surrounding region. Most species with different short-term trends at the smaller and larger spatial scales are deepwater species not sampled well in shallow water stations in CINMS. Data source: NMFS NWFSC; Table: NOAA

Common Name	Scientific Name	SoCA Bight	CINMS Region	CINMS
Blackgill Rockfish	*Sebastes melanostomus*	↗	↗	↔
Bocaccio	*Sebastes paucispinis*	↗	↗	↗
Chilipepper	*Sebastes goodei*	↗	↗	↗
Copper rockfish	*Sebastes caurinus*	↔	↔	↔
Dover sole	*Microstomus pacificus*	↔	↘	↘
English sole	*Parophrys vetulus*	↗	↗	↗
Halfbanded rockfish	*Sebastes semicinctus*	↗	↗	↔
Lingcod	*Ophiodon elongatus*	↗	↗	↗
Longnose skate	*Raja rhina*	↗	↔	↔
Longspine thornyhead	*Sebastolobus altivelis*	↔	↔	↗
Pacific electric ray	*Torpedo californica*	↘	↘	↔
Pacific hake	*Merluccius productus*	↗	↗	↔
Pacific sanddab	*Citharichthys sordidus*	↔	↔	↔
Petrale sole	*Eopsetta jordani*	↗	↗	↗
Pink seaperch	*Zalembius rosaceus*	↘	↘	↔
Rex sole	*Glyptocephalus zachirus*	↗	↗	↘
Sablefish	*Anoplopoma fimbria*	↔	↔	↗
Shortbelly rockfish	*Sebastes jordani*	↘	↔	↔
Shortspine thornyhead	*Sebastolobus alascanus*	↘	↘	↘
Splitnose rockfish	*Sebastes diploproa*	↗	↗	↔
Spotted ratfish	*Hydrolagus colliei*	↔	↔	↗
Stripetail rockfish	*Sebastes saxicola*	↗	↗	↗
Vermillion rockfish	*Sebastes miniatus*	↗	↗	↔

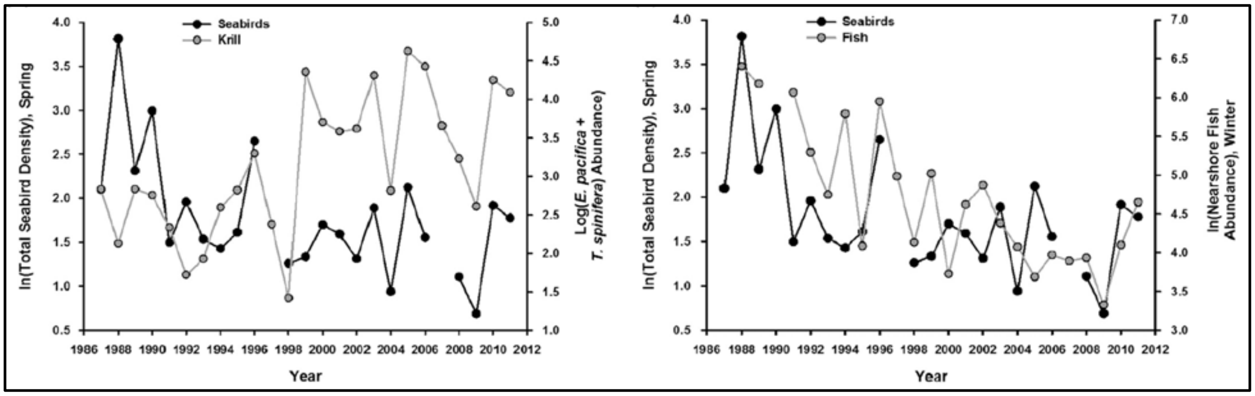


Figure App.F.13.22. Trends in seabird abundance and the relative abundance of krill and forage fish, based on CalCOFI/CCE LTER program data (1987–2011). Spring and summer seabird density declined by 2 percent per year, mostly in the northern sector of the study region. Krill showed variable trends. Nearshore forage fish, dominated by northern anchovy, and offshore mesopelagic species show declines in relative abundance over this period. Figure: Sydeman et al. 2015

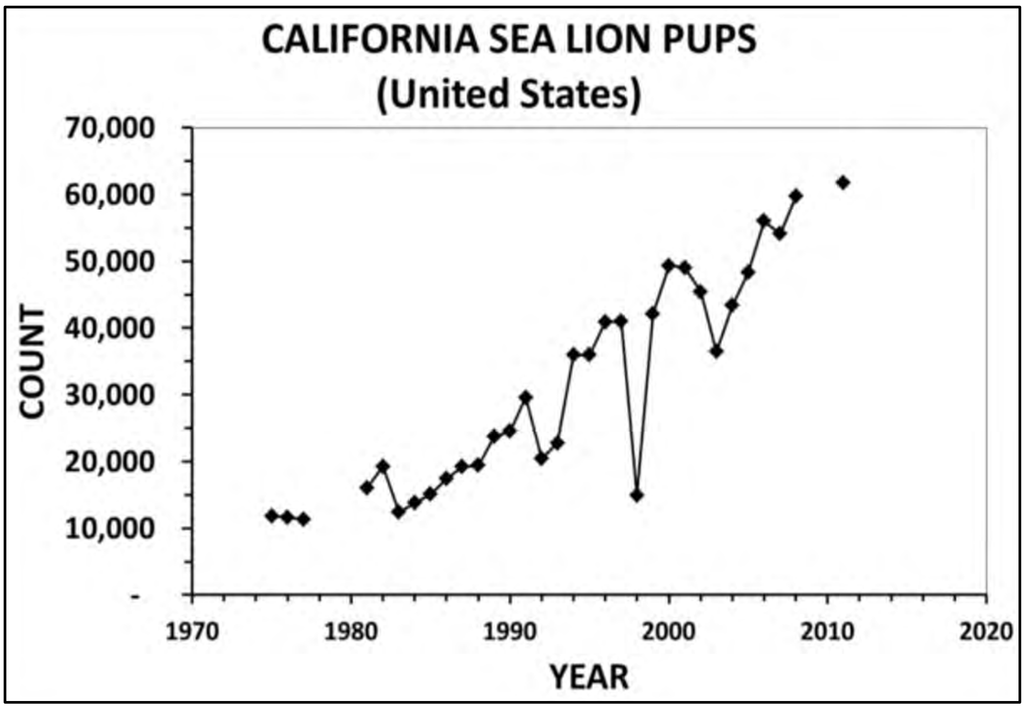


Figure App.F.13.23. U.S. pup count index for California sea lions *Zalophus californianus* (1975–2011). Trends in pup counts from 1975–2011 are shown for four rookeries in southern California and for haulouts in central and northern California. Figure: Carretta et al. 2016

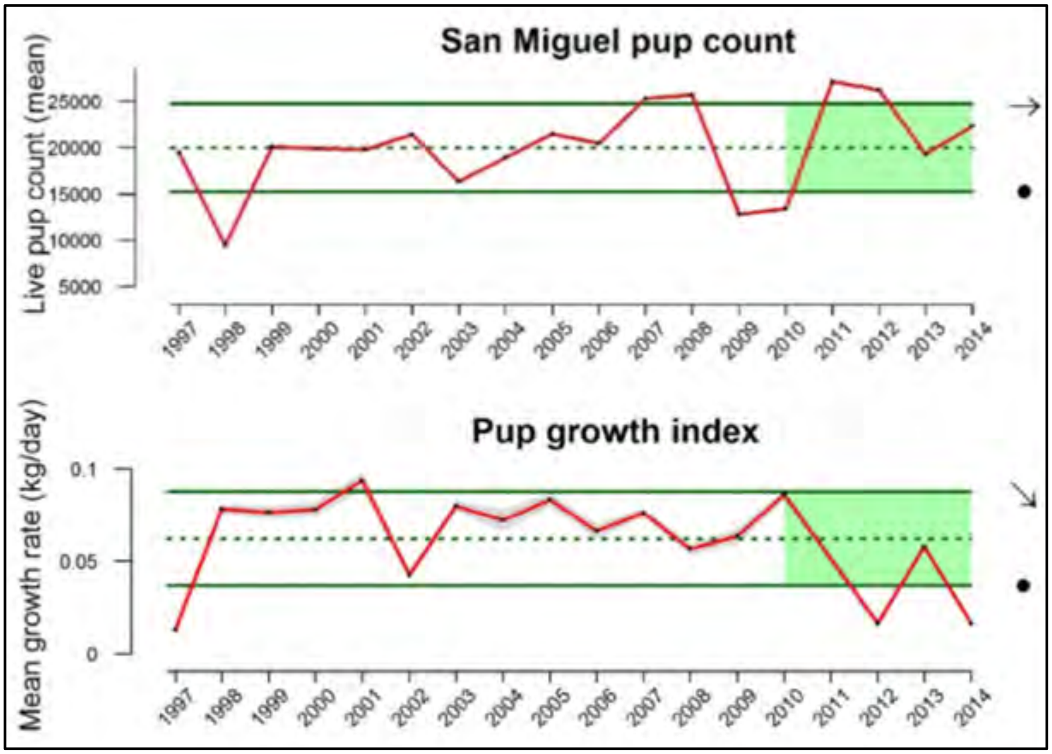


Figure App.F.13.24. Live pup count (top) and mean pup growth index for California sea lions *Zalophus californianus* (1997–2014). Recent trends in pup counts have been stable, but declining for pup growth likely due to low availability of prey resources in central and southern California, which is the foraging range of nursing females. Symbols on graph are explained in the caption of Figure App.F.12.18. Figure: NMFS 2016a

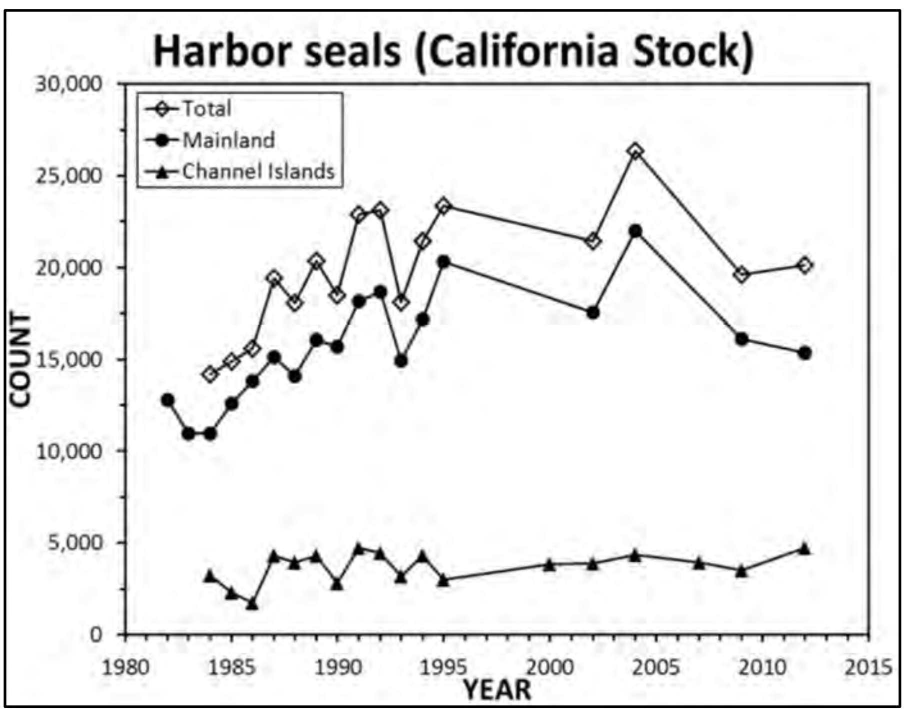


Figure App.F.13.25. Population size of harbor seals *Phoca vitulina* in California is estimated by counting the number of seals ashore during the peak haulout period (May to July) and by multiplying this count by a correction factor. The population on Channel Islands beaches (triangle) appears to be stable. Figure: Carretta et al. 2016

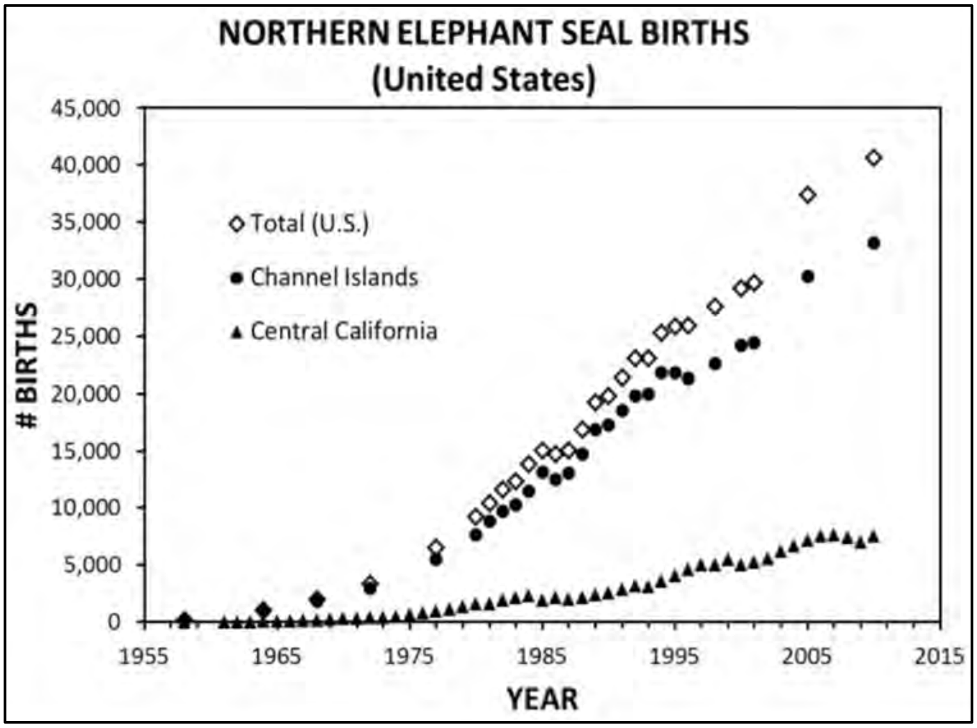


Figure App.F.13.26. Estimated number of northern elephant seal *Mirounga angustirostris* births in California from 1958–2010. There has been an increasing trend over the entire time series for Channel Islands (circles). Elephant seals have increased in abundance and taken up residence at locations on Santa Rosa Island that have historically not been inhabited (S. Whitaker, CINP, pers. comm.). Figure: Carretta et al. 2016

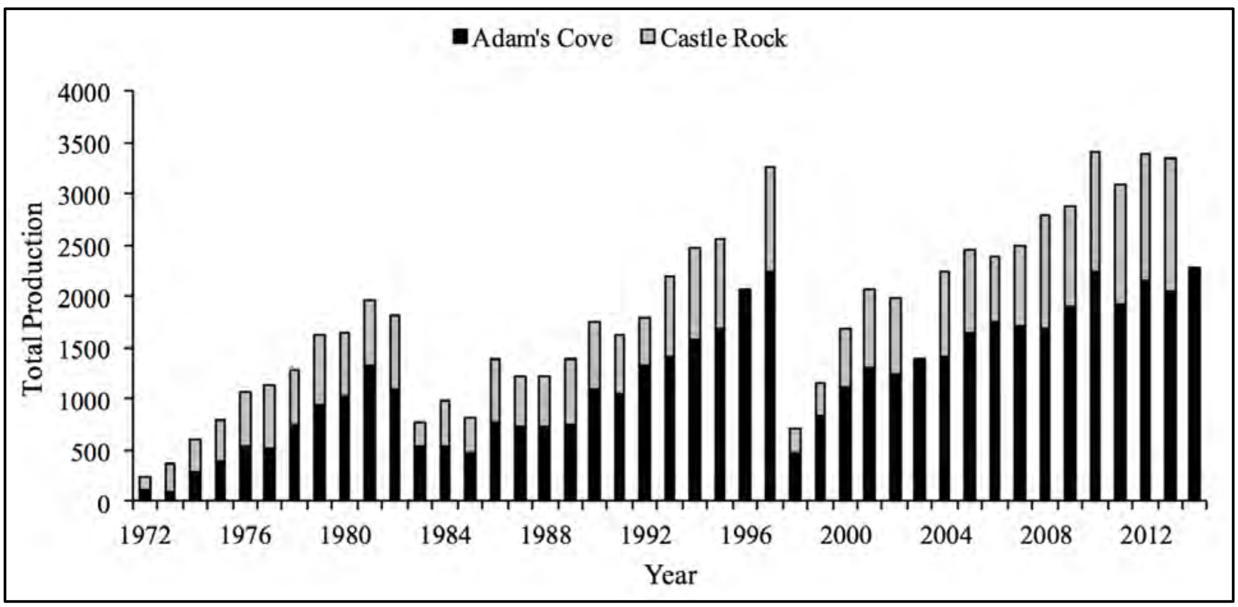


Figure App.F.13.27. Total production of Northern fur seal *Callorhinus ursinus* pups counted on San Miguel Island, including the mainland (Adam's Cove) and the offshore islet (Castle Rock), from 1972–2014. The total production of northern fur seals exceeded the 1997 levels during 2010, 2012, and 2013. The island's population has recovered from the 1997–1998 El Niño event. Figure: Carretta et al. 2016

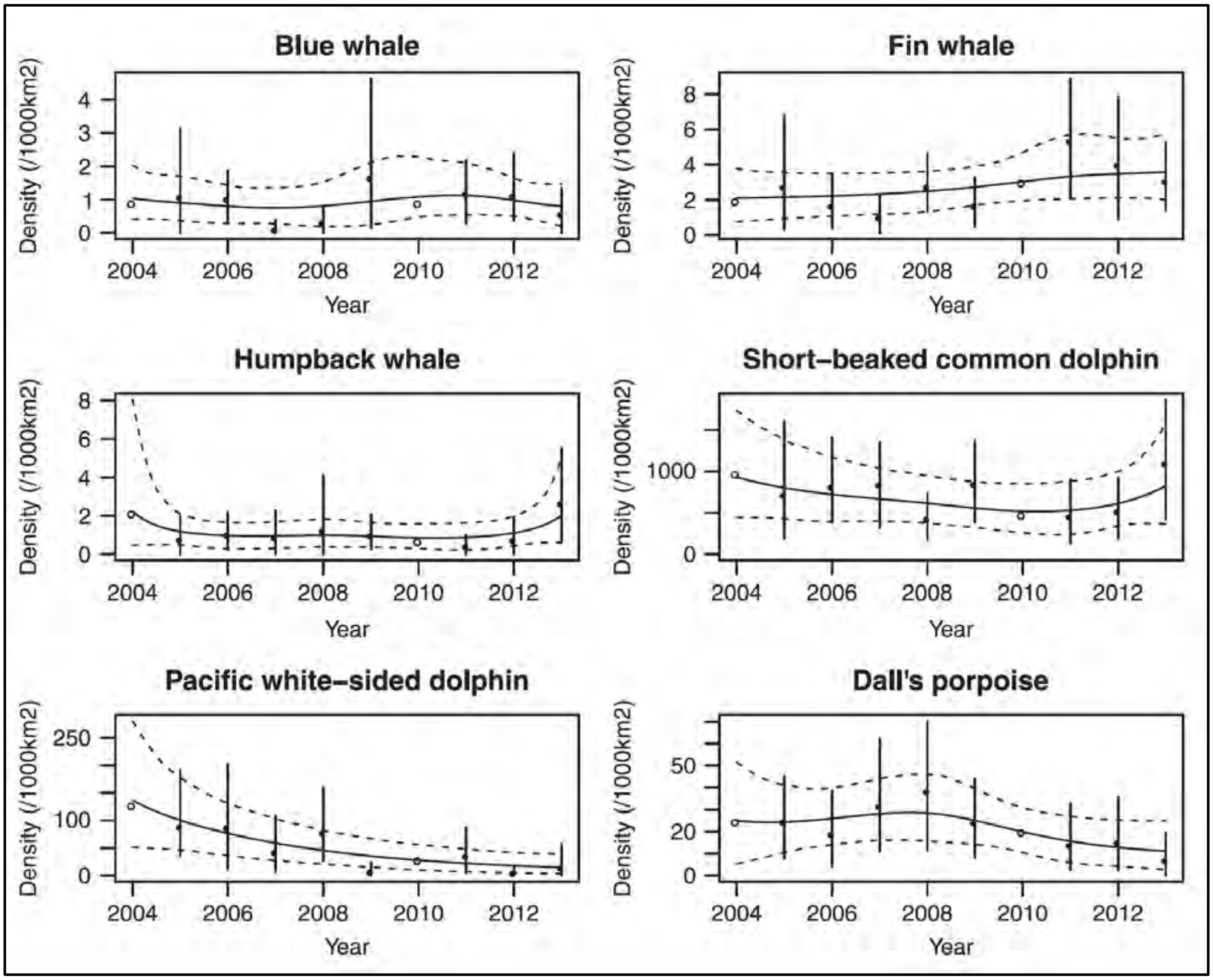


Figure App.F.13.28. Trend in density from 2004–2013, based on sightings from CalCOFI cruises, for the six most frequently sighted species of cetaceans off southern California. Blue and humpback whales, short-beaked common dolphins, and Dall's porpoises appear to be stable. Fin whale sightings have decreased while Pacific white-sided dolphin sightings have increased. Figure: Campbell et al. 2015

14. What is the status of non-indigenous species and how is it changing?

Table App.F.14.1. Data presented to the living resources experts at the workshop on June 1, 2016 to update status and trends assessments for Channel Islands National Marine Sanctuary (CINMS).
**Denotes graphs that were received after the expert workshops and were not available for experts to view during the status and trend workshop; however, a representative from the monitoring program discussed this data set during the meeting.

Indicator	Source	Figure #	Data Summary
Rocky Intertidal Habitat			
Non-indigenous species abundance	Blanchette et al. 2015	App.F.14.1	*Status:* Six non-indigenous species observed at PISCO sites on islands. *S. horneri* is moving up into the intertidal as well.
Beach Habitat (Long-term monitoring data for indicators in this habitat were not available.)			
Kelp Forest and Reef Habitat (< 30 meters)			
Sargassum horneri observations	Marks et al. 2015b; Pacific Rocky Intertidal NIS interactive map	App.F.14.2 –.F.14.3	*Status: S. horneri* is established at three islands in CINMS, only drift has reached San Miguel Island, but no sightings of established individuals. *Trend:* Increasing in abundance and spreading to new locations in CINMS.
Sargassum horneri density	CINP	App.F.14.4 **	*Status and Trend:* Increasing abundance at Anacapa, Santa Cruz,and Santa Barbara islands.
Watersipora spp. observations	Page et al. 2016; Sprague et al. 2013	App.F.14.5	*Status:* Observed at a few natural reefs in CINMS; low cover, patchy.
Sandy Seafloor Habitat (< 30 meters) (Long-term monitoring data for indicators in this habitat were not available.)			
Deep Seafloor Habitat (> 30 meters) (Long-term monitoring data for indicators in this habitat were not available.)			
Pelagic Habitat (Long-term monitoring data for indicators in this habitat were not available.)			

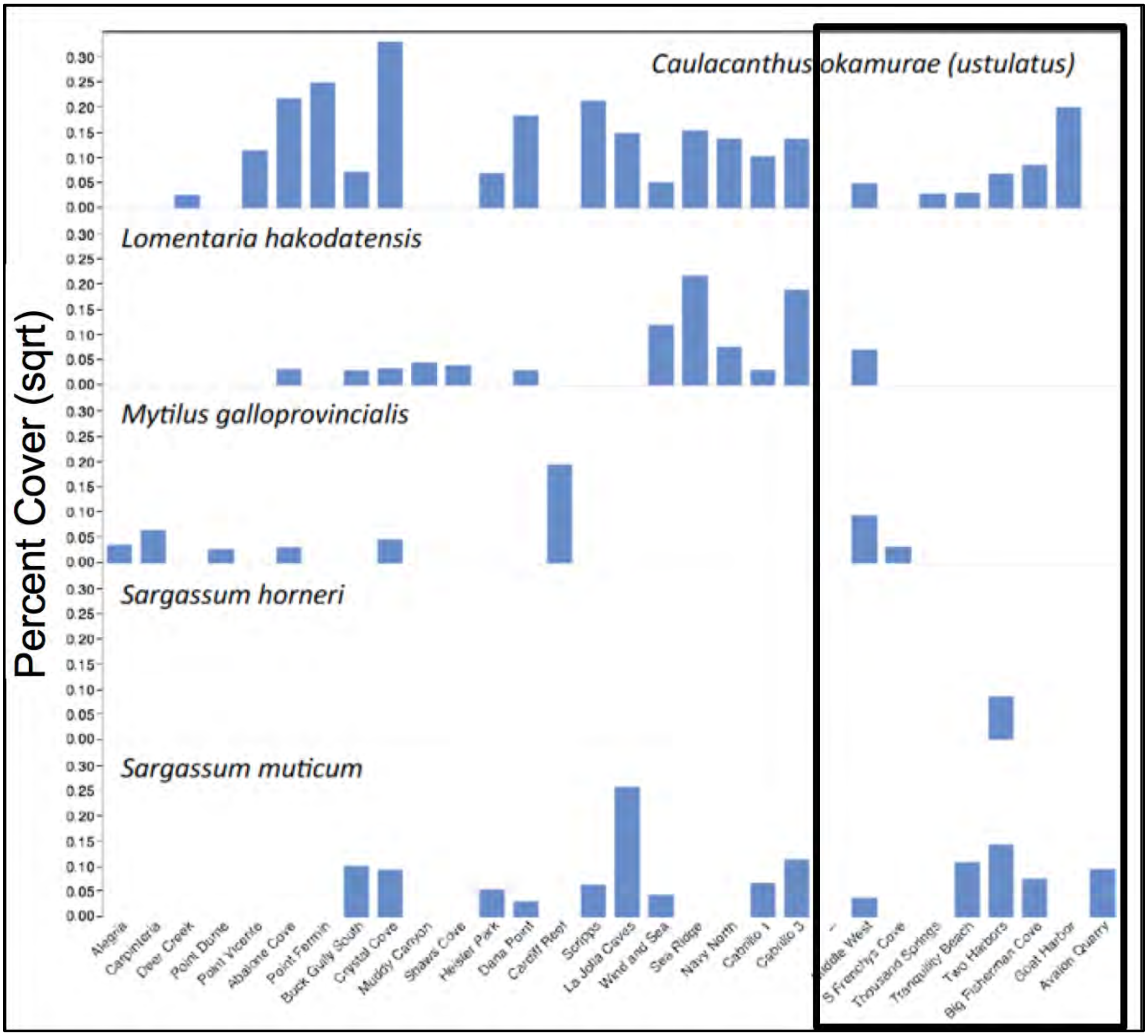


Figure App.F.14.1. Percent cover of non-indigenous taxa in PISCO biodiversity surveys at rocky intertidal sites in southern California; the eight sites in Channel Islands National Marine Sanctuary are highlighted by the black box. PISCO found the turfy red alga *Caulacanthus okamurae* (formerly C. *ustulatus*) at six sites, *Lomentaria hakodatensis* at one site, the mussel *Mytilus galloprovincialis* at two sites, the brown algae *Sargassum horneri* at 1 site, and *Sargassum muticum* at five sites. Additionally, the report noted that *Annalipus japonicus*, a brown alga, was found at Crook Point (San Miguel Island) south of its published southern range limit of Point Conception. Shallow subtidal *Sargassum muticum* was densely abundant in many areas in 1970s and 1980s, but has become relatively less common and more interspersed with native species in recent years (J. Engle, pers. comm.). Figure: Blanchette et al. 2015.

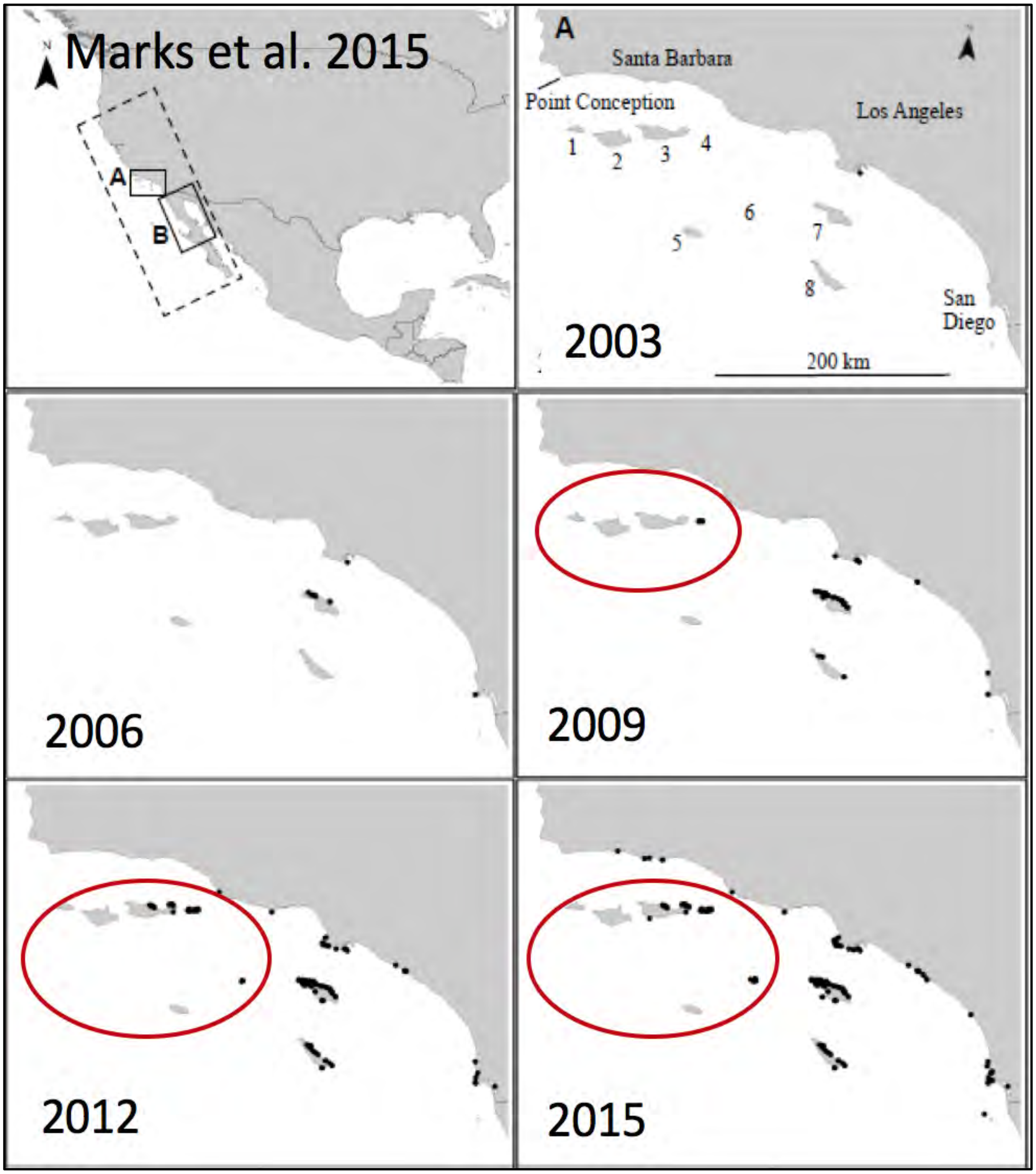


Figure App.F.14.2. First seen in Long Beach Harbor in 2003, *Sargassum horneri* had spread to many mainland and island sites in southern California by 2015. First observed in Channel Islands National Marine Sanctuary at Anacapa in 2009, it had expanded to both Santa Barbara and Santa Cruz islands by 2015. Red ovals highlight observations that are inside Channel Islands National Marine Sanctuary. Figure: Modified from Marks et al. 2015

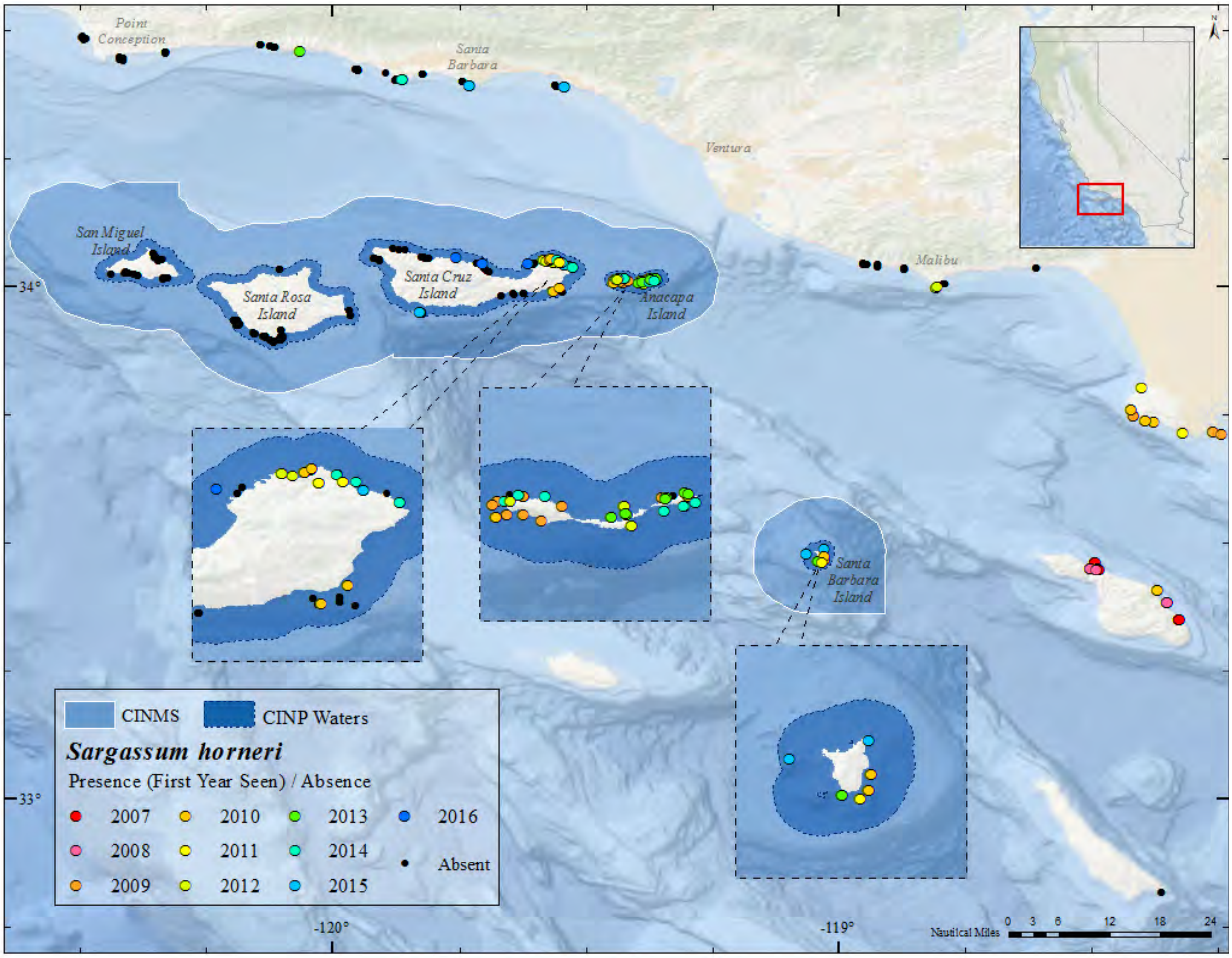


Figure App.F.14.3. Locations where the invasive kelp *Sargassum horneri* has been observed in the Southern California Bight. The color of circles denote the year *Sargassum* was first seen while black circles indicate sites where it has not been observed. Note: This is a more detailed variant of a map that was shown during the expert workshop. Data source: CINP, PISCO, and SBC LTER data courtesy of L. Marks/ UCSB; Map: M. Cajandig/NOAA

Note: This is variant of a similar figure shown during the expert workshop.

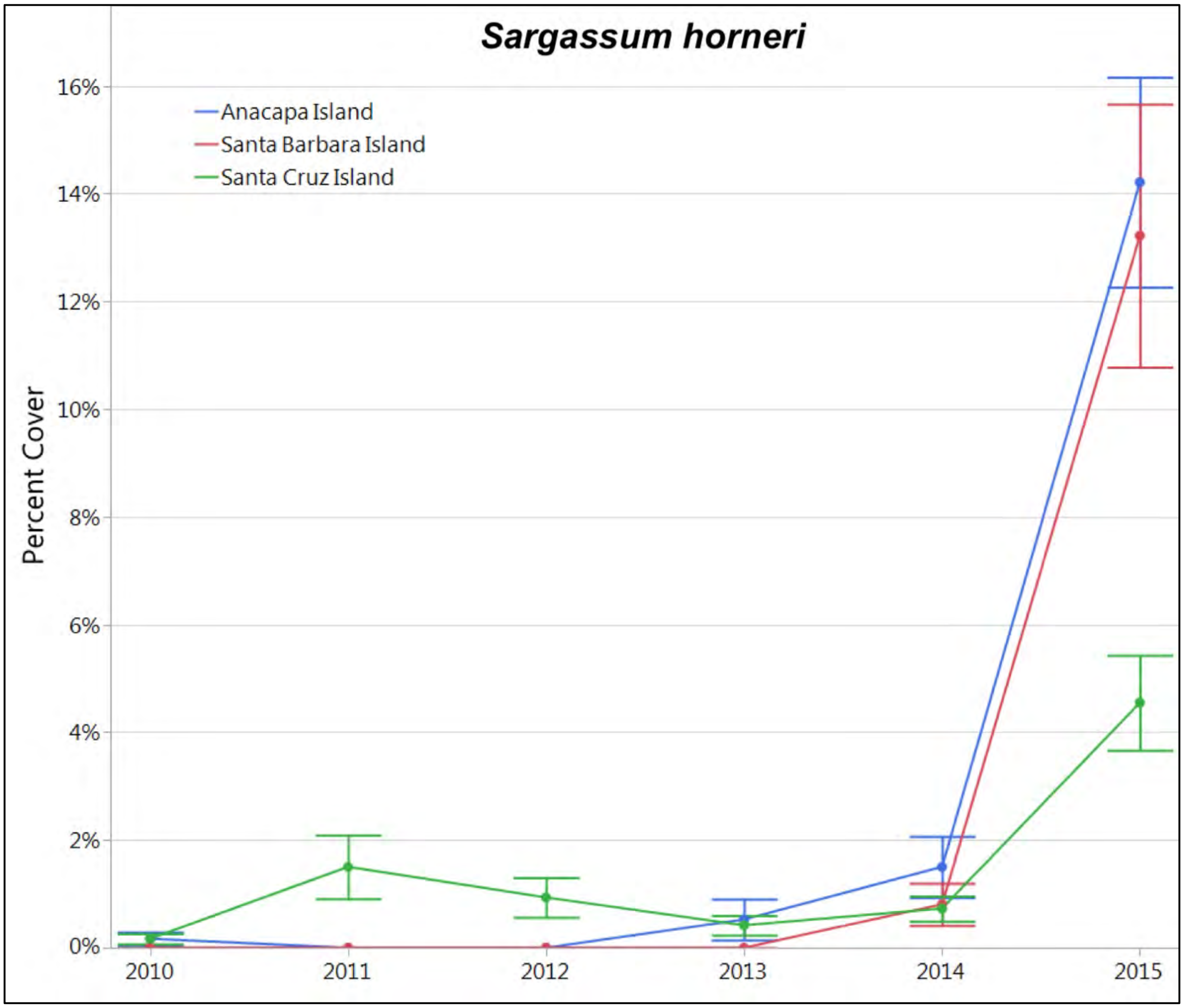


Figure App.F.14.4. Mean (+/- SE) percent cover of *Sargassum horneri* at sites monitored by Channel Islands National Park at Santa Cruz (green), Anacapa (blue), and Santa Barbara (red) islands. Cover has recently increased at all three islands. Figure: Channel Islands National Park.
Note: This figure was not available to be shown at the expert workshop.

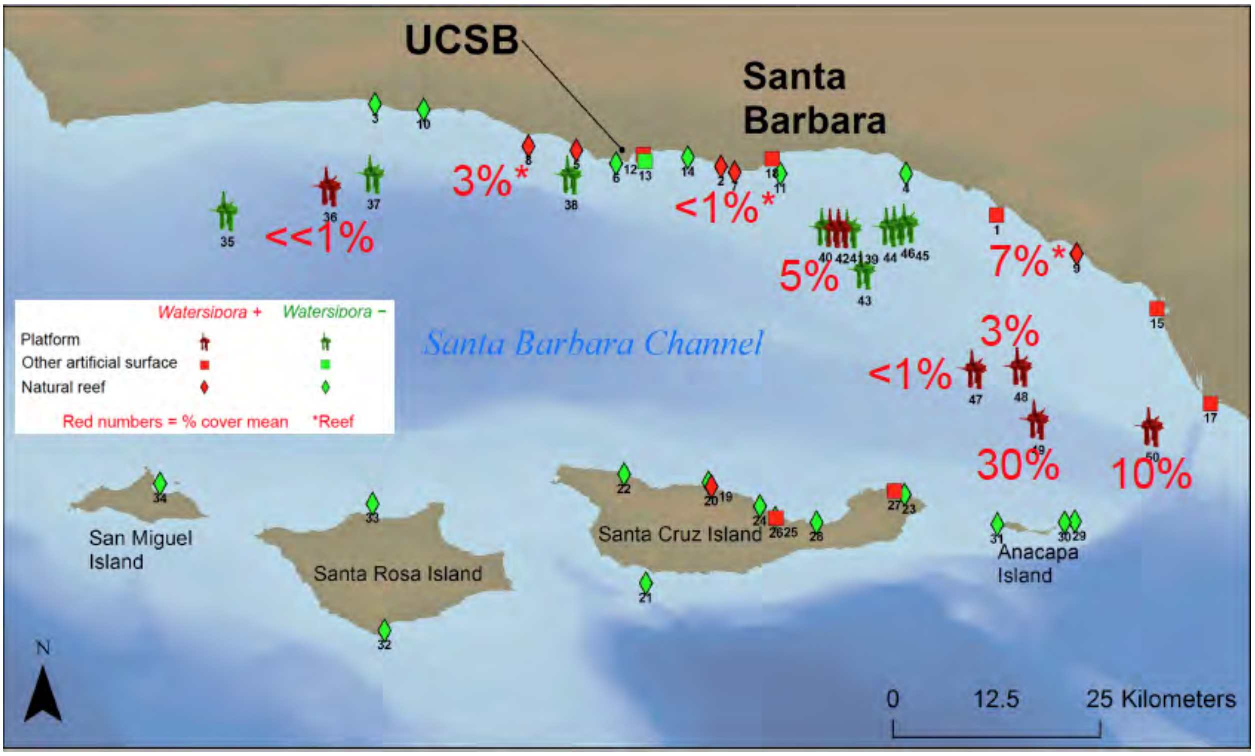


Figure App.F.14.5. Presence (red) and absence (green) of *Watersipora* spp. on recently surveyed oil platforms, other artificial surfaces, and natural reefs in the Santa Barbara Channel. This non-indigenous bryozoan was found to occur on only two of 15 natural reefs surveyed in the northern Channel Islands. Figure: Page et al. 2016

15. What is the status of biodiversity and how is it changing?

Table App.F.15.1. Data presented to the living resources experts at the workshop on June 1, 2016 to update status and trends assessments for Channel Islands National Marine Sanctuary (CINMS).
**Denotes graphs that were received after the expert workshops and were not available for experts to view during the status and trend workshop; however, a representative from the monitoring program discussed this data set during the meeting.

Indicator	Source	Figure #	Data Summary
Rocky Intertidal Habitat *(*Long-term monitoring data for indicators in this habitat were not available.)			
Beach Habitat (Long-term monitoring data for indicators in this habitat were not available.)			
Kelp Forest and Reef Habitat (< 30 meters)			
Kelp forest fish, mobile invertebrates	SBC MBON	App.F.15.1 **	*Statue and Trend:* kelp forest fish diversity possibly declining but high variability in the data; mobile invertebrate diversity lower since 2009 than was observed during 2001-2009.
Thermal affiliation of kelp forest fish fauna	CINMS using PISCO and CINP data	App.F.15.2	*Eastern Islands Status and Trend:* Higher ratio of warm:cool species; stable but Santa Cruz Island highly variable. *Western Islands Status and Trend:* Lower ratio of warm:cool species; stable.
Sandy Seafloor Habitat (< 30 meters) (Long-term monitoring data for indicators in this habitat were not available.)			
Deep Seafloor Habitat (> 30 meters)			
Deep fish, mobile invertebrates	SBC MBON	App.F.15.1	*Status and Trend:* Species density and richness and Shannon-Weaver diversity all at long-term mean.
Deep-sea coral diversity	Etnoyer et al. 2015	App.F.15.3	*Status:* Estimates of species richness of deep-sea coral fauna based on ROV studies at eight study sites in the Southern California Bight. The footprint in CINMS has high richness.
Infaunal community composition	SCCWRP	App.F.15.4	*Status and Trend:* Infaunal community composition at ten of 15 sites in CINMS are degraded in 2013 compared to 2008.
Demersal fish richness and diversity	NMFS NWFSC	App.F.15.2	*Trend:* Most diversity measures show declines in the near term, whereas mean trophic level shows consistent near-term increases.
Pelagic Habitat			
Cool vs. warm water ichthyoplankton	CalCOFI; CCIEA	App.F.15.5	*Status and Trend:* Cool-water associated species: stable to increasing abundance. Status and Trend: Warm-water associated species: increasing trend with very high abundance in 2015.
Ichthyoplankton richness and diversity	CalCOFI; CCIEA	App.F.15.6	*Status and Trend:* Average to high species richness with spike in 2014– 2015.
Seabird species richness	Santora and Sydeman 2015; Leising et al. 2015	App.F.15.7 – App.F.15.8	*Status:* Species richness hotspots along coast and around Channel Islands. *Trend:* Seabird species richness has exhibited a long-term decline in the southern CA region and has been negative 2013-2015.

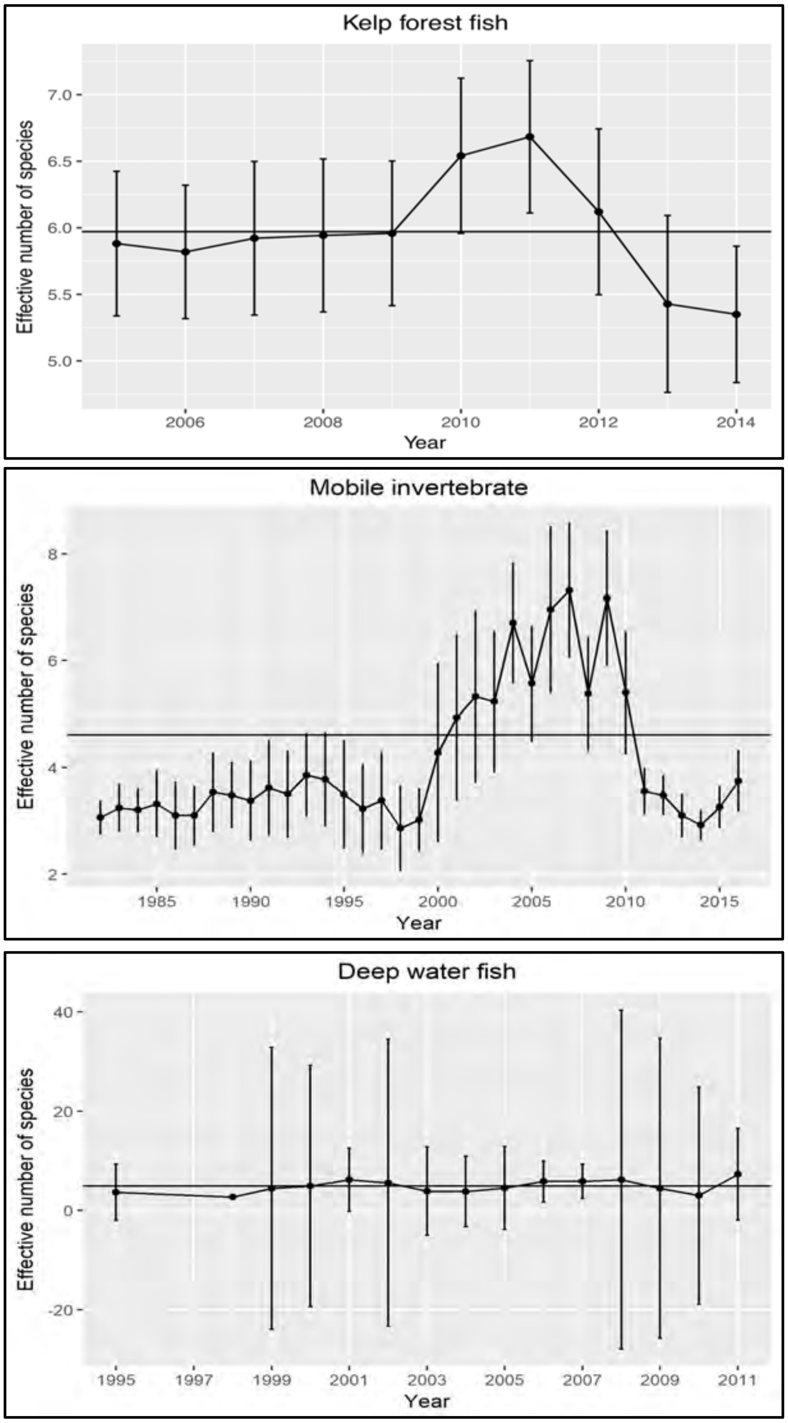


Figure App.F.15.1. Mean annual effective number of species for three taxonomic groups: kelp forest fishes (top), mobile demersal invertebrates (middle), and deeper water fishes (bottom). Shannon-Weiner diversity was converted to effective numbers of species, which allows for a more direct and intuitive comparison of community diversity over time. Kelp forest fish were surveyed across 86 shallow reef sites (3 to 16 meters depth) around the four northern Channel Islands from 2005 to 2014. Mobile invertebrates were surveyed across 63 shallow reef sites (3 to 16 meters depth) around the four northern Channel Islands from 1982 to 2016. Deep-water fish were surveyed at three reefs off the Channel Islands (Piggy Bank, Footprint, and Anacapa passage) at depths ranging from 40 to 407 meters in 1995 and annually between 1998 and 2011. Error bars indicate the 95 percent confidence interval in a given year. The horizontal line is the mean across sites over time. Data source: Amalgamated dataset of SBC LTER, CINP Kelp Forest Monitoring Program, and PISCO; Figure: SBC MBON
Note: This is variant of a similar figure shown during the expert workshop.

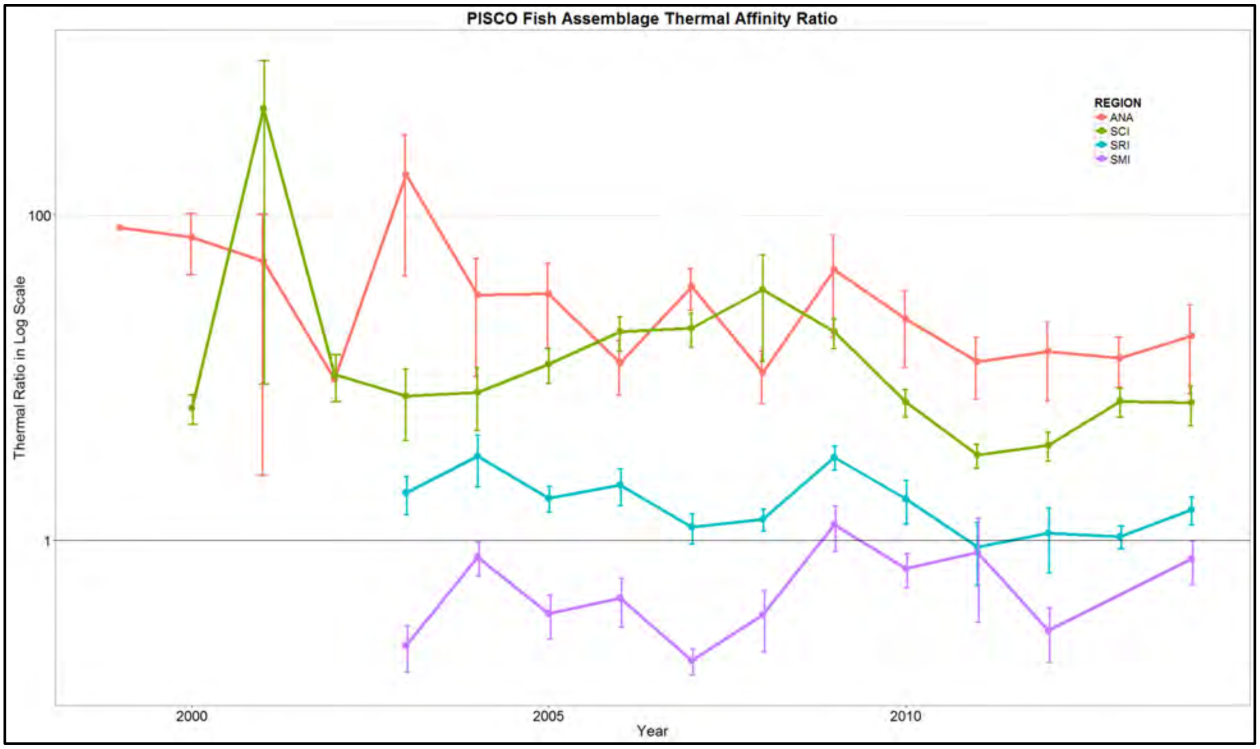


Figure App.F.15.2. The thermal ratio of the kelp forest fish assemblage shows the relative proportion of the fish community that have a southern (cooler) vs. northern (warmer) affiliation. Islands to the east, Anacapa (orange) and Santa Cruz (green), have a higher ratio of warm:cool species than Santa Rosa (blue) and San Miguel (purple), which are to the west. Santa Cruz Island is highly variable possibly because it is in a transition zone in the thermal gradient around the islands, which may make the fish community at this island more susceptible to the influence of climate changes. Note the log scale for the Y-axis.
Data source: PISCO and CINP kelp forest monitoring programs; Figure: R. Freedman/NOAA

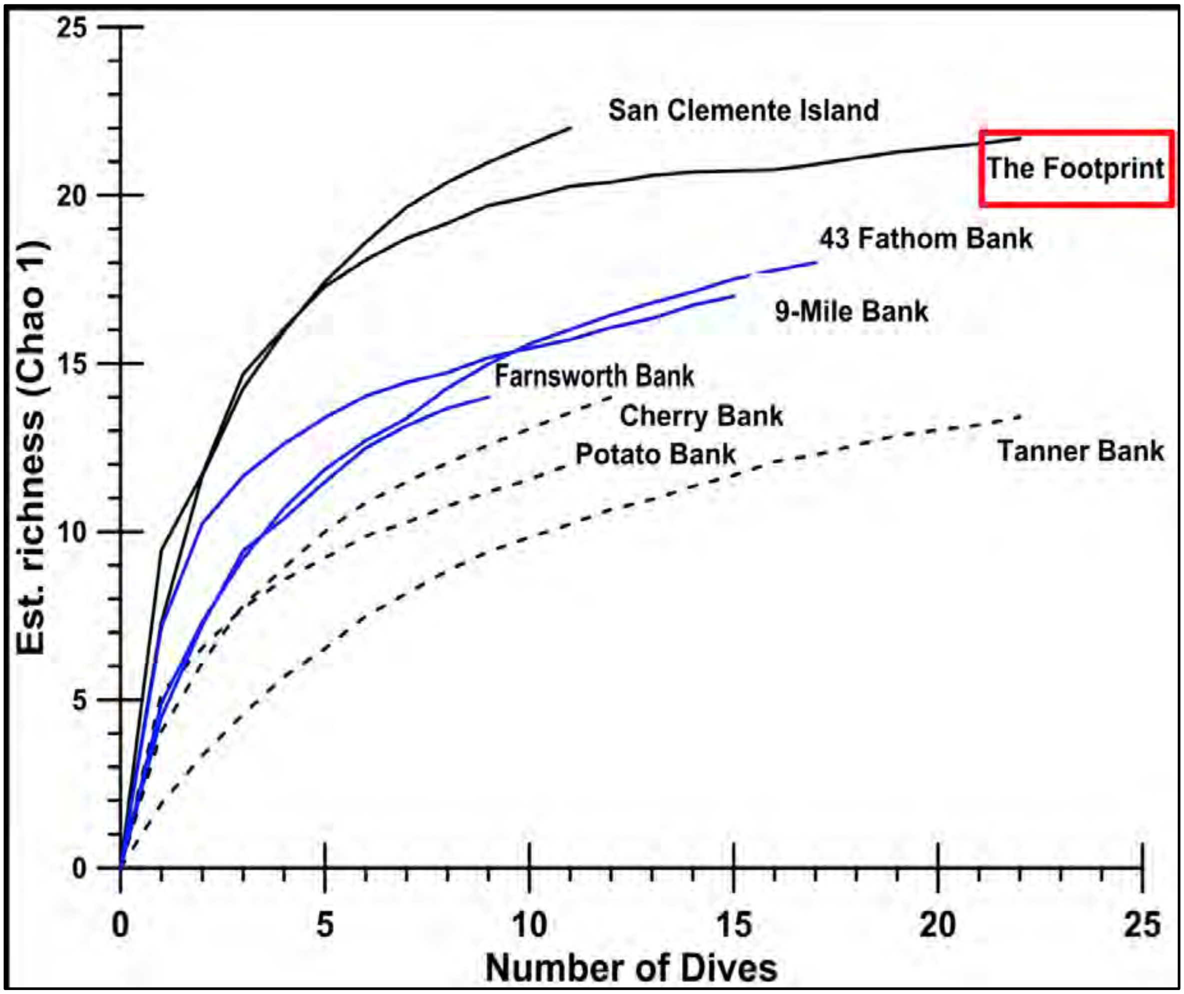


Figure App.F.15.3. Diversity of deep-sea corals at the eight study sites in southern California with the best ROV coverage, or research effort. The footprint (red) in the sanctuary ranks among the highest for biodiversity and abundance of deep-sea corals. Figure: Etnoyer et al. 2015

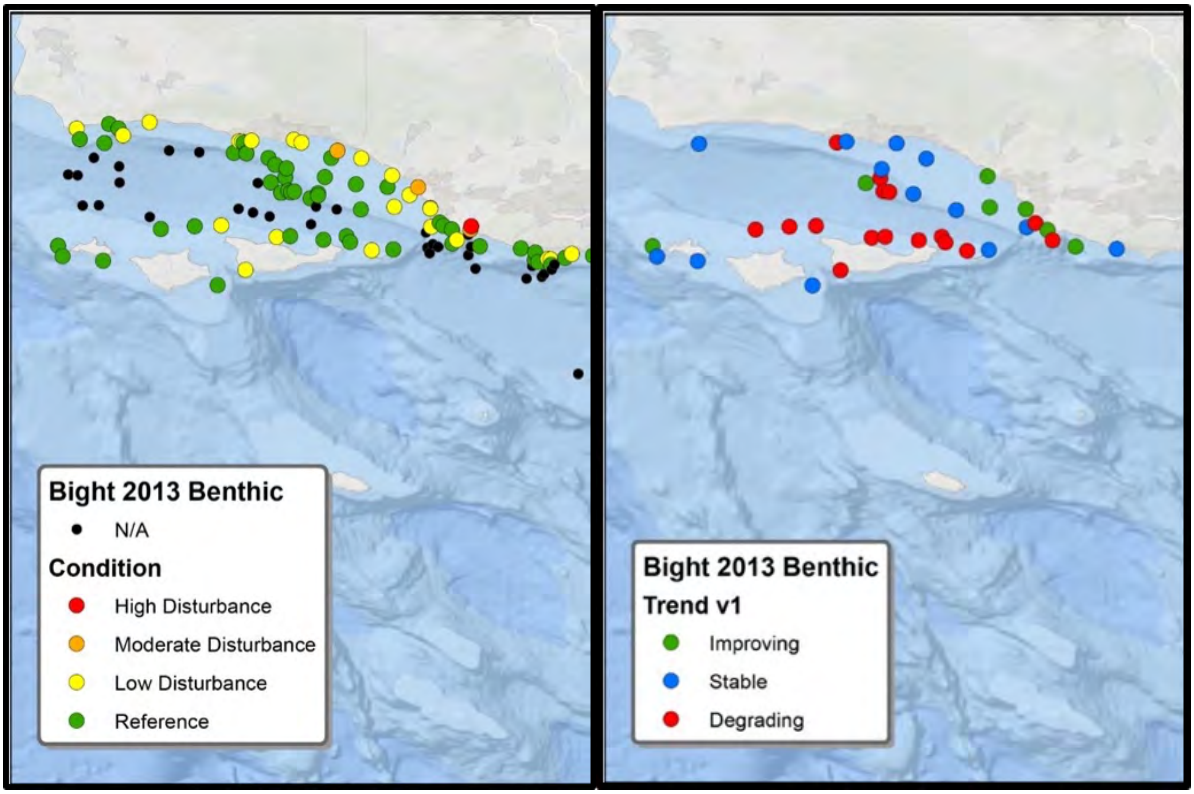


Figure App.F.15.4. (Left) Infaunal invertebrate communities are characterized based on the proportion of a sediment sample with taxa that are sensitive (green, reference) as opposed to tolerant (red, high disturbance) of contaminant levels. (Right) In the most recent samples collected in 2013, ten of the 15 sites in Channel Islands National Marine Sanctuary had an infaunal community composition that was shifting to that which is more tolerant of degraded conditions (red) compared to the samples collected previously. Figure: K. Schiff/SCCWRP

Table App.F.15.2. Short-term trend in annual mean species richness, species density, Simpson diversity, and mean trophic level (MTL) for West Coast demersal fishes collected during the NMFS U.S. West Coast Groundfish Bottom Trawl Survey from 2008 to 2014 at three spatial scales (see map Figure App.F.13.21). Species richness is the count of the number of species present in a net sample. Species density is the number of species per unit area. Simpson diversity takes into account the number of species present, as well as the relative abundance of each species. Mean trophic level is the biomass-weighted average trophic level of all species in a net sample. Short-term trends are consistent across all three spatial scales. Most diversity measures show declines in the near term, whereas MTL shows near-term increases. More Information about how these indicators were calculated are available at https://www.integratedecosystemassessment.noaa.gov/Assets/iea/california/Report/pdf/3.Ecological%20Integrity_2013.pdf. Data source: NMFS NWFSC; Table: NOAA

Biodiversity Metric	Southern California Bight	CINMS Vicinity	CINMS
Species Richness	↘	↘	↘
Species Density	↘	↘	↘
Simpson Diversity	↔	↔	↔
Mean Trophic Level	↗	↗	↗

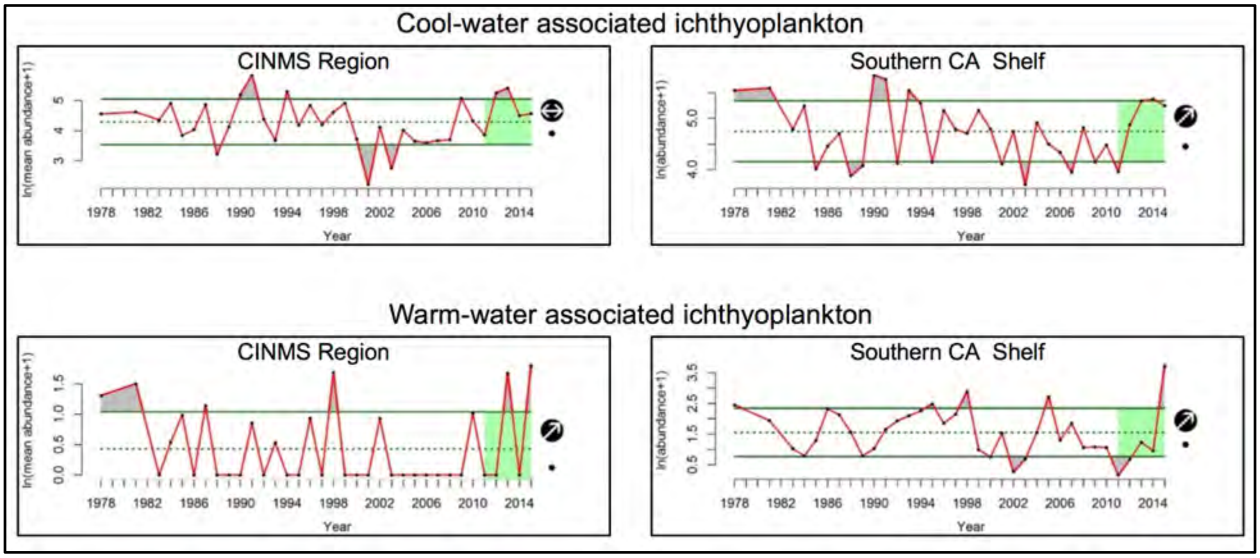


Figure App.F.15.5. Relative abundance of cool-water (top panels) and warm-water (bottom panels) associated ichthyoplankton (fish larvae) groups collected in net samples during spring CalCOFI cruises at sites in the Channel Islands National Marine Sanctuary (CINMS) region (left panels) and over the Southern California Shelf (right panels) from 1978 to 2015. Sampling sites are shown on Figure App.F.12.17. Symbols on the graph are explained in the caption for Figure App.F.12.18. Data source: CalCOFI; Figure: A. Thompson/NOAA

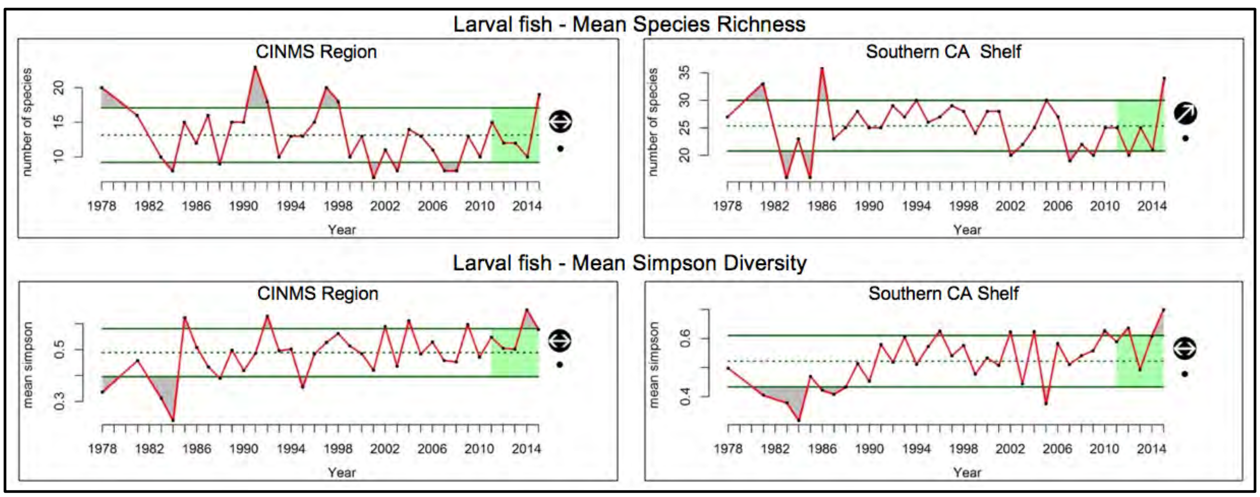


Figure App.F.15.6. Mean species richness (top panels) and mean Gini-Simpson diversity (bottom panels) of fish larvae (ichthyoplankton) collected in net samples during spring CalCOFI cruises at sites in the Channel Islands National Marine Sanctuary (CINMS) region (left panels) and over the Southern California Shelf (right panels) from 1978 to 2015. Species richness is the number of species present in a net sample. Gini-Simpson diversity (1-λ form) takes into account the number of species present, as well as the relative abundance of each species. Species richness tends to increase in El Niño years due to influx of central Pacific species to the shelf. Gini-Simpson diversity is high when individuals are well-distributed among species suggesting that the 2015 spike in richness was not due to rare species. Sampling sites are shown on Figure App.F.12.17. Symbols on the graph are explained in the caption for Figure App.F.12.18. Data source: CalCOFI; Figure: A. Thompson/NOAA

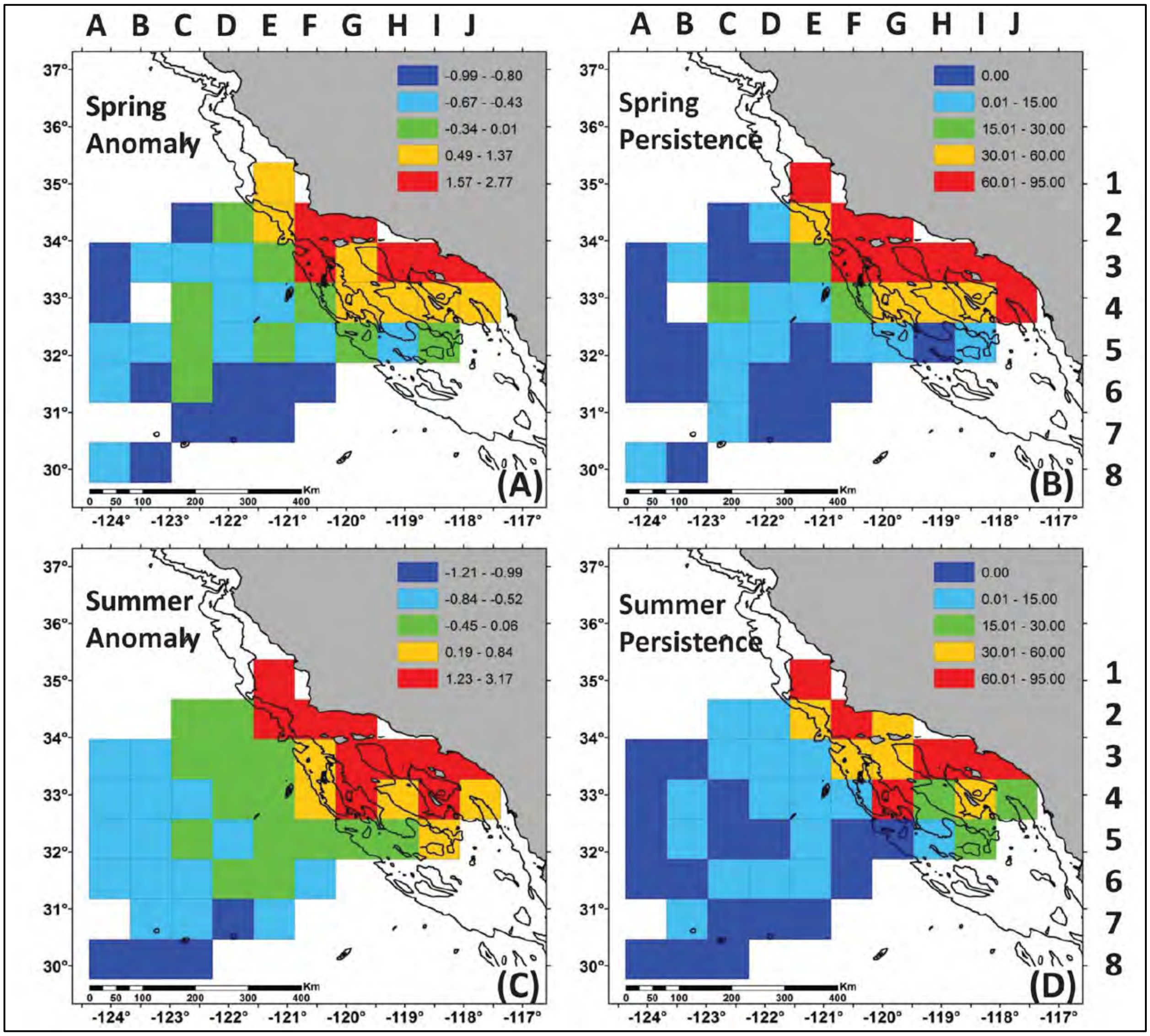


Figure App.F.15.7. Seabird species richness spatial anomalies (A,C) and persistence of hotspots (B,D) based on visual survey for seabirds during spring and summer CalCOFI surveys from 1987 to 2012. A spatial anomaly was computed from the grand spatial mean and standard deviation for each block. Cool colors denote blocks below the mean and warm colors denote blocks above. Higher species richness and hotspot persistence (red, yellow) is observed along the coast and around Channel Islands compared to offshore (blue). Seabird species richness calculations based on 68 species/taxa. Figure: Santora and Sydeman 2015

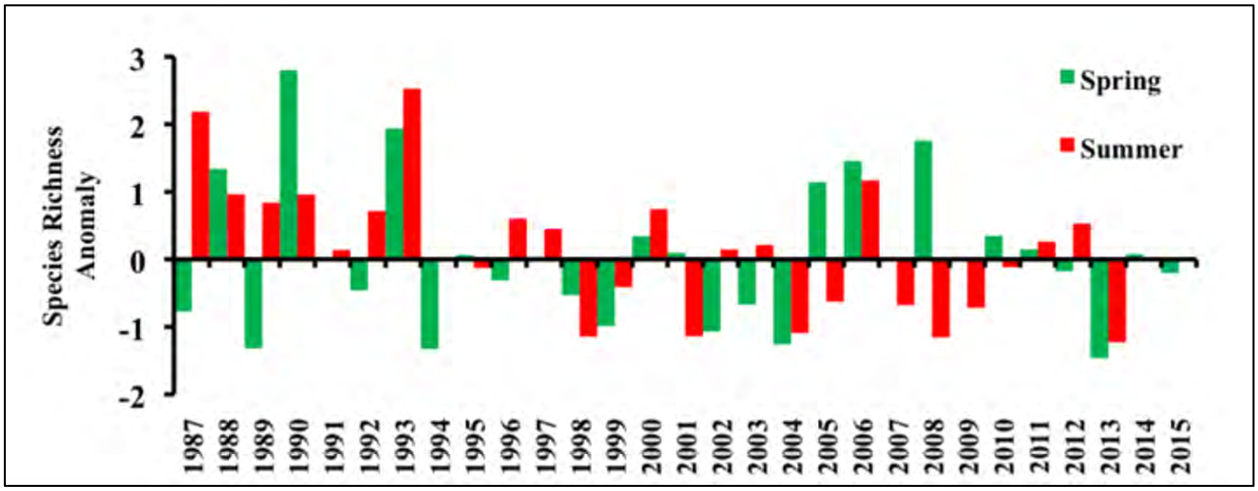


Figure App.F.15.8. Change over time in seabird species richness anomaly (i.e., number of species observed per survey compared to the long-term average) based on visual survey of seabird distribution and abundance during CalCOFI spring and summer surveys since spring 1987. Seabird species richness has exhibited a long-term decline in the CalCOFI region, and has been negative since 2013. The decline in species richness possibly indicates that biophysical changes occurring in the southern California Current is impacting the overall at-sea seabird community. Figure: Leising et al. 2015

APPENDIX G: Developing Indicators of Condition for Channel Islands National Marine Sanctuary[55]

The California Current Integrated Ecosystem Assessment[56] (CCIEA), a cross-NOAA initiative led by the National Marine Fisheries Service's (NMFS) regional science centers (Southwest and Northwest fisheries science centers), provides a process and analytical tools for examining the condition of, and implementing management in, the California Current ecosystem (see Figure DI1, Levin et al. 2009, Samhouri et al. 2014). CCIEA seeks to better understand the web of interactions that drive patterns and trends in ecosystem components and forecast how changing environmental conditions and management strategies affect the status of these components. Sanctuary condition reports are essentially IEAs at the sanctuary scale that serve as a management support tool to assist in the protection and conservation of these special places by assessing current condition, and identifying gaps in current monitoring efforts as well as causal factors that may require monitoring and potential remediation.

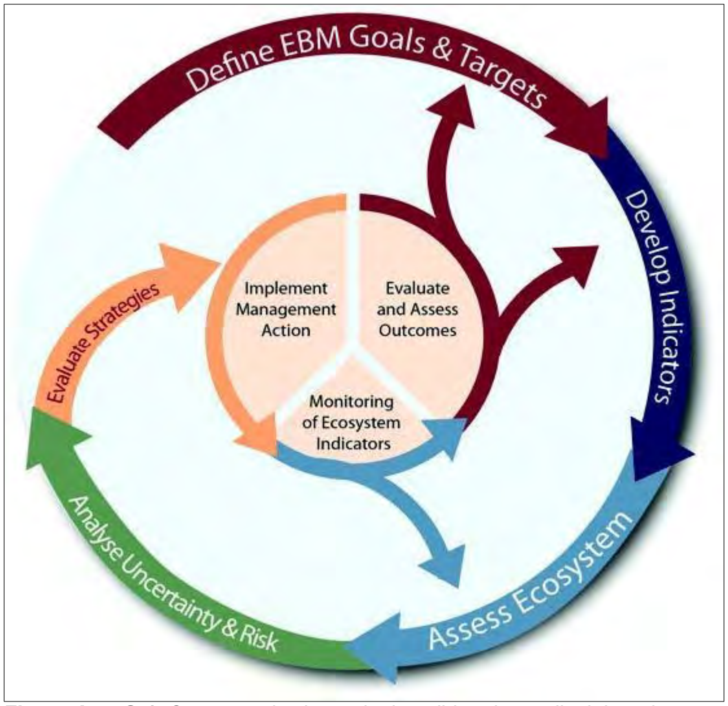


Figure App.G.1. Conceptual schematic describing the cyclical, iterative process of Integrated Ecosystem Assessments developed by the National Oceanic and Atmospheric Administration. The CINMS and CCIEA collaboration has been focused on the indicator development (dark blue) and ecosystem assessment (light blue) steps. Indicators represent key components in an ecosystem and allow change to be measured. They provide the basis to assess the status and trends in the condition of an element within the system. Individual indicators are assessed to determine the underlying cause for the observed ecosystem status and trends. Ecosystem indicator data are then assessed together to evaluate overall ecosystem status and trends relative to ecosystem management goals and targets. Figure: Samhouri et al. 2014

In 2015, CINMS joined an existing collaboration between Monterey Bay National Marine Sanctuary (MBNMS) and CCIEA to apply IEA processes and products to sanctuary resource assessment and management. The main focus of this collaboration has been developing ecosystem indicators and assessing ecosystem status and trends (steps shown in blue in Figure App.G.1).

The CINMS process began by subdividing the sanctuary into six major habitat types as shown in Figure App.G.2. These major habitats were selected because they 1) differ substantially in physical structure and species assemblages; (2) are targets of existing monitoring programs that use different data collection methods; and 3) are complementary to habitat categories delineated by other regional indicator monitoring plans (e.g., COST 2011, see Table App.G.1 below)

[55] This work was led by Greg Williams (NMFS NWFSC) and Jennifer Brown (CINMS).

[56] For more information on the California Current Integrated Ecosystem Assessment, visit https://www.integratedecosystemassessment.noaa.gov//regions/california-current-region/index.html.

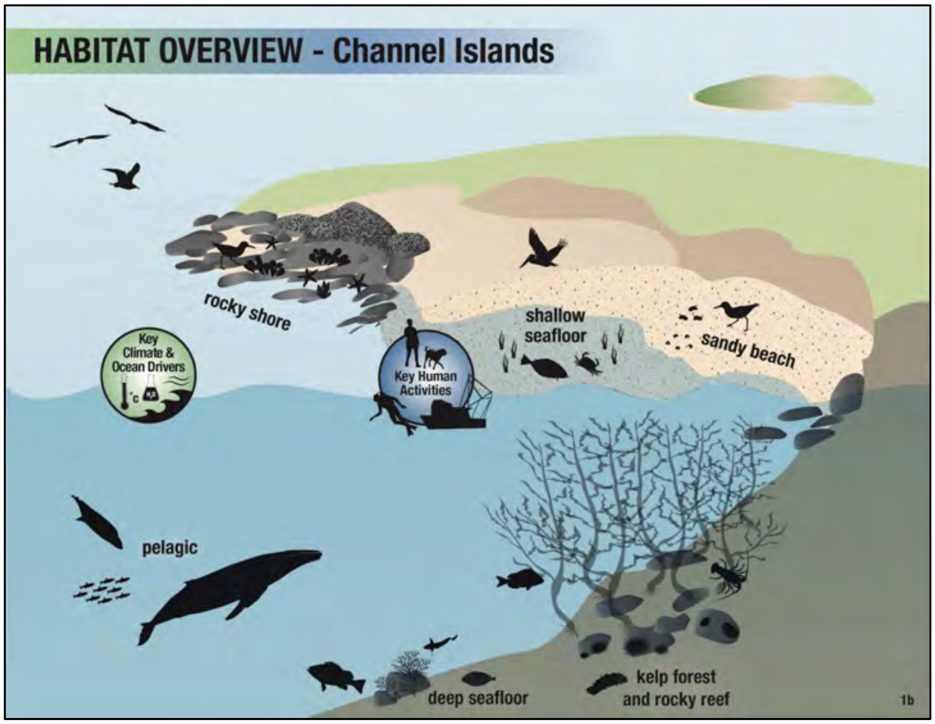


Figure App.G.2. Graphic illustrating the six major habitats within Channel Islands National Marine Sanctuary, and icons representing climate and ocean drivers and human activities. Indicators, which serve as the basis for assessing ecosystem status and trends, were identified for all of these components. Figure: S. Kim/NOAA

Next, ONMS surveyed a variety of sources to build portfolios of potential indicators of ecosystem condition for each major habitat, including focal species, biogenic habitat, oceanographic drivers, and human pressures. Sources included past condition reports for CINMS and MBNMS (ONMS 2009a,b, 2015), the Sanctuary Integrated Monitoring Network (SIMoN) website, and seven West Coast indicator development efforts (Table App.G.1), including the indicators developed by CCIEA to assess the state of the California Current ecosystem (NMFS 2016a).

Table App.G.1. Complementary efforts to develop indicators of ecosystem status, human pressures, and environmental drivers along the U.S. West Coast.

Indicator Development Effort	Report	Acronym	Online Access
Pacific Fishery Management Council Annual State of the California Current Ecosystem Report	NMFS 2016a	PFMC CCE	http://www.pcouncil.org/ecosystem-based-management/annual-state-of-the-california-current-ecosystem
South Coast MPA Monitoring Plan	COST 2011	SCMP	http://oceanspaces.org/sites/default/files/regions/files/sc_mpa_monitoring_plan_full.pdf
Gulf of the Farallones National Marine Sanctuary Ocean Climate Indicators	Duncan et al. 2014	GFNMS OCI	http://farallones.noaa.gov/manage/climate/indicators.html
Washington State Marine Spatial Planning Process — Conceptual Models and Indicator Selection Process	Andrews et al. 2015	WAMSP	http://www.msp.wa.gov/wp-content/uploads/2015/03/NWFSC_EcosystemIndicatorReport.pdf

The State of San Francisco Bay Estuary Report	SFEP 2015	SFBAY	http://www.sfestuary.org/wp-content/uploads/2015/10/SOTER_2.pdf
Puget Sound Partnership Vital Signs	Hamel et al. 2015	PSP	http://www.psp.wa.gov/vitalsigns/
CalCOFI: CalCOFI State of the California Current and State of California Current: Live supplement	Leising et al. 2015	CalCOFI	http://calcofi.org/ccpublications/state-of-the-california-current-live-supplement.html

The next step involved internal evaluation of the portfolios of potential indicators, using a modified version of CCIEA screening criteria and considerations (Kershner et al. 2011, Levin and Schwing 2011), to identify the most promising candidate indicators. This process was driven by an accelerated timeline that did not allow a comprehensive literature evaluation of all 19 criteria considered by Kershner et al. (2011); accordingly, this report focused on indicators that met most, if not all, of the following six criteria:

1. Theoretically sound — scientific, peer reviewed findings demonstrate that an indicator acts as a reliable surrogate for a key ecosystem attribute;
2. Relevant to management goals — indicator provides information related to condition report questions or management concerns;
3. Spatial coverage — data available from Southern California Bight; coverage within CINMS preferred;
4. Historical data or information availability — supported by existing data to facilitate current status evaluation; long-time series preferred to allow comparison with past conditions;
5. Regionally compatible — comparable to those indicators used by partners along the West Coast to contextualize status;
6. Complements existing indicators — a post hoc consideration, based on whether the indicator complements, and is not redundant to, others within the indicator suite.

The indicator portfolios which emerged from the internal screening effort were used to create conceptual models. Conceptual models provided visual representations of the indicator portfolio for each habitat, and provided not only an aesthetically appealing venue for expert review and debate of the indicator portfolio (see screening criterion 6), but also the ability to map specific condition report questions to each habitat (e.g., Figure App.G.3).

The indicator portfolios and accompanying conceptual models then were vetted by two expert groups, the wider CCIEA science team and the CINMS Research Activities Panel (RAP). The CINMS RAP is composed of 25 representatives from regional research institutions and organizations and cover a wide variety of research disciplines (e.g., biological oceanography, deep-sea ecology, fisheries management). Expert input was compiled and incorporated into new versions of the indicator portfolios and conceptual models.[57]

The vetted indicator portfolios for the six major habitats were used by ONMS to identify the key data needed to update the CINMS Condition Report. Available data on current status and recent trend were compiled for as many indicators as possible and organized according to the standardized questions in the

[57] List of reviewers provided in Acknowledgements.

condition report. ONMS presented the compiled data during three condition report workshops in which subject experts discussed current conditions and recent changes in water quality (Questions 2, 6–9), habitat (Questions 3, 10, 11), and living resources (Questions 4, 12–15), and then determined current status and recent ratings for each question. These assessments are summarized in the State section of this report. All the data that were shown during the expert workshops are provided in the three data appendices (Appendix D: Water Quality Graphs, Appendix E: Habitat Graphs, Appendix F: Living Resources Graphs).

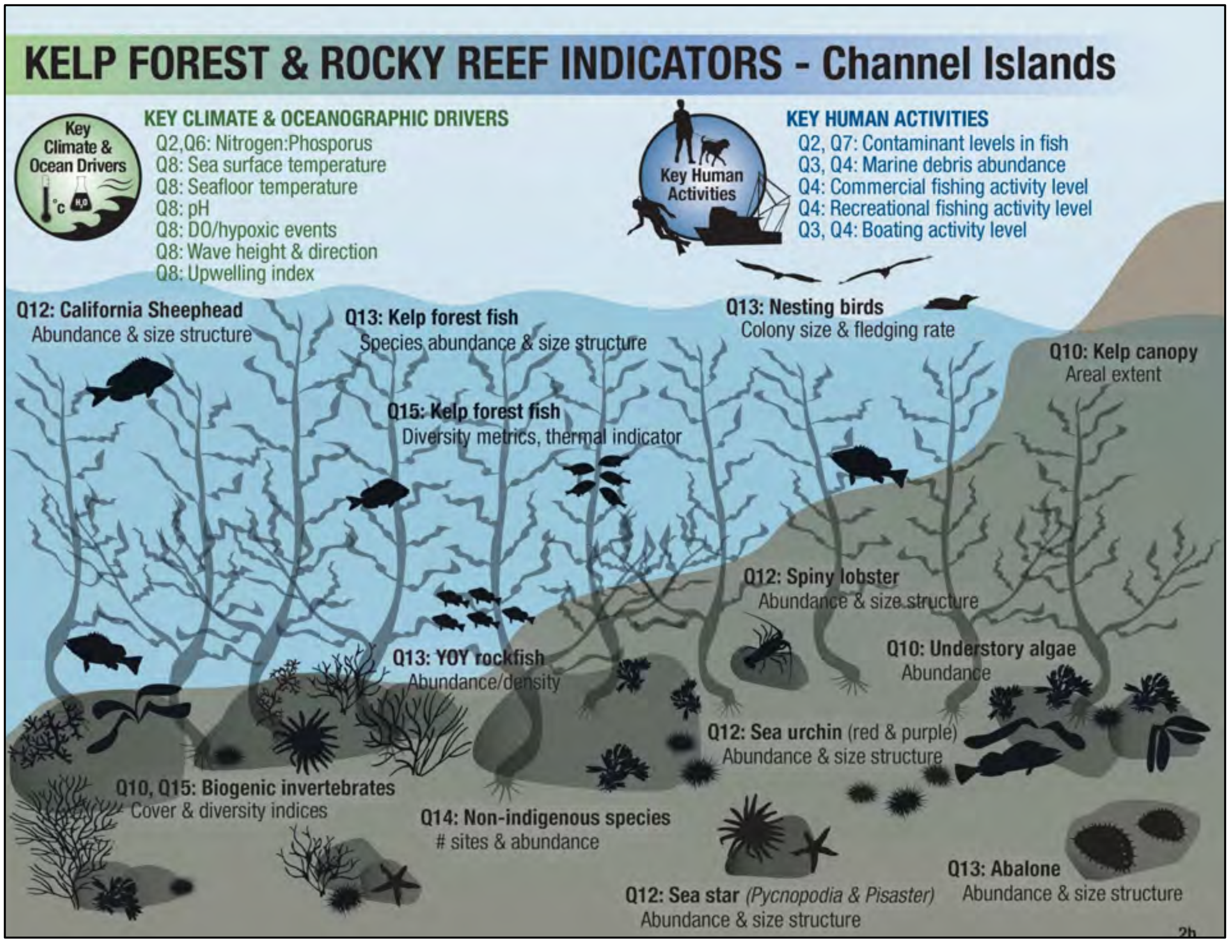


Figure App.G.3. Conceptual model depicting the portfolio of indicators of ecosystem components (black font), climate and ocean drivers (green font), and human pressures (blue font) for the kelp forest and rocky reef habitat in Channel Islands National Marine Sanctuary. Each indicator is aligned with one or more of the standardized questions in Office of National Marine Sanctuaries condition reports (depicted by Q numbers). Indicator portfolios were selected through an internal screening and expert review process. Figure: S. Kim/NOAA

Status and trend information was not available for all portfolio indicators. High quality, long-term monitoring data were available for more indicators in the portfolios for rocky shore, kelp forest and pelagic habitats compared to the portfolios for sandy beach, shallow seafloor, and deep seafloor habitats. This discrepancy appears to be due, in part, to fewer programs focused on research and monitoring of soft bottom communities in the region. This discrepancy may also be due in part to the fact that Channel Islands were selected as a sanctuary due to a strong public appreciation of and concern for the rocky shore, kelp forest, and pelagic resources. Deeper habitats are also more logistically challenging and expensive to study than those accessible from shore. In addition, relatively little long-term monitoring data were available to assess the status and recent trends in human activities that could negatively impact condition of sanctuary resources. These data gaps will serve as targets for future collaborations with regional science partners, as staff time and funding levels allow.

APPENDIX H: Description of Ecosystem Services and Methods to Determine Ratings

The following provides descriptions of the various ecosystem services considered in sanctuary condition reports and the process for rating them. Office of National Marine Sanctuaries (ONMS) defines ecosystem services (ES) in a slightly more restrictive way than some other experts. Specifically, "ecosystem services" are defined herein as the benefits *people* obtain from nature through use, consumption, enjoyment, and/or simply knowing these resources exist. The descriptions below reflect this definition, and therefore, only those ecosystem services are evaluated in sanctuary conditions reports. In contrast, there are some supporting services, such as biodiversity, decomposition, and carbon storage, that are included in the State section of these reports instead. Specifically, these services are critical to ecosystem function and considered "intermediate" ecosystem services that are not directly used, consumed, or enjoyed by humans to meet the ONMS condition report definition of ecosystem services. In other words, these secondary or intermediate services support ecosystems and are not final ecosystem services in and of themselves.

As an example, biodiversity is often considered an ecosystem service, but ONMS recognizes biodiversity as an *attribute* of the ecosystem on which many "final" ecosystem services depend (e.g., recreation and food supply/commercial fishing). For this reason, it is considered a secondary ecosystem service and it is evaluated in the State section of the report.

In addition, ONMS does not consider climate regulation or stabilization in condition reports. The impacts of climate change on water quality and biodiversity, however, are considered separately in the State section of the report. While sanctuaries are not large enough to influence climate stability, they may locally buffer climate-related factors, such as temperature change and ocean acidity; thus, the extent to which they may locally buffer climate-related factors is reflected in resource conditions in the State section.

Below are brief descriptions of the ecosystem services considered within each sanctuary condition report (more complete descriptions are provided below the list).

Cultural (non-material benefits)

1. Heritage — Recognition of historical or heritage legacy
2. Consumptive recreation — Recreational activities that result in the removal of or damage to natural or cultural resources
3. Non-consumptive recreation — Recreational activities that do not result in the removal of or damage to natural or cultural resources
4. Sense of Place — Aesthetic and spiritual attraction, and the level of recognition and appreciation given to efforts to protect a place's iconic elements
5. Science — The capacity to acquire and contribute information and knowledge
6. Education — The capacity to acquire and provide intellectual enrichment

Provisioning (products and supplies)

7. Food — The capacity to support market demands for nutrition-related commodities through various fisheries
8. Water — Providing water for human use by minimizing pollution, including nutrients, sediments, pathogens, chemicals, and trash
9. Ornamentals — Resources collected for decorative or aesthetic purposes
10. Biotechnology — Medicine and other chemicals found in sanctuary animals or plants, or manufactured from them
11. Energy — Use of ecosystem-derived materials or processes for the production of energy

Regulating (buffers to change)

12. Coastal Protection — Flow regulation that protects habitats, property, coastlines and other features

Sanctuaries vary with regard to the ecosystem services they support, so each sanctuary is likely to have a different mix of services and information to support its assessment. To rate the status and trends for each relevant ecosystem service, experts consider the following:

- the ecosystem services relevant to the sanctuary
- the best available indicators for each ecosystem service (economic, non-economic human dimensions, and ecological)
- the status and direction of change of each ecosystem service
- whether economic and non-economic human dimensions indicators yield the same conclusions about the status and trend for each ecosystem service
- whether economic indicators send a false signal about the status and trend of an ecosystem service (namely, conflicting ecological and economic indicators, suggesting that people are sacrificing natural capital for short-term economic gain)

The steps used to rate ecosystem services were adapted from the multi-year study "Marine and Estuarine Goal Setting for South Florida" (MARES) of three South Florida marine ecosystems, including Florida Keys National Marine Sanctuary. It used Integrated Conceptual Ecosystem Models (ICEMs) for each ecosystem under the Driving forces (Drivers)-Pressure-State-Ecosystem Services-Response (DPSER) Model (Nuttle and Fletcher 2013), and evaluation of three types of indicators: (1) economic; (2) human dimension non-economic (Lovelace et al. 2013); and (3) ecological for each ecosystem service.

Rating is a two-step process with data from economic indicators being used to develop preliminary ratings prior to an expert workshop. Discussions during each workshop consider and integrate non-economic and resource indicators, allowing subject experts to characterize an ecosystem service within the five-tier rating system below. The final rating ("Good," "Fair," etc.) corresponds to the criteria in the table above. The Description of Findings from that table is used to convey the rating in the condition report.

Rating Scheme for Ecosystem Services

Rating	Description of Findings	Indicators
Good	The capacity to provide the ecosystem service has been either enhanced or remained unaffected.	Economic indicators are positive and increasing, human dimension non-economic indicators are increasing or stable, and resource indicators do not indicate there is a decline in the natural capital stock.
Good/Fair	Unable to fully provide the ecosystem service due to prior or existing human activity, but performance is acceptable.	Economic indicators are positive and stable, human dimension non-economic indicators are increasing or stable, and resource indicators do not indicate there is a decline in the natural capital stock.
Fair	Ability to provide ecosystem service is compromised, and existing management would require enhancement to enable acceptable performance.	Mixed results for the economic and non-economic indicators and some resource indicators indicate a decline in the natural capital stock but not widespread.
Fair/Poor	Ability to provide ecosystem service is compromised, and it is uncertain whether new or enhanced management would restore it.	Economic indicators are negative and declining, while non-economic indicators are negative or stable. Resource indicators are showing more widespread declines in natural capital stock.
Poor	Unable to deliver ecosystem service due to the extreme, pervasive, or widespread nature of human activities, and it is doubtful that new or enhanced management would restore it.	Economic and non-economic indicators are negative and declining. Resource indicators are negative showing widespread declines in the natural capital stock.

The discussion of ecosystem services ratings within the written report should focus on the influence of drivers and societal values considered responsible for the ratings. This discussion may also consideration of whether economic and non-economic indicators yield the same conclusions; this will enable consideration of the sometimes conflicting relationship between economic gain and the preservation of natural capital. For example, economic indicators (e.g., dive operator income) may suggest improving recreational services while resource indicators (e.g., anchor damage) suggest that natural resource qualities are being sacrificed for short-term gain, making the activity unsustainable.

Descriptions of Ecosystem Services

Cultural (non-material benefits)

Sense of place — Aesthetic and spiritual attraction, and the level of recognition and appreciation given to efforts to protect a place's iconic elements

Marine environments serve as places of aesthetic and spiritual attraction for many people, and inspire works of art, music, architecture, and tradition. Many people also value particular places as sources of therapeutic rejuvenation and to offer a change of perspective. Iconic places serve as motifs in books, film, artworks, and folklore and as part of national symbols, architecture, and advertising efforts. Many people even consider places as defining parts of their personality, especially if they have lived there during or since childhood; they associate them with fond memories and past experiences. Many people even incorporate water or water-related activities as habitual or significant parts of their lives and cultures. Different factors are considered to measure/assess sense of place, including level of uniqueness, recognition, reputation, reliance, and appreciation for a place. By accounting for sense of place, managers can evaluate or find reasons to support conservation, preservation, and restoration efforts.

Despite its value as a cultural ecosystem service indicator, it is difficult to quantify a sense of place with direct measures. Polls are often used to evaluate public opinions regarding economic and non-economic values of a place. One type considers “passive economic use values” (also called “non-use value”). Using estimates generated from survey analyses, this is the value people would be willing to pay for resources to stay in a certain condition even though they may never actually use them.

Non-consumptive recreation — Recreational activities that do not result in removal of or damage to natural or cultural resources

Recreational activities, including ecotourism and outdoor sports, are often considered a non-consumptive ecosystem service that provides experiential opportunities. Non-consumptive recreational activities include those on shore or from private boats and for-hire operations, such as relaxing, exploring, diving and snorkeling, kayaking, birdwatching, surfing, sailing, and wildlife viewing.

It should be noted that private boating often includes both non-consumptive and consumptive recreational activities (e.g., snorkeling and fishing during a single trip). Thus, field and survey data can be ambiguous, reflecting the heterogeneous preferences of boaters. This also has implications for interpretations of data regarding attitudes and perceptions of management strategies and regulations to protect and restore natural and cultural resources.

Indicators used to assess status and trends in market values for recreation can include direct measures of use (e.g., person-days of use by type of activity) that result in spending, income, jobs, gross regional product, and tax revenues. They can also be non-market economic values (the difference between what people pay to use a good/service and what they would be willing to pay). The data can be used to estimate the value a consumer receives when using a good or service over and above what they pay to obtain the good or service. Indirect measures are also used. For example, populations and per capita incomes at numerous scales influence demand for recreational products and services. Fuel prices can even serve as indirect measures of recreational demand because the levels of use by some recreational users tracks fuel prices.

Consumptive recreation — Recreational activities that result in the removal of or damage to natural or cultural resources

Sometimes culturally valued pursuits, rituals, or traditions involve activities that result in the death or disturbance of wildlife, or the destruction of natural habitats, whether intentional or not. Perhaps the most popular activity that involves consumptive recreation is sport fishing from private boats and for-hire operations. Targeted species and bycatch are removed from the environment, and those that are released (e.g. “catch-and-release” fishing) sometimes die due to stress or predation. Nonetheless, fishing is a highly valued cultural tradition for many people, as well as a popular recreational activity; therefore, for these reasons, sport fishing is considered here as a cultural ecosystem service. Other activities than can affect habitats or wildlife including beachcombing (shell collecting) and tidepooling (trampling), are also considered to be a cultural ecosystem service.

Indicators of status and trends for consumptive recreation often include levels of use (direct counts or estimates made from commercial vessel records and catch levels, and fishing license registrations) and production of economic value through job creation, income, spending, and tax revenue. Public polls can also be used to assess non-market indicators, such as importance and satisfaction, social values, willingness to pay, and facility and service availability.

Science — The capacity to acquire and contribute information and knowledge

Sanctuaries serve as natural laboratories that can advance science and education. NOAA provides vessel support, facilities, and information that is valuable to the research community, including academic, corporate, non-governmental and government agency scientists, citizen scientists and educators that instruct using research. Sanctuaries serve as long-term monitoring sites, provide minimally disturbed focal areas for many studies, and provide opportunities to restore or maintain natural systems.

Status and trends for science can be assessed by counting and characterizing the number of research permits and tracking the accomplishments and growth of partnerships, activity levels of citizen monitoring, and participation of the research community in sanctuary management. The number and types of research cruises and other expeditions conducted can also provide useful indicators. Indirect indicators, such as per capita income and gross regional or national product, may be helpful as higher incomes and better economic conditions often result in higher investments in research and monitoring.

Education — The capacity to acquire and provide intellectual enrichment

As with science, national marine sanctuaries' protected natural systems and cultural resources of attract educators at many levels for both formal and informal education. Students and teachers often either visit sanctuaries or use curricula and information provided by sanctuary educators.

The status and trends for education can be tracked by evaluating the number of educators and students visiting the sanctuary and visitor centers, the number of teacher trainings, use of sanctuary-related curricula in the classroom, and levels of activity in volunteer docent programs. The number of outreach offerings provided during sanctuary research and education expeditions can also be a good indicator. Education can also follow trends in populations and per capita income locally, regionally, and nationally. Populations create demand for services, and higher incomes lead to investment, making these useful indirect indicators.

Heritage — Recognition of historical or heritage legacy

The iconic nature of many national marine sanctuaries or particular places within them generally means that they have long been recognized, used, and valued. Communities developed around them, traveled through them, and depended on their resources. This shared past created the unique cultural character of many present-day coastal communities, and can be an important part of the current economy. The remnants of the past, including artifacts, records, and stories, provide not only a tangible link to the maritime heritage of these areas, but a way to better understand their history.

Economic indicators that reflect status and trends for heritage value as an ecosystem service may include spending, income, jobs, and other revenues generated from visitation, whether it is to dive on wreck sites or patronize museums and visitor centers where artifacts are displayed and interpreted. Non-market indicators, such as willingness to pay, activity levels for training and docent interpretation, and changes in threat levels (looting and damage caused by fishing), may also be considered.

Provisioning (products and supplies)

Among the valued products provided to people by marine and freshwater ecosystems are: wild and cultured seafood, a source of freshwater, keepsakes, energy and biochemical, medical, and genetic resources.

Food — The capacity to support market demands for nutrition-related commodities through various fisheries

Humans consume a large variety and abundance of products originating from the oceans and Great Lakes, whether for nutrition or for use in other sectors. This includes fish, shellfish, other invertebrates, roe, and algae. More than a billion people worldwide depend on fishing for their main source of animal protein and it accounts for 16 percent of world animal protein consumption. Ten to twelve percent of people around the world depend of fishing for their livelihoods.

Fisheries located in national marine sanctuaries are usually encompassed by larger regional fisheries that are regulated by fisheries management plans. Fisheries management plans may include sanctuary-specific restrictions to protect sanctuary habitats, living resources, and archaeological resources. Different data can be used to assess status and trends for this ecosystem service including: catch levels by species and species groups; and economic contributions in the form of sector-related jobs, income, sales, and tax revenue. Indirect measures include data on licensing, fleet size, fishing vessel types and sizes, days at sea, and commodity prices.

Water — Providing water for human use by minimizing pollution, including nutrients, sediments, pathogens, chemicals, and trash

Clean water is considered a final ecosystem service when the natural environment is improving water quality for human consumption or other direct use (e.g., irrigation). Although sanctuary ecosystems often function to improve water quality, most do not result in the final ecosystem service of clean water for human use. For most natural resources, improving water quality in a sanctuary is a supporting or intermediate ecosystem service that may, for example, result in better water quality for fish species that are then enjoyed by commercial or recreational anglers, safer water in which to swim, or improved water clarity for diving. These are aspects of other final ecosystem services and the water quality itself is an indicator that is inherently important to them; however, ONMS does not include this aspect of clean water in condition reports because it would result in a double counting of its ecosystem service value. Instead, ONMS evaluates clean water as a final ecosystem service, where the natural environment is improving water for human consumption, such as drinking water, or for irrigation (e.g., through filtration or suitability for desalination). In this way, the benefits of management policies and actions that improve water quality are captured separately, but in relation to the relevant final ecosystem services they support.

Ornamentals — Resources collected for decorative or aesthetic purposes

In marine sanctuaries where the collection of ornamental products is not prohibited or is allowed under permit, they are taken for their aesthetic or material value for souvenirs, fashion, handicrafts, jewelry, display, and worship. This includes live animals for aquaria and trade, pearls, shells, corals, sea stars, furs, feathers, ivory, and more. Some, particularly animals for the aquarium trade, are sold commercially and can be valued like other commodities; others cannot. Status and trends can also be evaluated using indicators, such as the number of permitted collectors, and frequency of operations and collection levels.

Biotechnology — Medicine and other chemicals found in sanctuary animals or plants, or manufactured from them

Biochemical and genetic resources, medicines, chemical models, and test organisms are all potential products that can be derived or sourced from national marine sanctuaries. Biochemical resources are compounds extracted from marine animals and plants and used to develop or manufacture medicines, pharmaceuticals, cosmetics, and other products (e.g., omega-3 fatty acids from fish oil). Genetic resources are the genetic content of marine organisms used for animal and plant breeding and for biotechnology. Natural resources can also used as a model for new products (e.g., the development of fiber optic technology, based on the properties of sponge spicules).

In marine sanctuaries, activities involving the collection of biochemical products may be allowed under permit. The value of many products associated with biotechnology may be available. Sanctuary permit databases can be used to gauge demand and collection activity within a given national marine sanctuary.

Energy — Use of ecosystem-derived materials or processes for the production of energy

In the offshore environment, energy production sources are considered to be either non-renewable (oil and gas) or renewable (wind, solar, tidal, wave, or thermal). While oil and gas technically are ecosystem-sourced and may be renewable over a time frame measured in millions of years, as an ecosystem service, they are not subject to management decisions in human time frames; therefore, they are not considered an ecosystem service in this section. The activities and management actions related to hydrocarbon production are, however, considered elsewhere in condition reports, primarily with regard to resource threats, impacts, and protection measures.

In contrast, “renewable” forms of energy that depend on ecosystem materials and processes operating over shorter time periods are evaluated. Indicators of status and trends for these energy sources include the types and number of permitted or licensed experimental or permanent operations, energy production, revenues generated, and jobs created. Indirect indicators that inform trends and provide some predictive value include social and market trends, energy costs, and expected demand based on service market populations trends.

Regulating (buffers to change)

Coastal protection — Natural features that control water movement and/or wind energy, thus protecting habitat, property, and coastlines.

Coastal and estuarine ecosystems can buffer the potentially destructive energy of environmental disturbances, such as floods, tidal surges and storm waves, and wind. Wetlands, kelp forests, mangroves, seagrass beds, and reefs of various types all absorb some of the energy of local disturbances, protecting themselves, submerged habitats closer to shore, intertidal ecosystems, and emergent land masses. They also can trap sediments and promote future protection through shoaling. They can also become sources of sediments for coastal dunes and beaches that control flooding and protect coastal properties from wave energy and the impacts of sea level rise.

The value of coastal protection can be estimated by evaluating the basis of the value of vulnerable coastal properties and infrastructure and modeled estimates of losses expected under different qualities of coastal ecosystems (replacement cost). Levels of historical change under different energy scenarios can be used to support these estimates. Public polls can also reveal information on willingness to pay that is used to value this service.

APPENDIX I: Ecosystem Services Tables and Graphs

Figure App.I.1. How much protection should be given to the environment?
Source: Gallup News, 2018

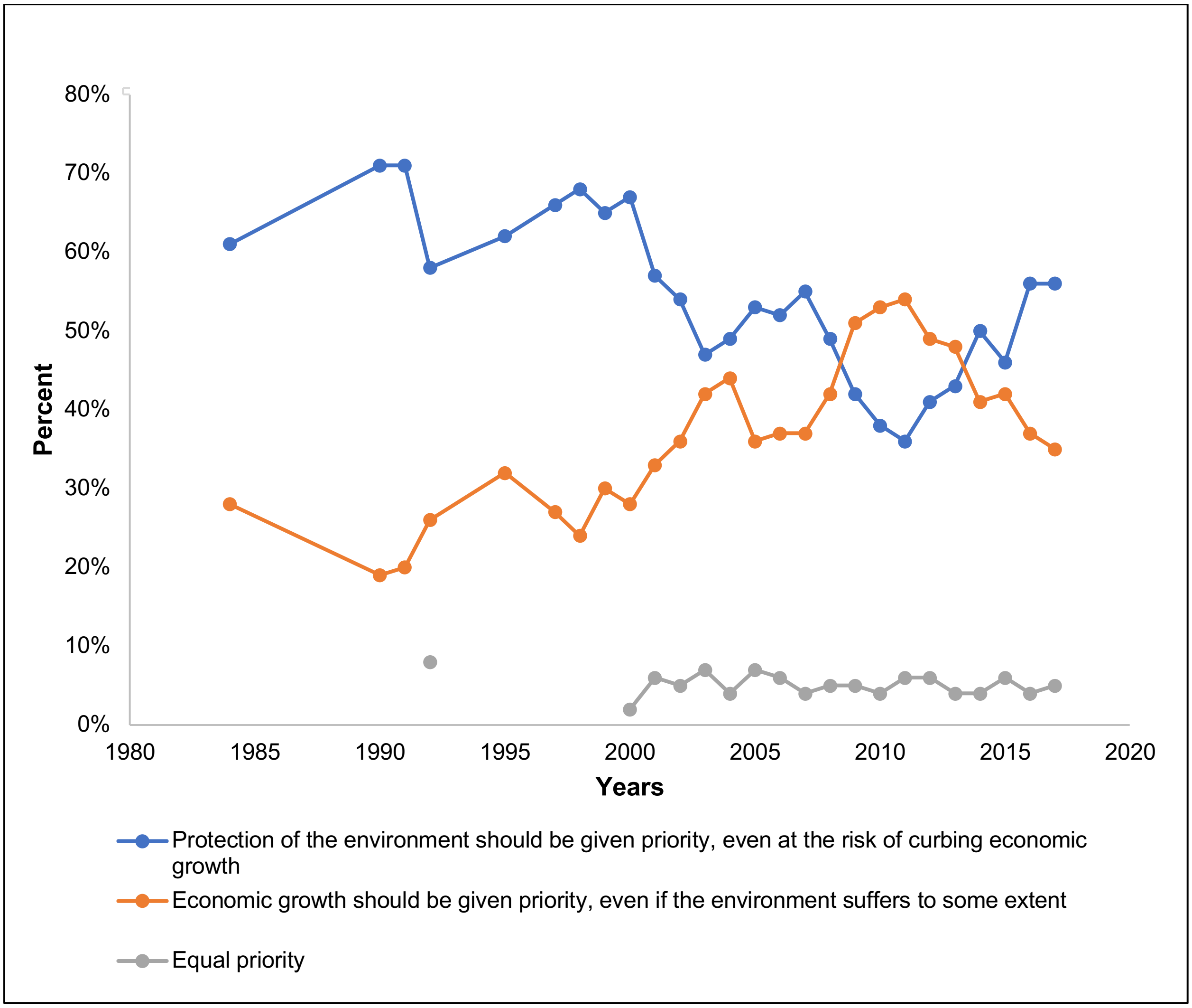


Table App.I.1. How much protection should be given to the environment?
Source: Gallup News, 2018

	Protection of the environment should be given priority, even at the risk of curbing economic growth	Economic growth should be given priority, even if the environment suffers to some extent	Equal priority	No opinion
1984	61%	28%		11%
1990	71%	19%		10%
1991	71%	20%		9%
1992	58%	26%	8%	8%
1995	62%	32%		6%
1997	66%	27%		7%
1998	68%	24%		8%
1999	65%	30%		5%
2000	67%	28%	2%	3%
2001	57%	33%	6%	4%
2002	54%	36%	5%	5%
2003	47%	42%	7%	4%
2004	49%	44%	4%	3%
2005	53%	36%	7%	4%
2006	52%	37%	6%	4%
2007	55%	37%	4%	4%
2008	49%	42%	5%	3%
2009	42%	51%	5%	3%
2010	38%	53%	4%	5%
2011	36%	54%	6%	4%
2012	41%	49%	6%	4%
2013	43%	48%	4%	5%
2014	50%	41%	4%	5%
2015	46%	42%	6%	5%
2016	56%	37%	4%	3%
2017	56%	35%	5%	4%

Figure App.I.2. Do you think the U.S. government is doing too much, too little, or about the right amount in terms of protecting the environment?
Source: Gallup News, 2018

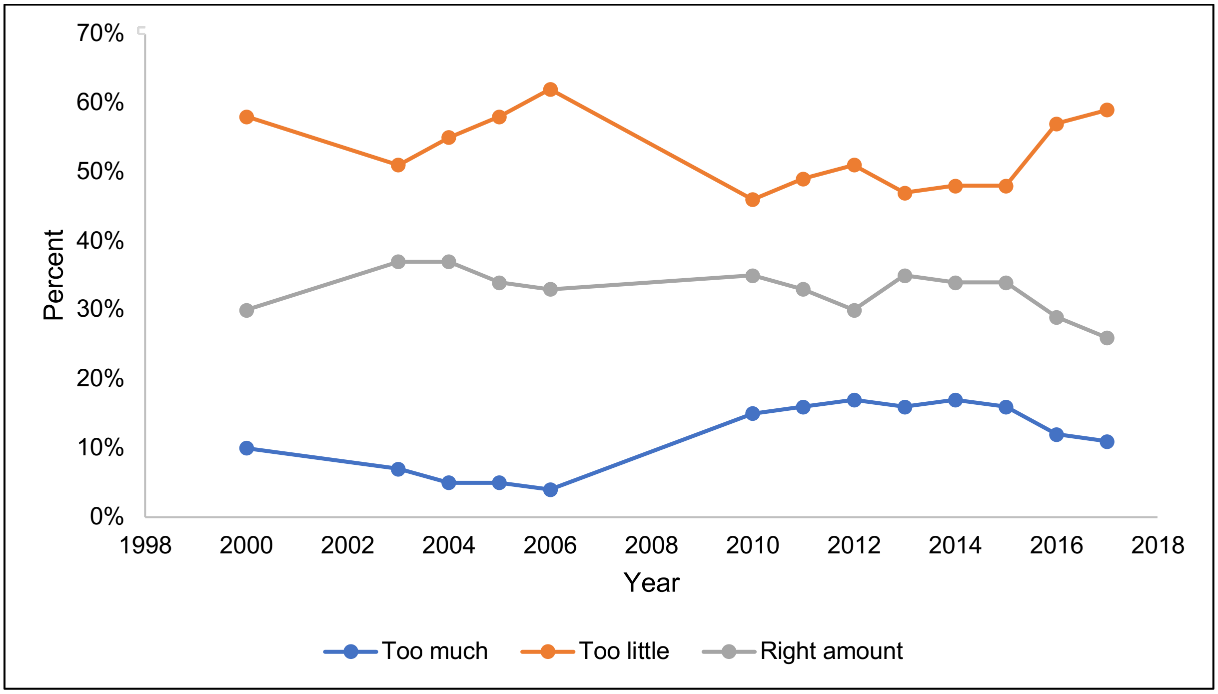


Table App.I.2. Do you think the U.S. government is doing too much, too little, or about the right amount in terms of protecting the environment?
Source: Gallup News, 2018

	Too much	Too little	Right amount
2000	10%	58%	30%
2003	7%	51%	37%
2004	5%	55%	37%
2005	5%	58%	34%
2006	4%	62%	33%
2010	15%	46%	35%
2011	16%	49%	33%
2012	17%	51%	30%
2013	16%	47%	35%
2014	17%	48%	34%
2015	16%	48%	34%
2016	12%	57%	29%
2017	11%	59%	26%

Figure App.I.3. Boat registrations in California from 2005 to 2016
Sources: National Marine Manufacturers Association (NMMA 2016) and U.S. Coast Guard (pers. comm.)

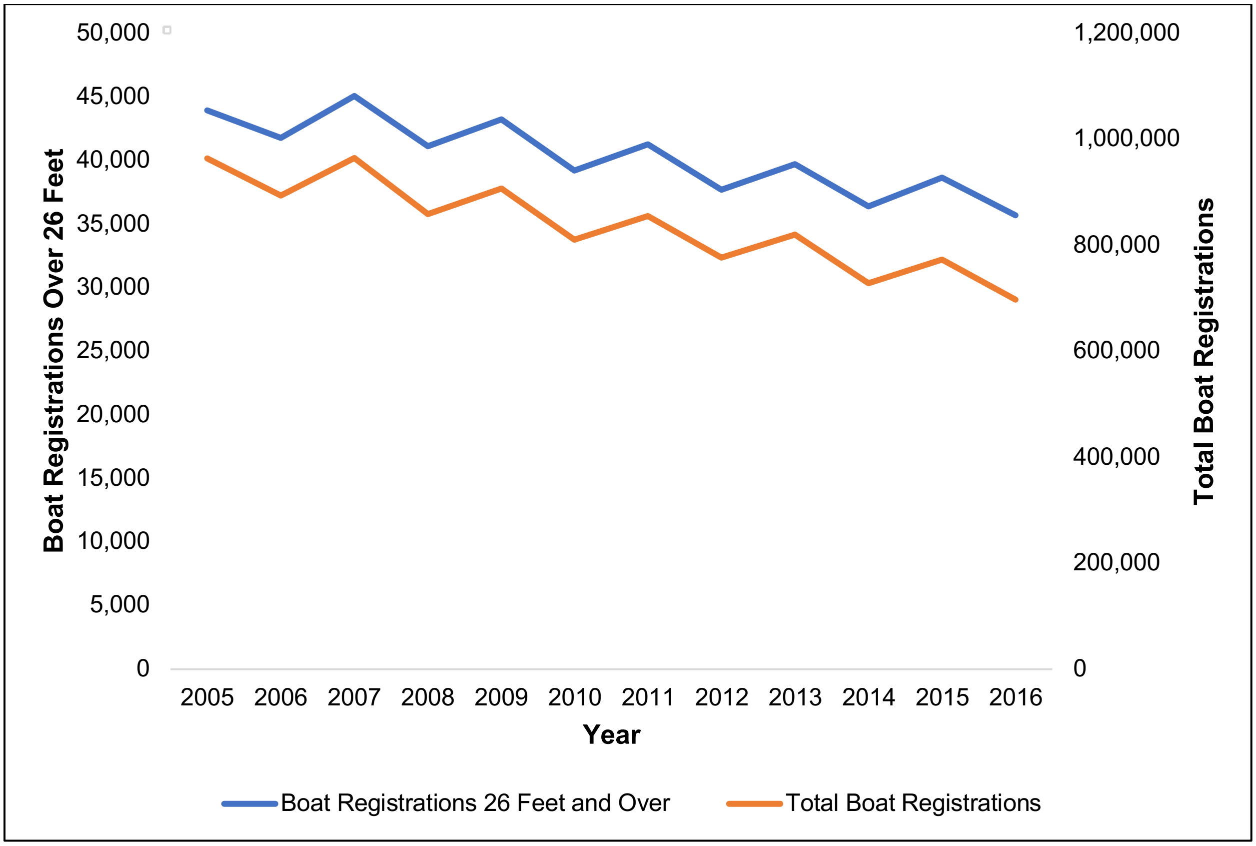


Figure App.I.4. Commercial passenger fishing vessels (CPFV) hours (in 10,000s) per year
Source: California Data Basin (https://caoffshorewind.databasin.org/datasets/ce8e904dc98640e4b8af60c66e22b3a2)

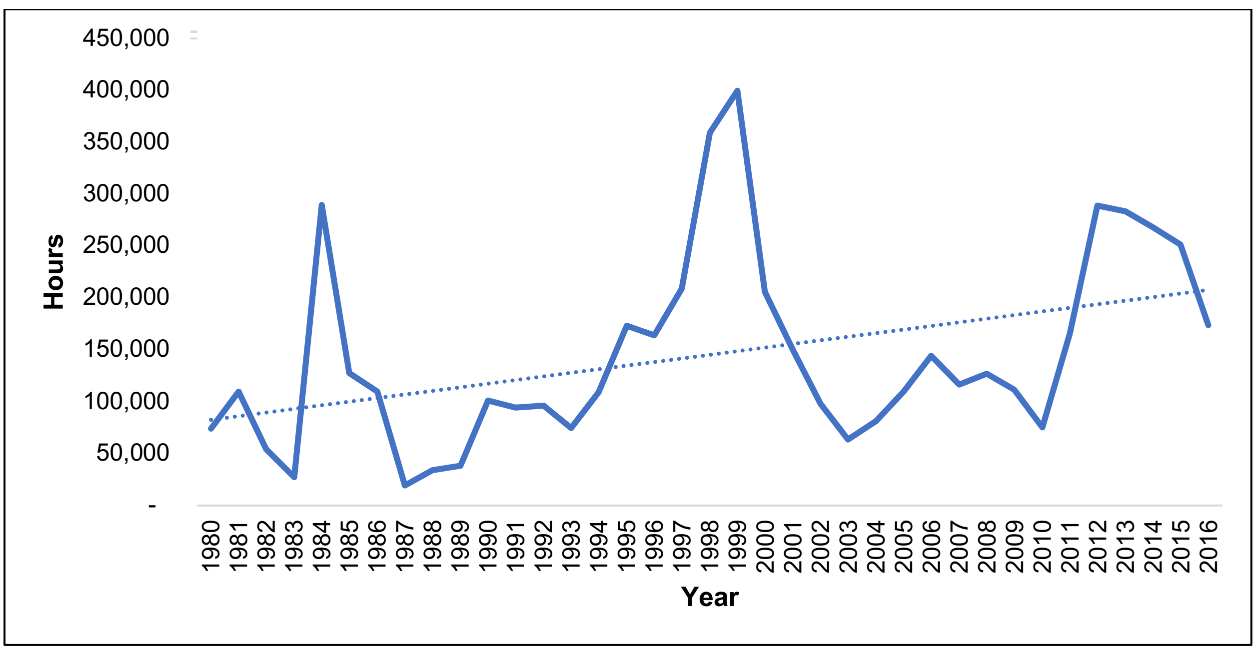


Figure App.I.5. Commercial passenger fishing vessels person-days per year
Source: California Department of Fish and Wildlife

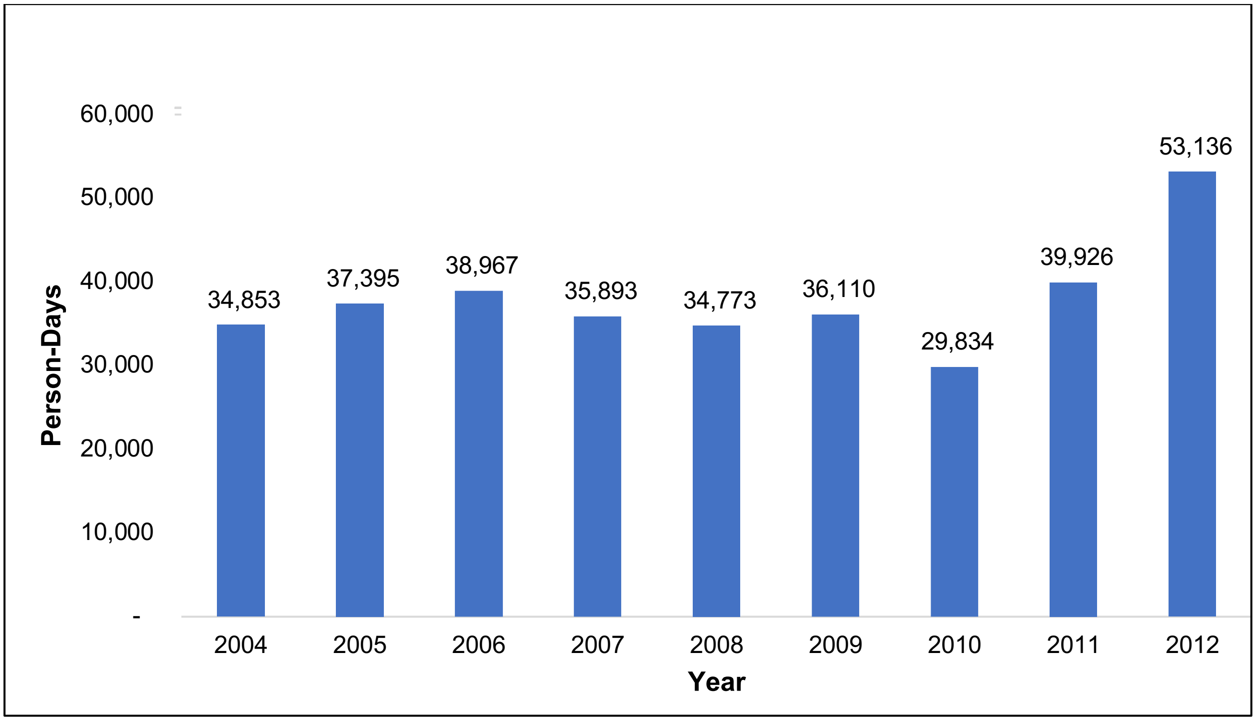


Table App.I.3. The total annual expenditures within CINMS by fishing mode of access (in 2014 $).
Source: Leeworthy and Schwarzmann, 2015

Mode of Access	2010	2011	2012	Average
Private/rental Boat	$1,394,968	$2,604,478	$2,738,473	$2,245,973
CPFV	$8,038,158	$10,727,474	$14,764,025	$11,176,552
Total	***$9,433,126***	***$13,331,952***	***$17,502,498***	***$13,422,525***

Table App.I.4. The total economic annual contributions within CINMS by fishing mode of access (in 2014 $).
Source: Leeworthy and Schwarzmann, 2015

	Output	Value Added	Income	Employment
2010				
Private/rental	$1,946,080	$1,145,460	$677,209	14
CPFV	$13,295,223	$8,010,729	$4,830,079	121
Total	***$15,241,303***	***$9,156,189***	***$5,507,288***	***135***
2011				
Private/rental	$4,322,249	$2,479,377	$1,453,027	27
CPFV	$17,745,765	$10,692,437	$6,447,611	162
Total	***$22,068,014***	***$13,171,814***	***$7,900,638***	***189***
2012				
Private/rental	$3,952,893	$2,287,602	$1,351,466	26
CPFV	$24,384,153	$14,690,032	$8,848,451	222
Total	***$28,337,046***	***$16,977,634***	***$10,199,917***	***248***

Table App.I.5. The average annual economic contributions from 2010-2012 within CINMS by fishing mode of access (in 2014 $).
Source: Leeworthy and Schwarzmann, 2015

	Output	Value Added	Income	Employment
Private/rental	$3,407,074	$1,970,813	$1,160,567	22
CPFV	$18,475,047	$11,131,066	$6,708,714	168
Total	***$21,882,121***	***$13,101,879***	***$7,869,281***	***191***

Figure App.I.6. Person-days of private/rental boats in CINMS by year
Source: Leeworthy & Schwarzmann, 2015

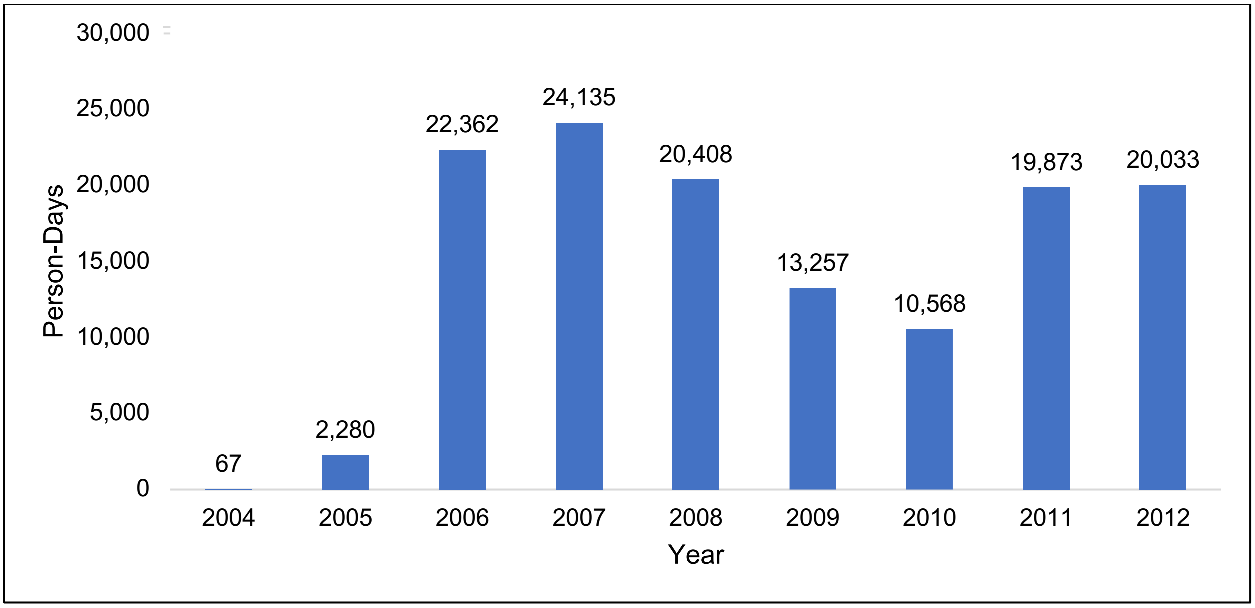


Figure App.I.7. Person-days of Private/rental Boats in CINMS by Resident Status
Source: Leeworthy & Schwarzmann, 2015

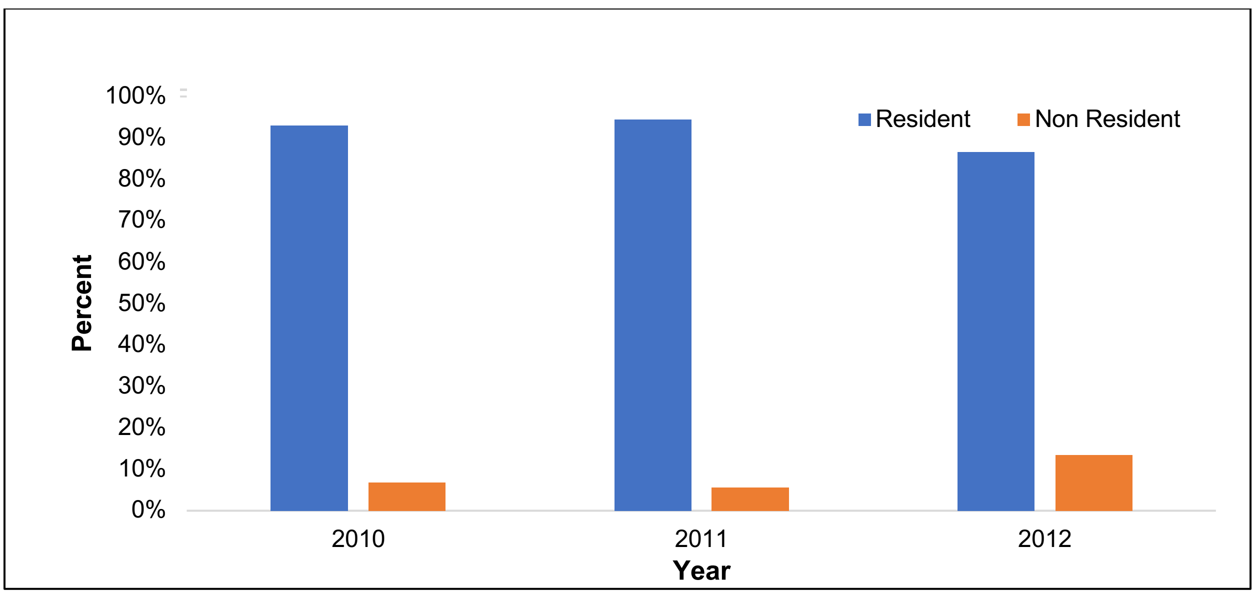


Figure App.I.8. Catch per unit angler (CPUA) for all catch in block for year
Source: California Data Basin. California Recreational Fishing Surveys (https://caoffshorewind.databasin.org/)

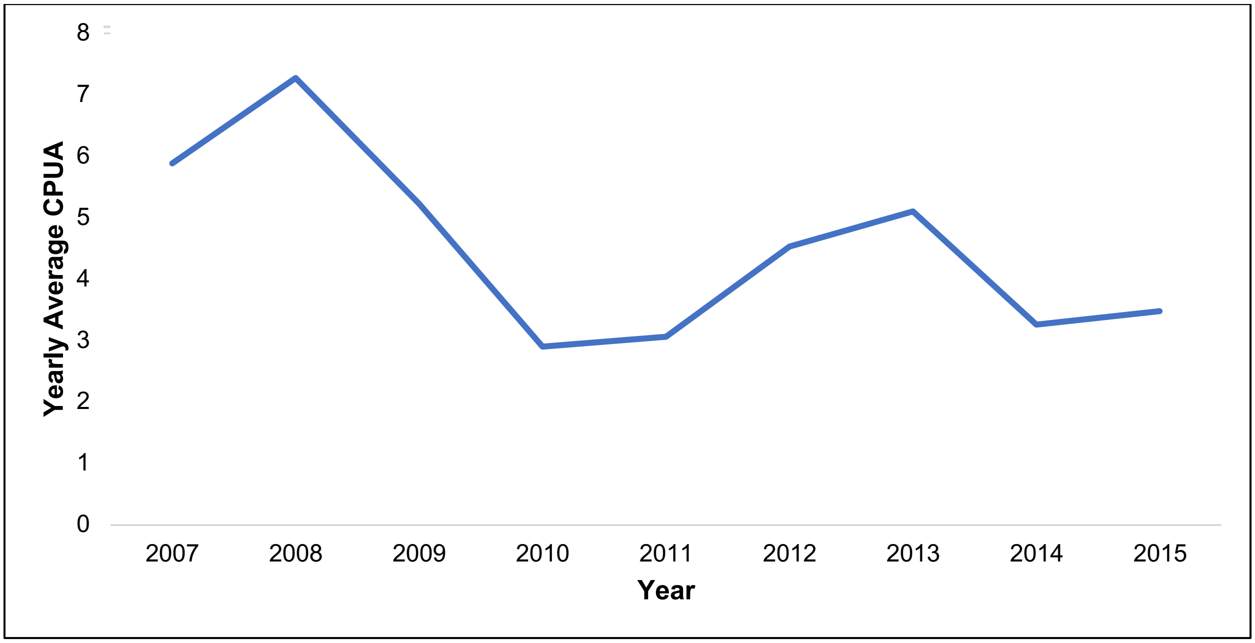


Figure App.I.9. Research permits issued by year
Source: OSPREY Sanctuary Permitting Database, 2017

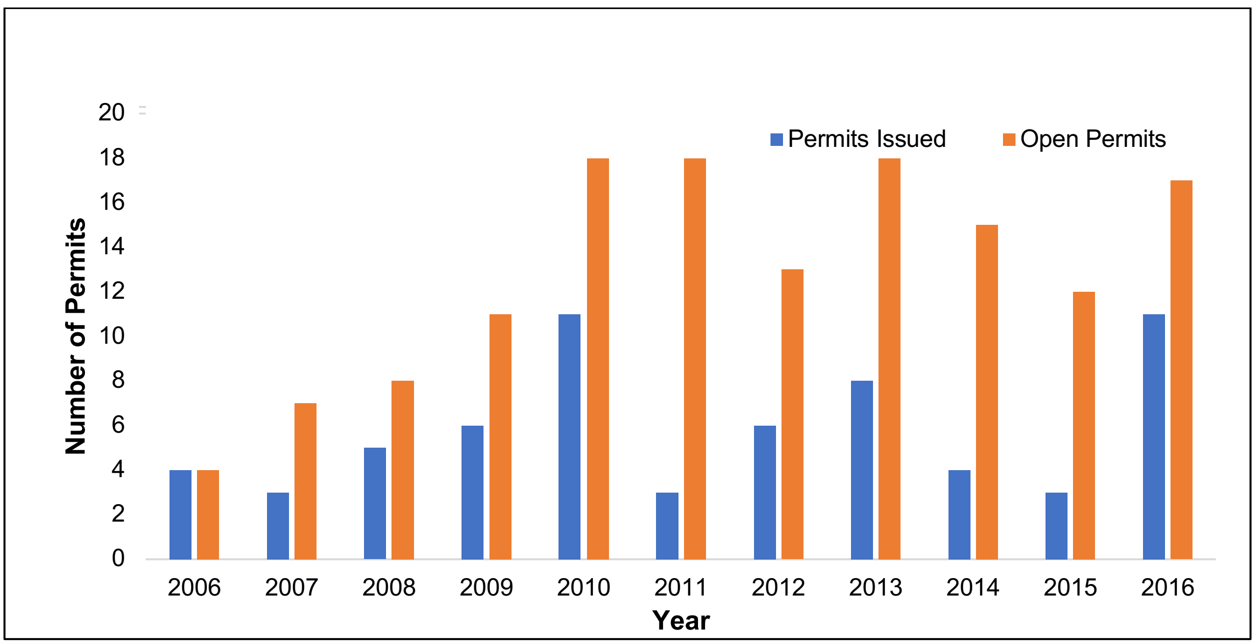


Figure App.I.10. Assessment of Research by Subject Area conducted in the CINMS
Source: A Preliminary Assessment of Research Conducted in the Channel Islands National Marine Sanctuary in 2009-2014: Laying the Groundwork for Science Needs Assessment. 2014. Ryan Freedman and Sean Herron.

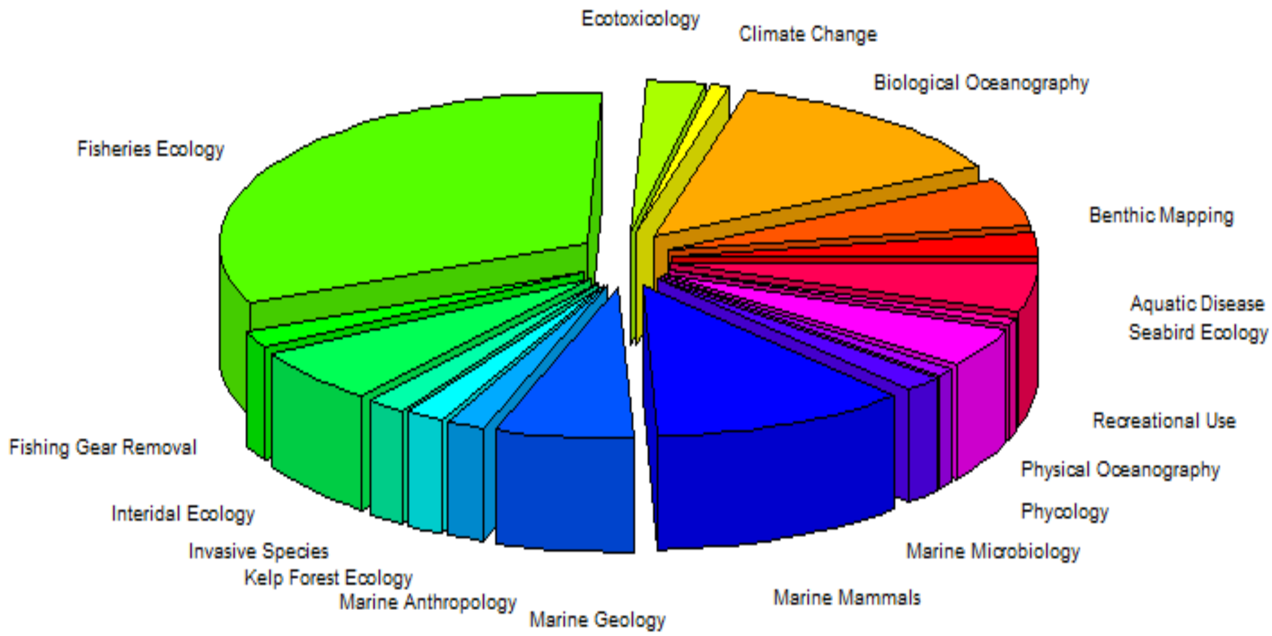


Figure App.I.11. Vessel by research subject
Source: A Preliminary Assessment of Research Conducted in the Channel Islands National Marine Sanctuary in 2009-2014: Laying the Groundwork for Science Needs Assessment. 2014. Ryan Freedman and Sean Herron.

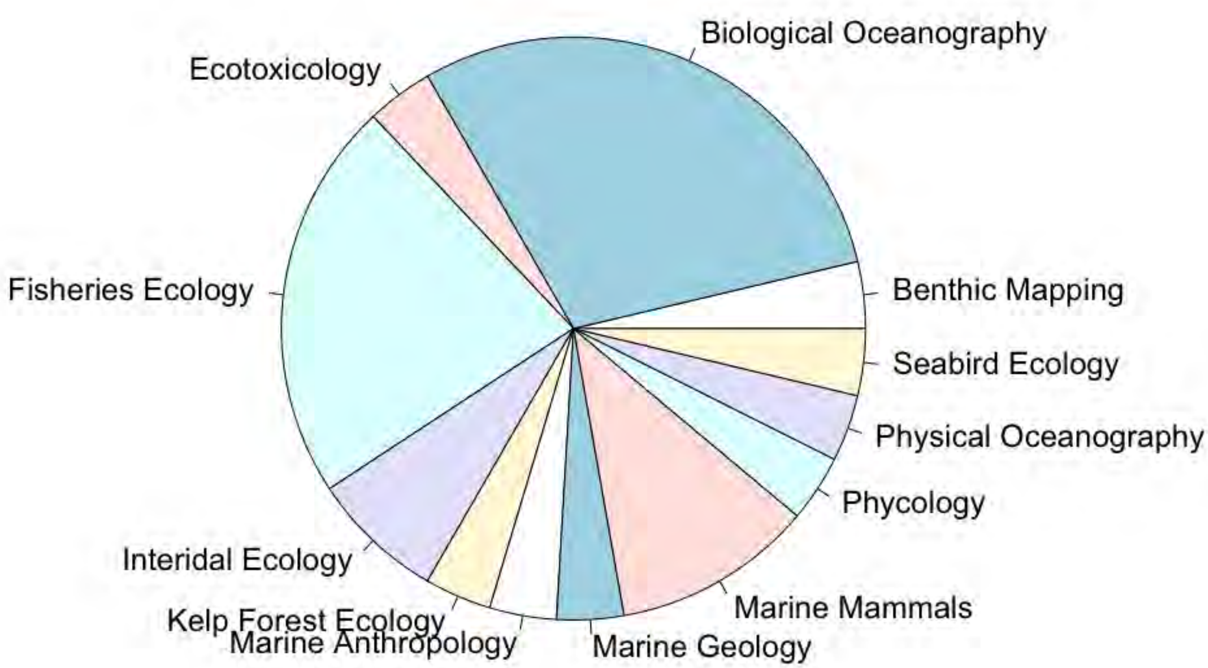


Figure App.I.12. Days CINMS research vessels conducted field operations, 2008-2017
Source: Peavey, ONMS/CINMS, 2018

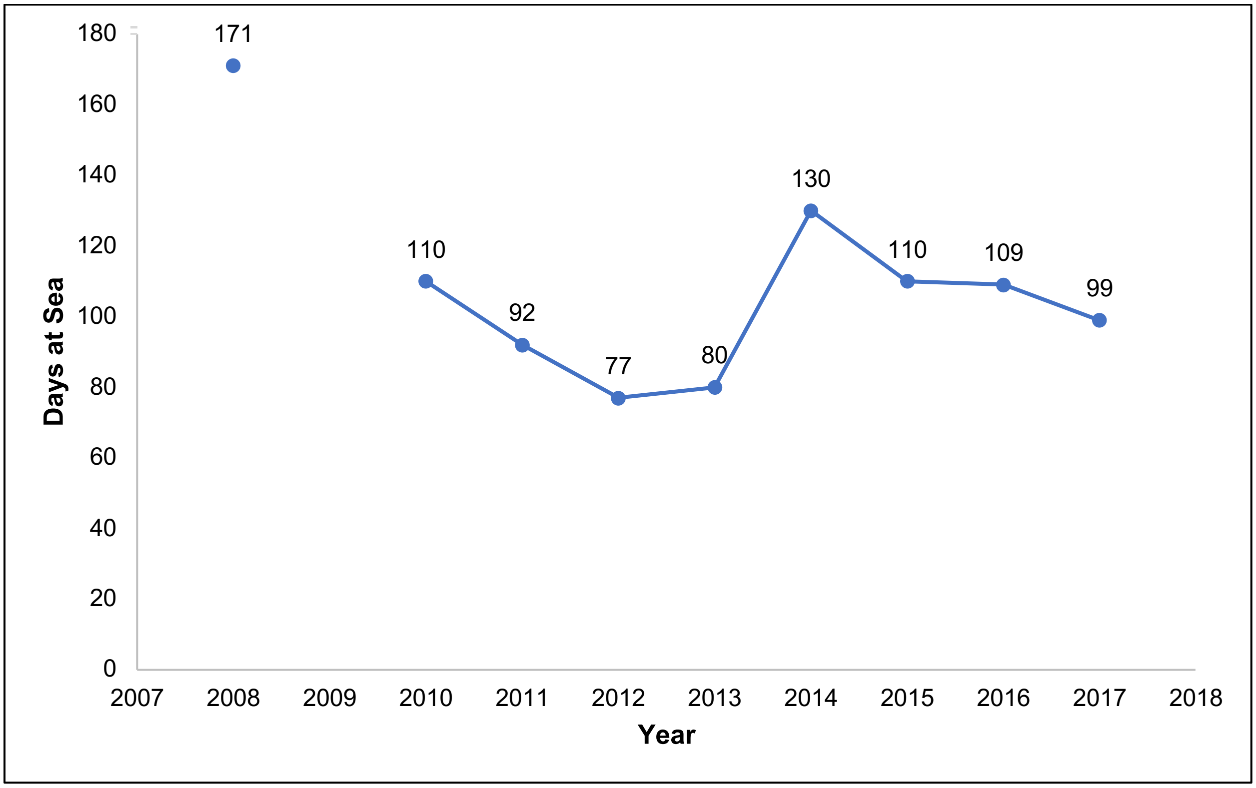


Figure App.I.13. Dollar value of volunteer time (in 2016 $)
Source: Fackler, ONMS, 2017 and https://www.independentsector.org/resource/the-value-of-volunteer-time/

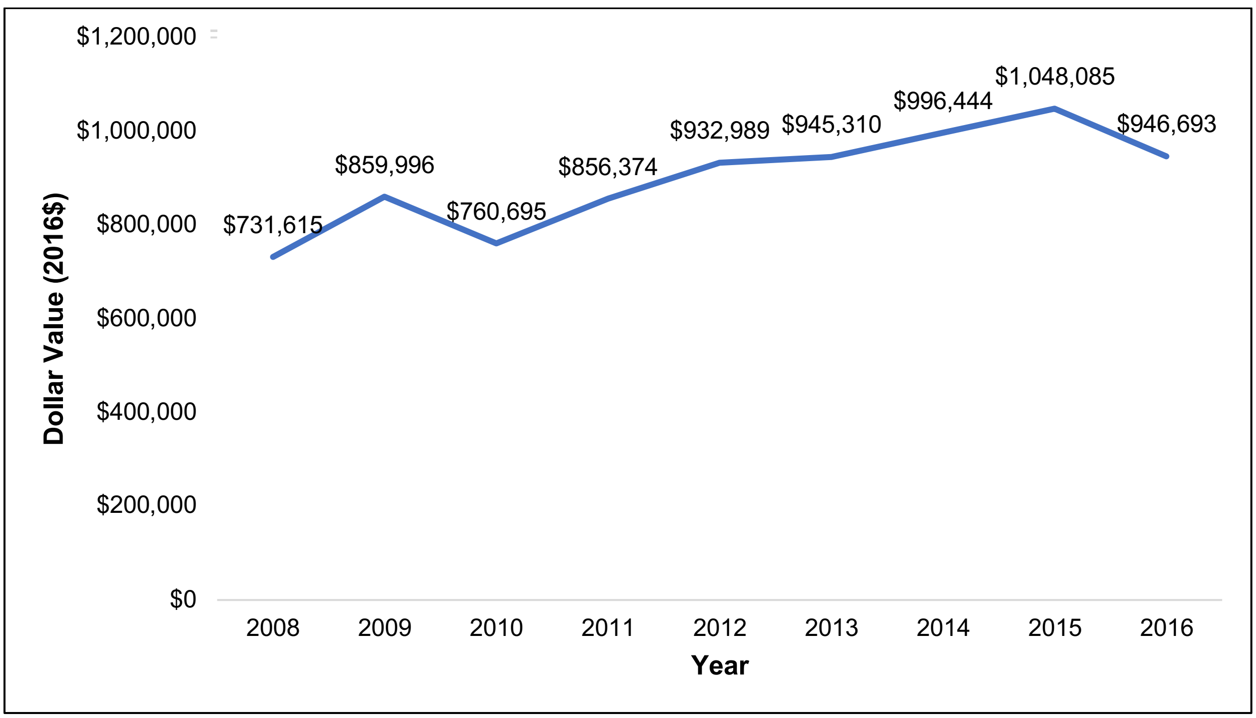


Figure App.I.14a. Number of students per school year from the Multicultural Education for Resource Issues Threatening Oceans (MERITO) Foundation, a long-standing education partner that works closely with Channel Islands National Marine Sanctuary
Source: Second Semi-Annual Progress Report Award #NA15NOS4290028 (2016–2017)

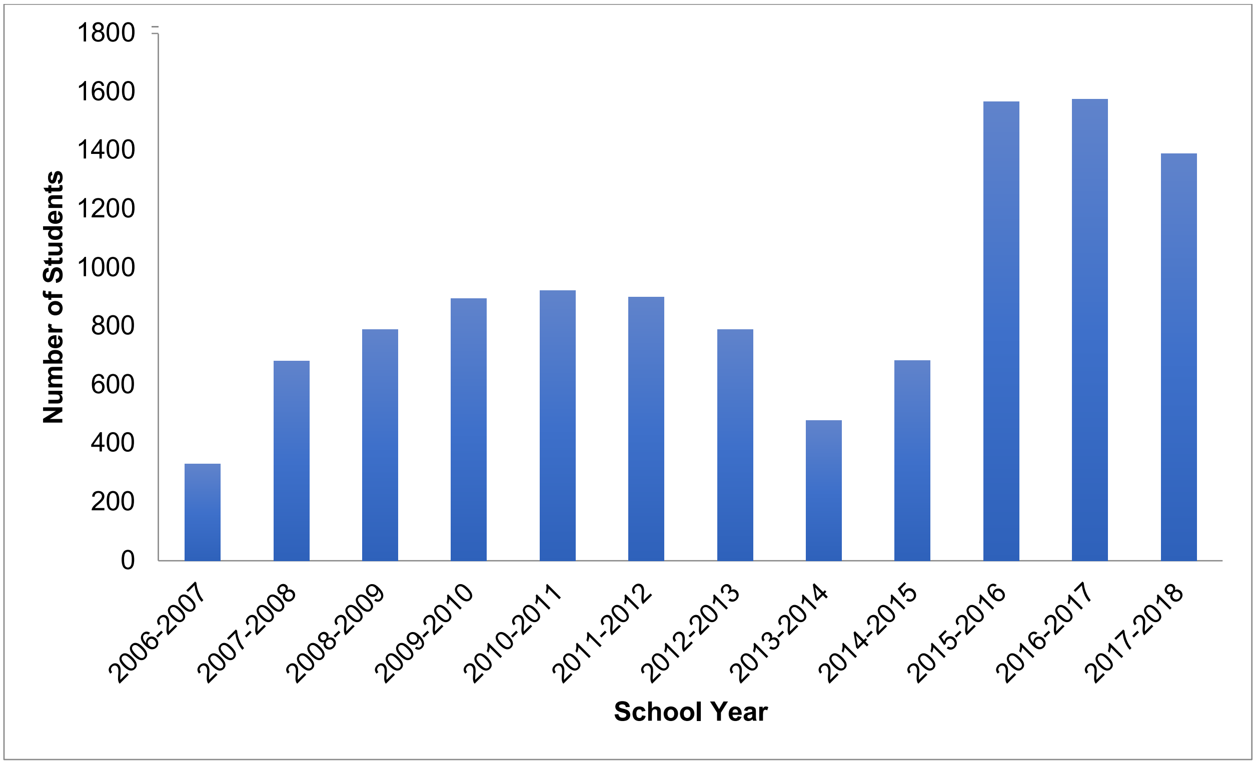


Figure App.I.14b. Student knowledge of environmental science and conservation content covered during programs implemented by MERITO
Source: Second Semi-Annual Progress Report Award #NA15NOS4290028 (2016–2017)

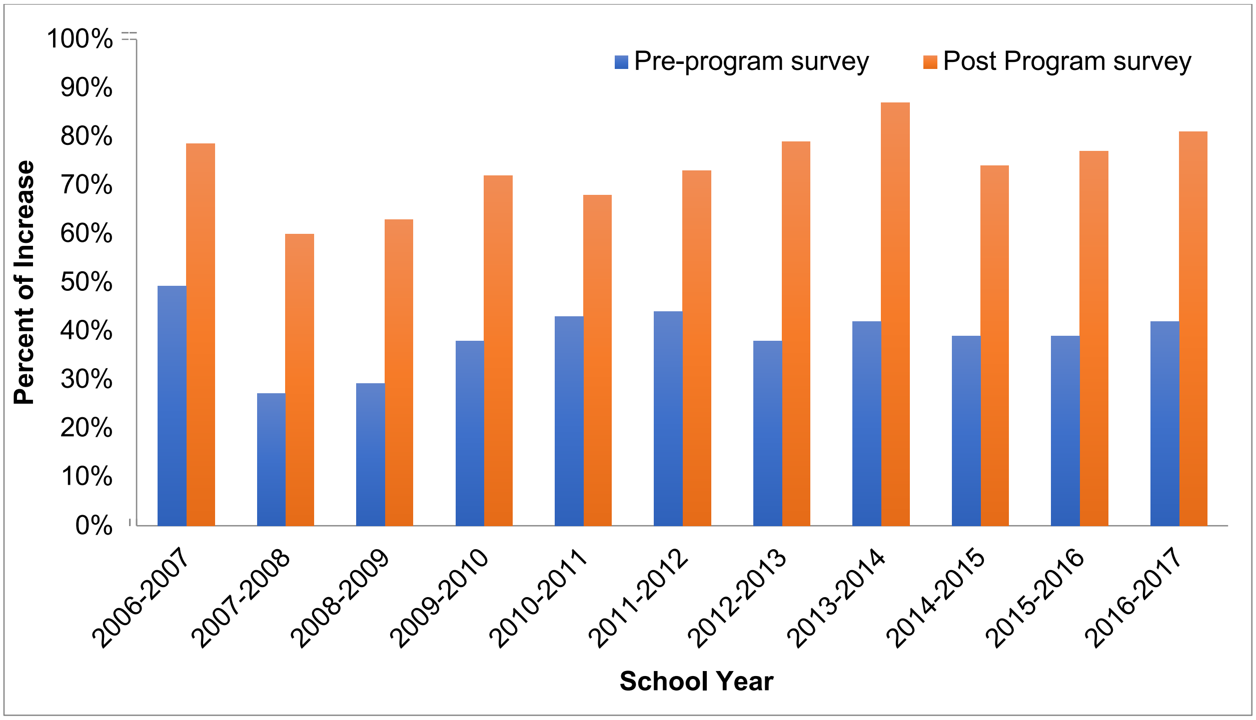


Figure App.I.15. Visitors to CINMS specific kiosks
Source: Cale-Huebner, ONMS, 2018

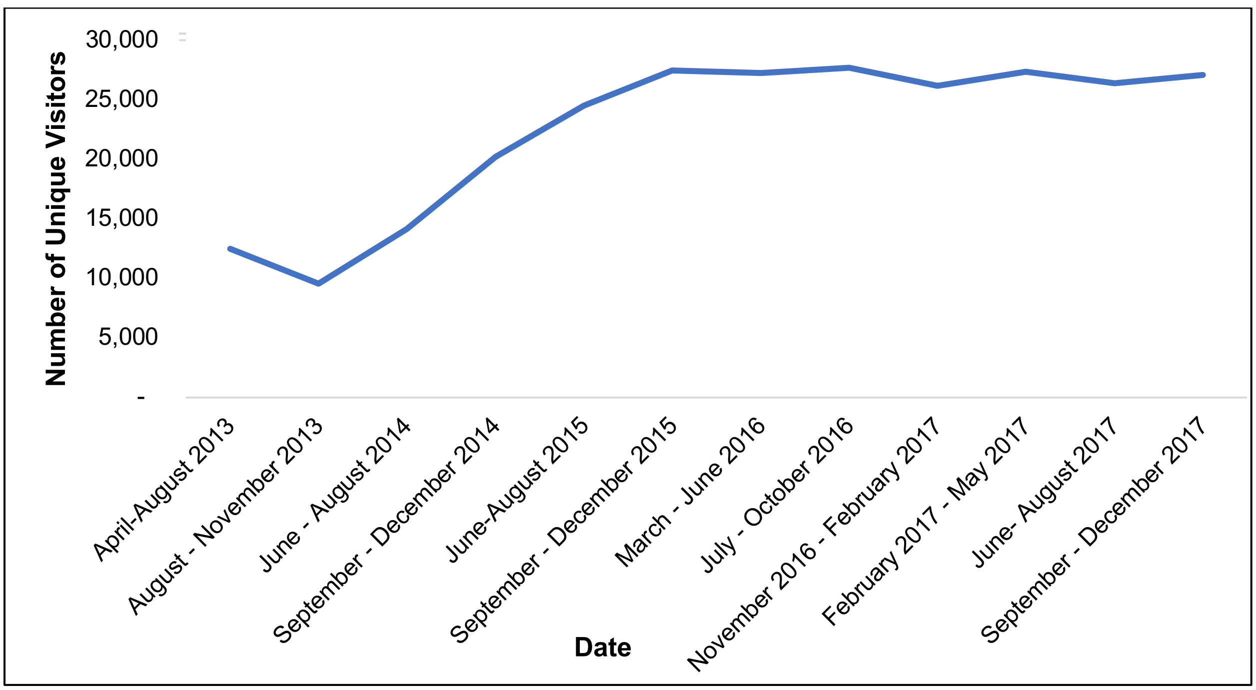


Figure App.I.16. K-12 Island Packer education participants from 2005-2017
Source: Mills, Island Packers, 2018

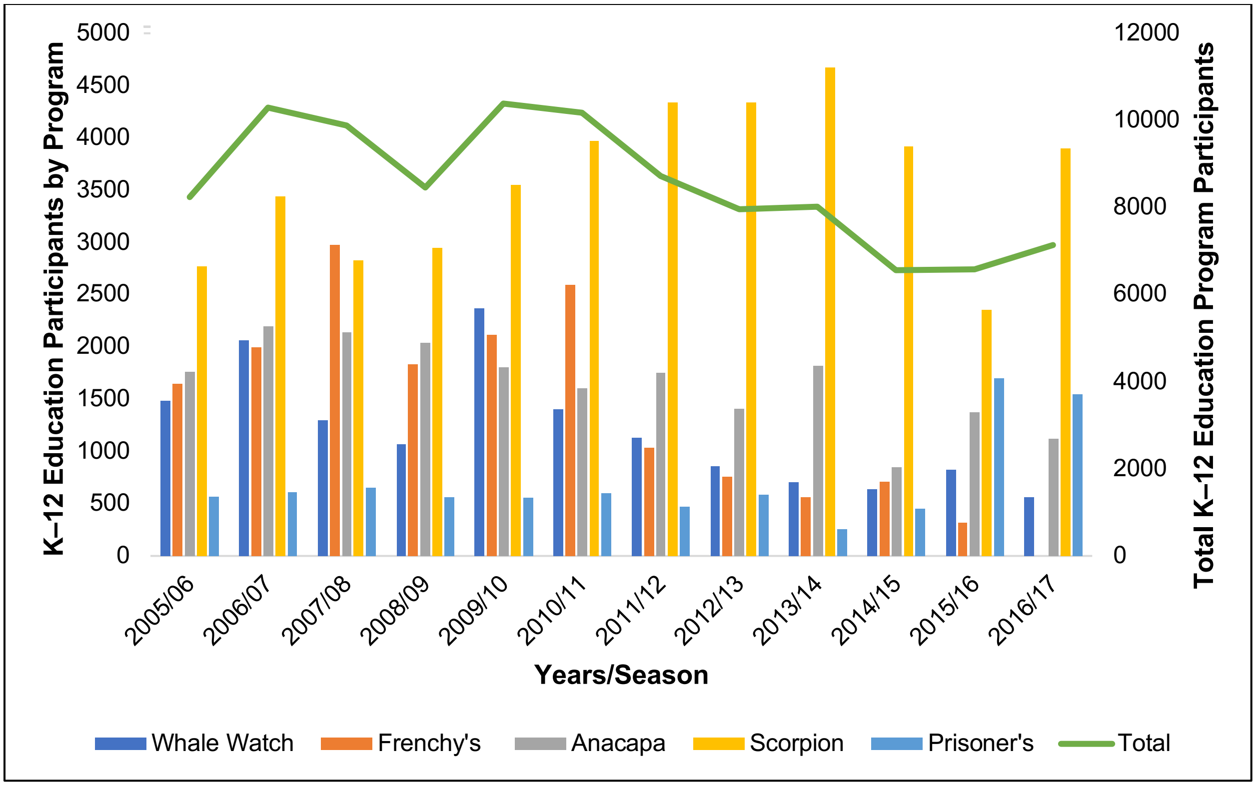


Figure App.I.17. Amount of volunteers and volunteer hours from 2008-2016
Source: Fackler, ONMS, 2017

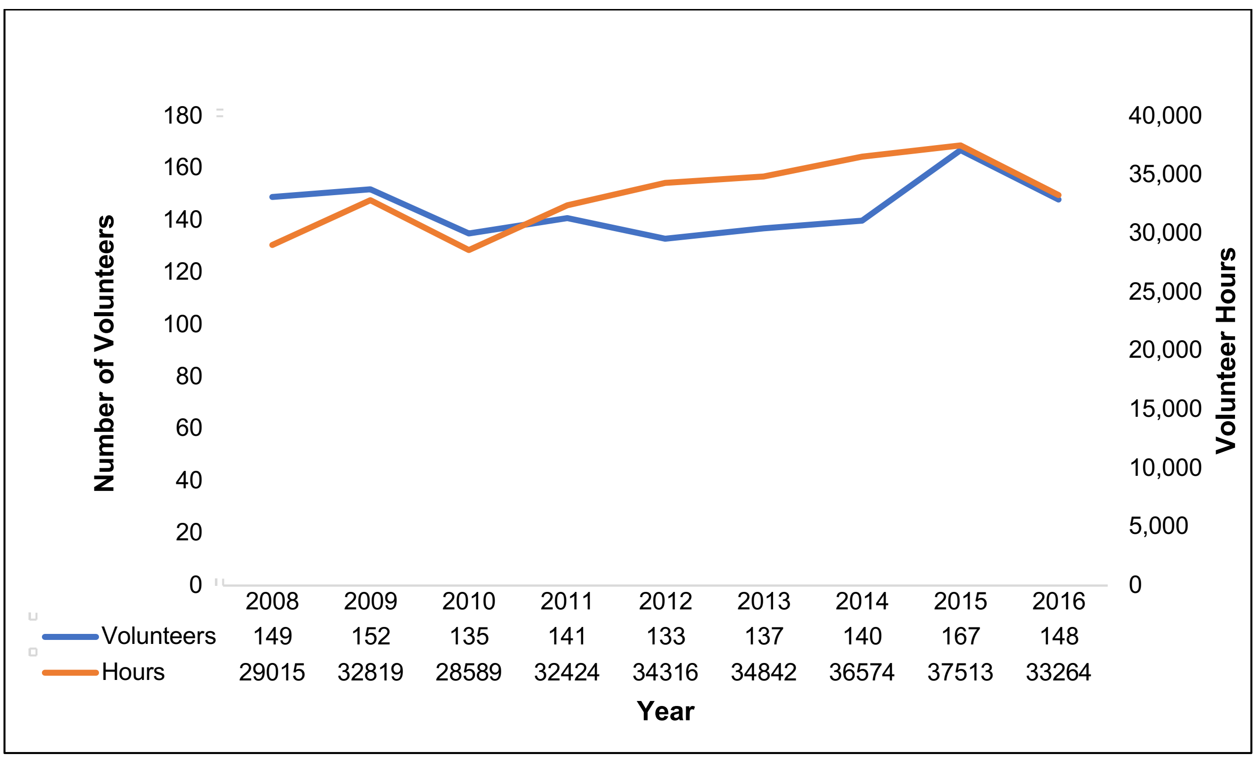
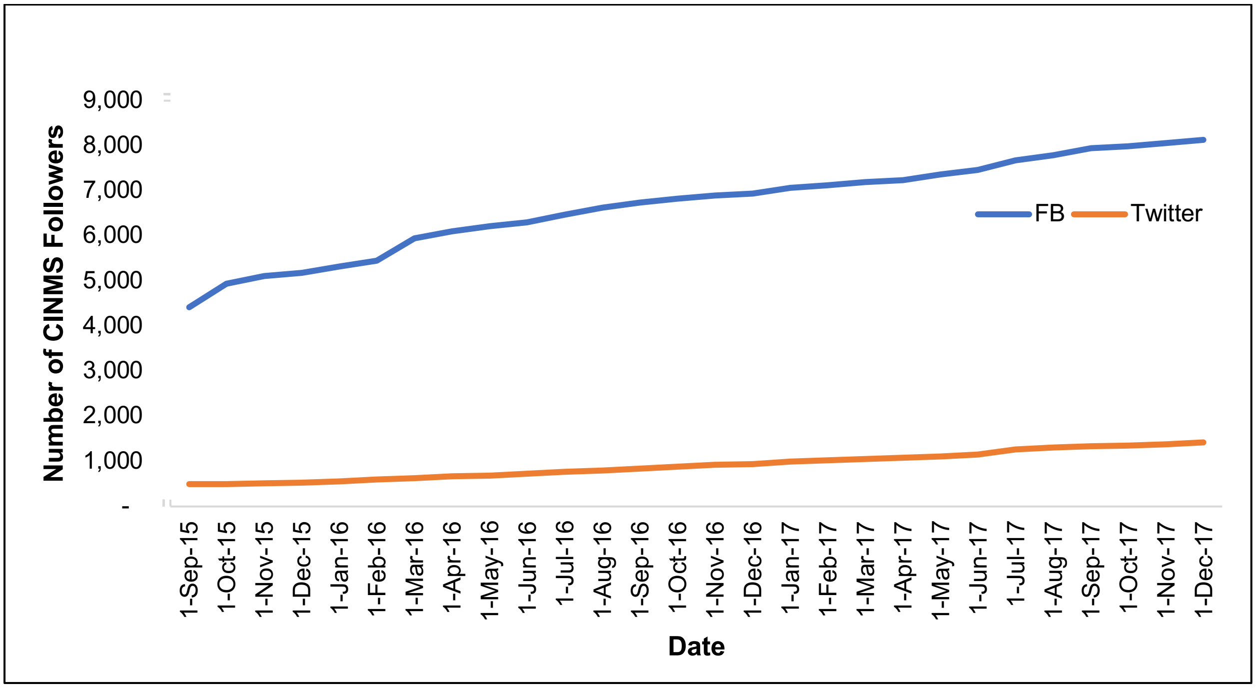


Figure App.I.18. Social media followers for CINMS Accounts
Source: Weinberg, ONMS, 2018



9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
-
Number of CINMS Followers
FB
Twitter
1-Sep-15
1-Oct-15
1-Nov-15
1-Dec-15
1-Jan-16
1-Feb-16
1-Mar-16
1-Apr-16
1-May-16
1-Jun-16
1-Jul-16
1-Aug-16
1-Sep-16
1-Oct-16
1-Nov-16
1-Dec-16
1-Jan-17
1-Feb-17
1-Mar-17
1-Apr-17
1-May-17
1-Jun-17
1-Jul-17
1-Aug-17
1-Sep-17
1-Oct-17
1-Nov-17
1-Dec-17
Date

Figure App.I.19. Trends in squid caught in CINMS, 2000 to 2012 (2013 $)
Source: California Fishing Information System, California Department of Fish and Wildlife

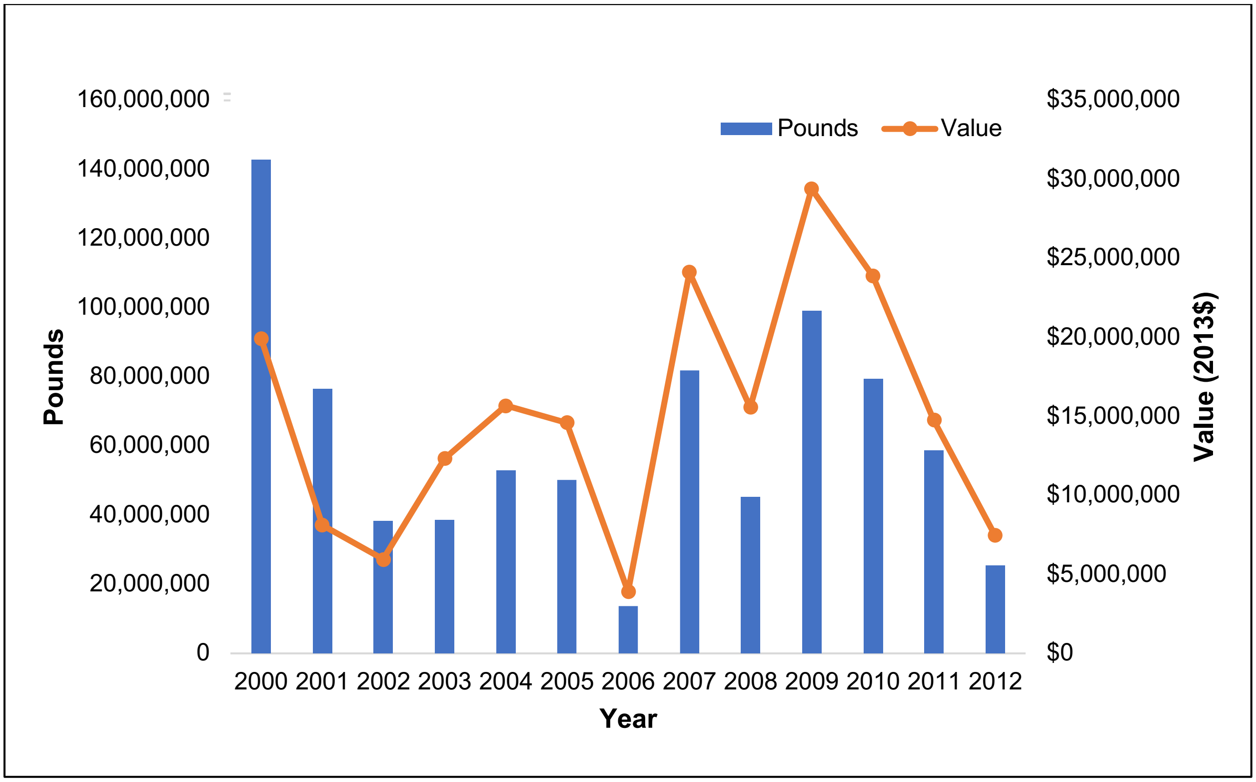


Figure App.I.20. Trends in urchin caught in CINMS, 2000 to 2012 (2013 $)
Source: California Fishing Information System, California Department of Fish and Wildlife

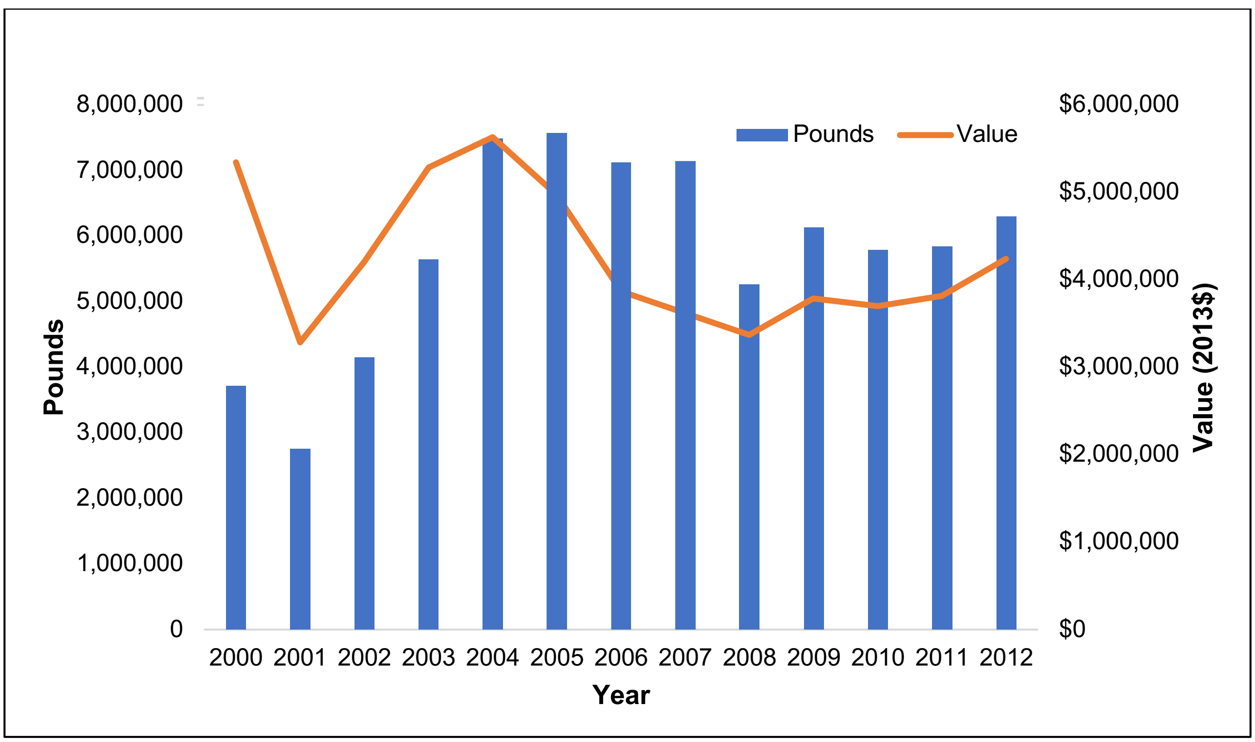


Figure App.I.21. Trends in spiny lobsters caught in CINMS, 2000 to 2012 (2013 $)
Source: California Fishing Information System, California Department of Fish and Wildlife

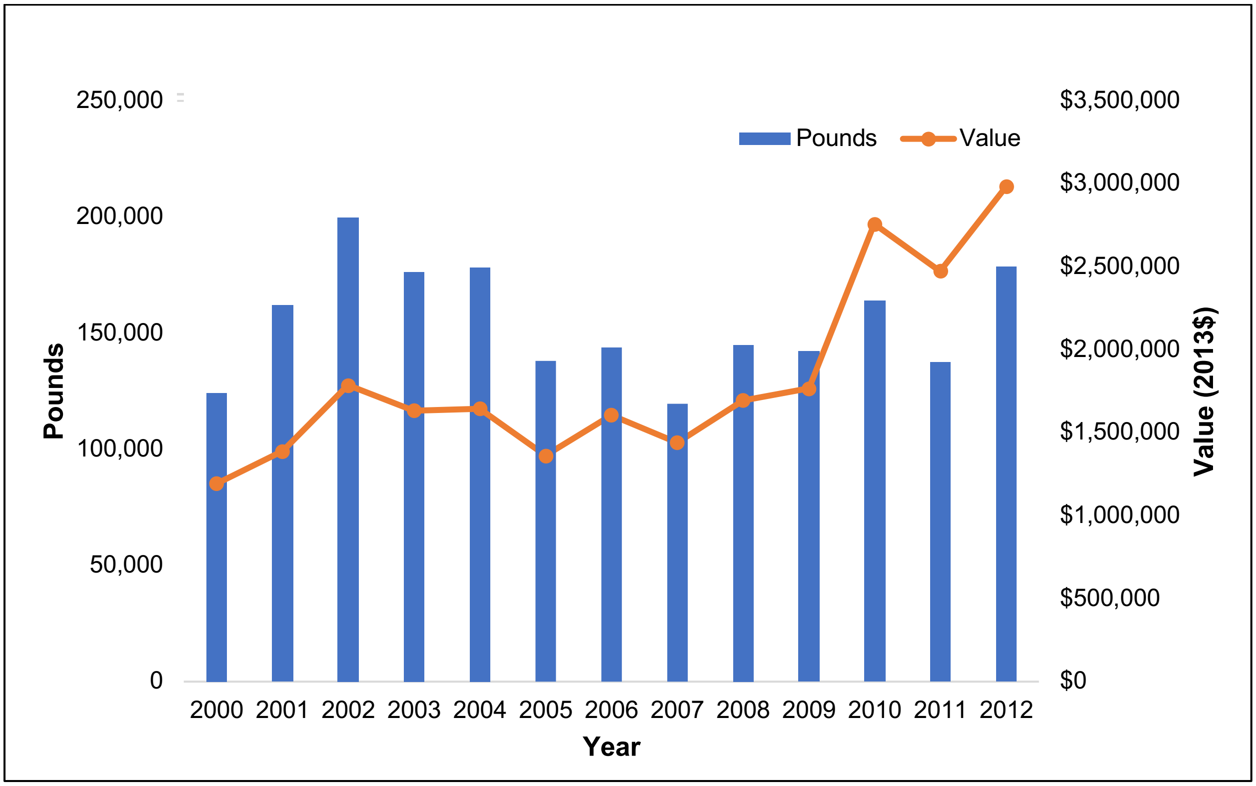


Figure App.I.21. Trends in crab caught in CINMS, 2000 to 2012 (2013 $)
Source: California Fishing Information System, California Department of Fish and Wildlife

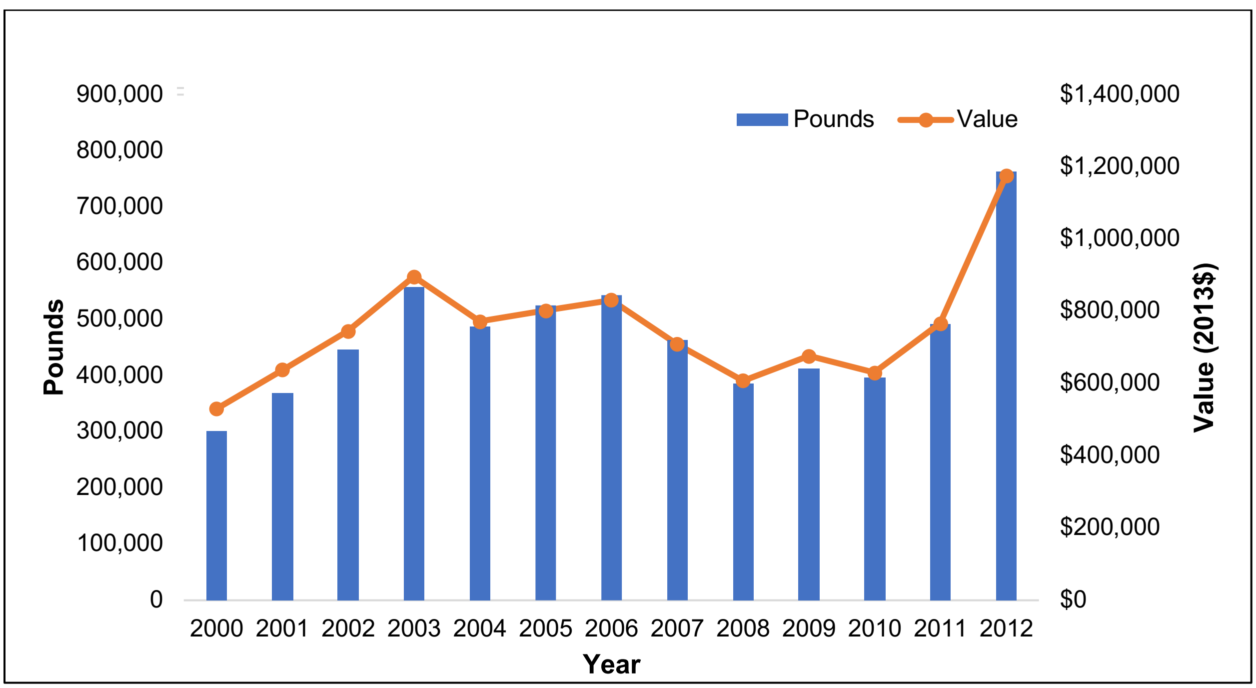


Figure App.I.22. Trends in prawn and shrimp caught in CINMS, 2000 to 2012 (2013 $)

Source: California Fishing Information System, California Department of Fish and Wildlife

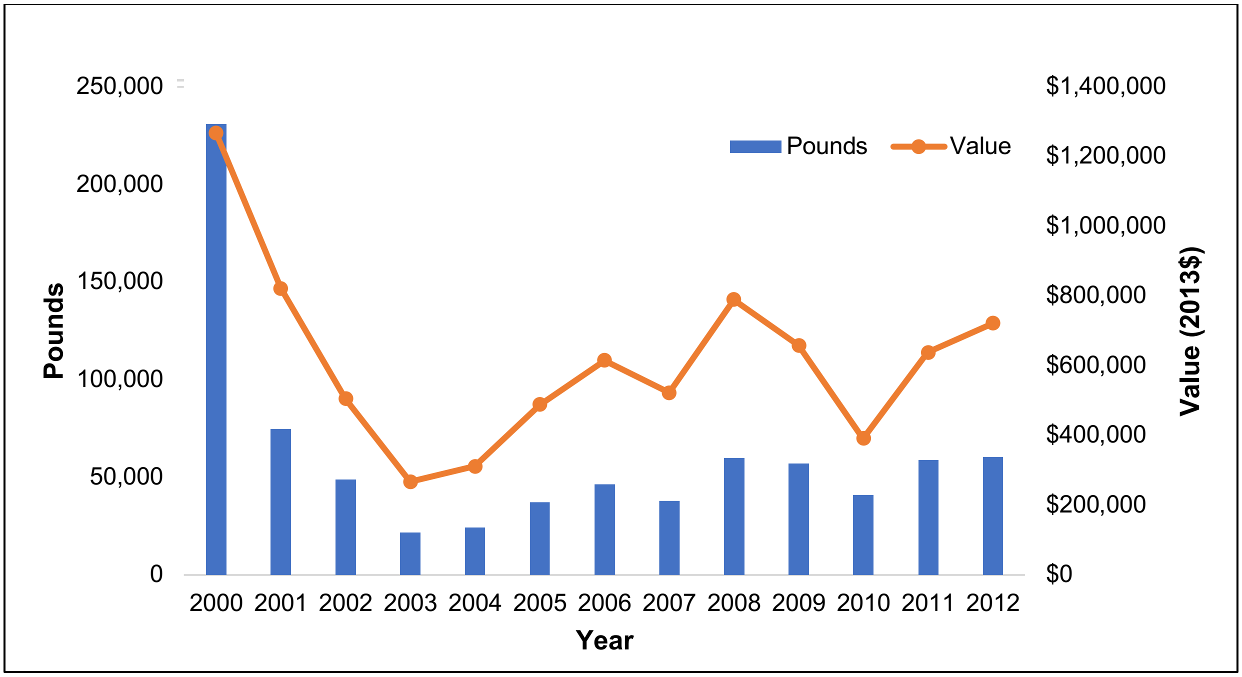


Figure App.I.23. Trends in anchovies caught in CINMS, 2000 to 2012 (2013 $)
Source: California Fishing Information System, California Department of Fish and Wildlife

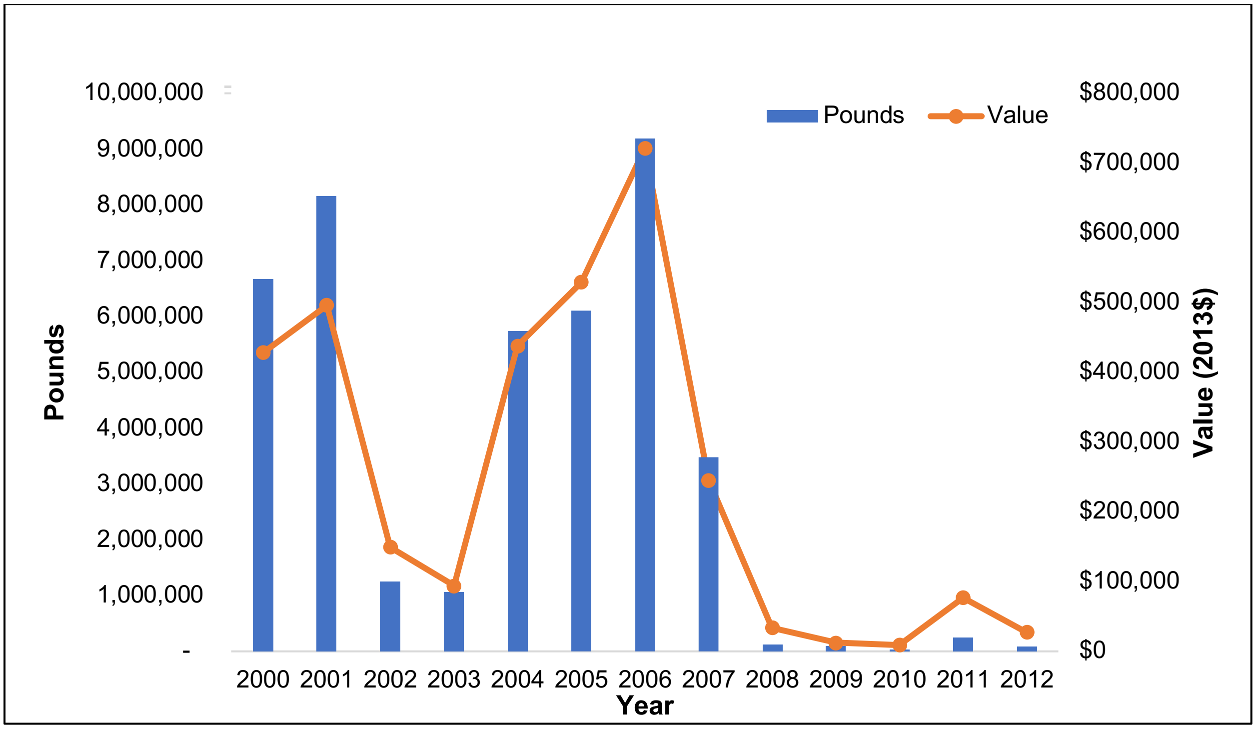


Figure App.I.24. Trends in sardines caught in CINMS, 2000 to 2012 (2013 $)
Source: California Fishing Information System, California Department of Fish and Wildlife

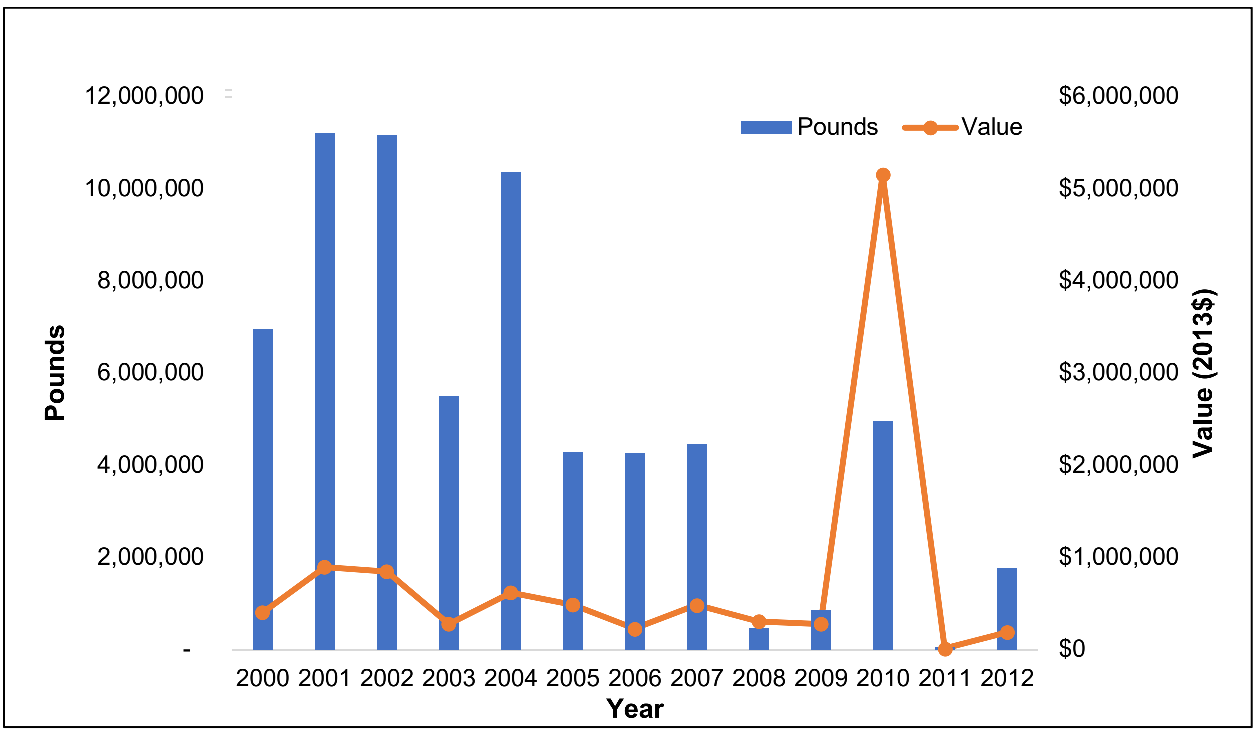


Table App.I.6. Pounds and value of landings from CINMS by species/species groups, 2012 (2013 $)
Source: California Fishing Information System, California Department of Fish and Wildlife

Species/Species Groups	Pounds	Value	Percent of Total Value
Market squid	25,447,604	$7,463,746	40.44%
Urchin	6,294,324	$4,238,338	22.96%
Spiny lobsters	178,669	$2,983,013	16.16%
Crab	763,156	$1,175,611	6.37%
Prawn & shrimp	60,371	$721,228	3.91%
Sea cucumber	121,494	$537,207	2.91%
Flatfish	56,768	$309,054	1.67%
Sablefish, louvar, whiting, whitefish	81,051	$258,290	1.40%
Sardines	1,783,262	$191,297	1.04%
Rockfish	36,397	$157,768	0.85%
CA scorpionfish, cabezon, thornyheads	30,070	$153,716	0.83%
Sculpin, basses, greenlings, grenadier	25,193	$77,369	0.42%
CA sheephead	12,843	$61,223	0.33%
Mackerel	215,024	$33,422	0.18%
Anchovies	88,902	$27,041	0.15%
Swordfish	1,255	$20,567	0.11%
Shellfish	6,757	$10,313	0.06%
Shark	5,146	$7,231	0.04%
Yellowtail	1,123	$2,663	0.01%
Tuna	1,413	$2,584	0.01%
Salmon	377	$2,281	0.01%
All other[58]	6,552	$21,991	0.12%
Total	***35,217,751***	***$18,455,950***	***100.00%***

[58] Species Groups "Rays & Skates", "Surfperch", "Octopus", and "Smelts" were added to "All Other" for having a value less than $1,000

Table App.I.7. Economic impact on local county economies from commercial fishing in CINMS, three-year average from 2010, 2011, and 2012 (2013 $)
Source: Leeworthy et al. 2013

County	Harvest Revenue	Output	Value Added	Total Income	Employment[59]
Los Angeles	$ 966,846.00	$ 1,875,630.26	$ 1,338,757.67	$ 1,221,721.09	13.9
Orange	$ 13,312.00	$ 25,828.72	$ 18,899.16	$ 17,583.46	0.2
San Luis Obispo	$ 23,343.67	$ 26,824.26	$ 14,799.46	$ 13,071.61	0.7
Santa Barbara	$ 6,125,564.00	$10,091,901.91	$ 5,284,082.72	$ 4,519,854.11	260.4
Ventura	$20,146,473.00	$33,376,039.69	$24,237,853.78	$22,064,321.89	383.8
Total	***$27,275,538.67***	***$45,396,224.83***	***$30,894,392.80***	***$27,836,552.15***	***659.1***

Table App.I.8. Evidence ratings for ecosystem services[60]

Ecosystem Service	Number of Experts that Reviewed Service	Number of Experts that Provided Evidence Rating	Results
Sense of Place	4	2	2-Medium
Consumptive Recreation	5	5	3-Medium, and 2-Limited
Non-consumptive Recreation	4	2	2-Medium
Food Supply	4	4	4-Medium
Maritime Heritage	2	0	None
Science	4	3	1-Robust and 2-Medium
Education	3	1	Medium

[59] Number of full and part-time jobs.
[60] Evidence ratings are part of the confidence ratings of status and trends of the services. The group of experts did not meet together to perform full confidence ratings. Instead, each expert was asked to provide a rating on evidence. Evidence ratings are Limited, Medium and Robust.

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