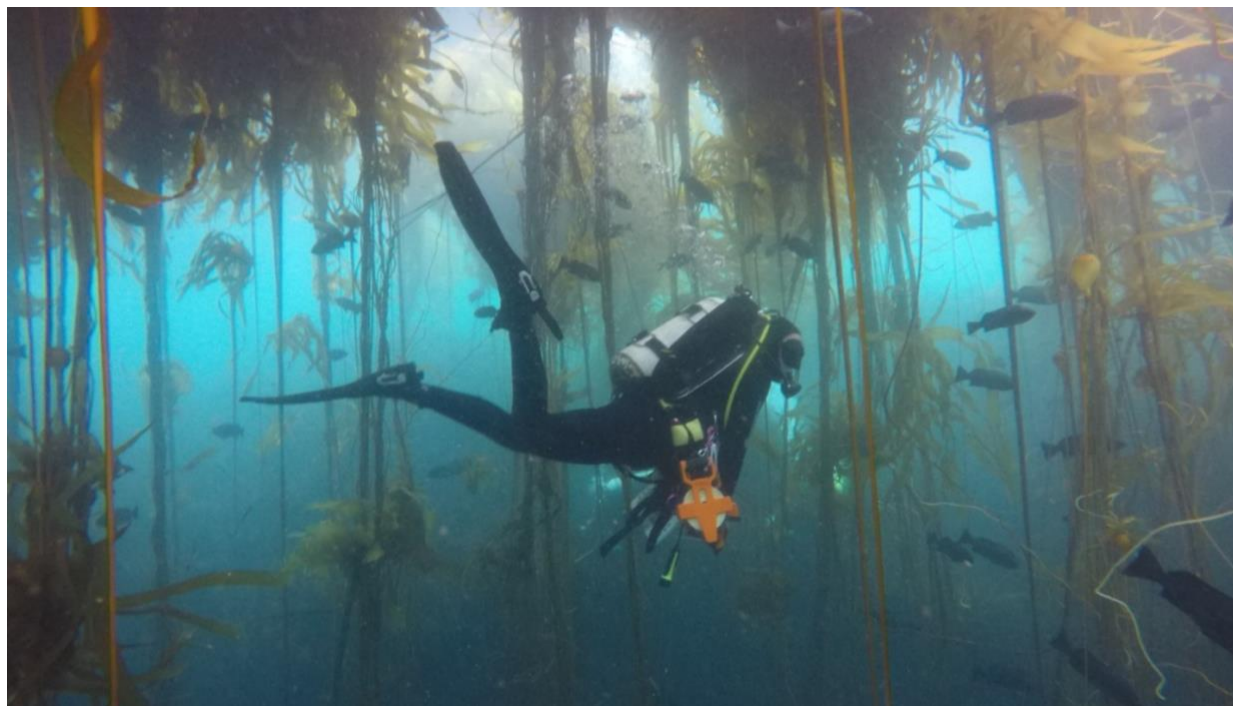
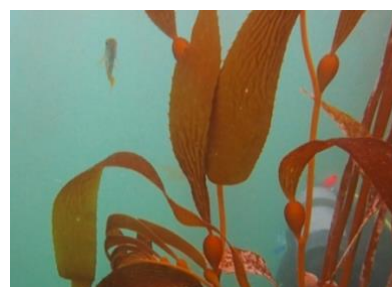
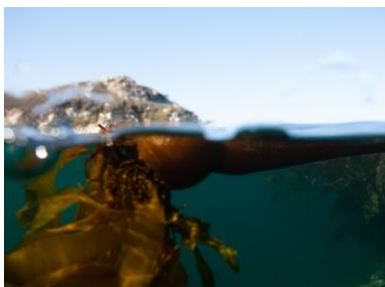




Monterey Bay National Marine Sanctuary Iconic Kelp Action Plan



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**NATIONAL
MARINE
SANCTUARIES**

Cover photos (left to right, top to bottom):

Bull kelp (*Nereocystis luetkeana*). Photo: Steve Lonhart/NOAA

Giant kelp (*Macrocystis pyrifera*). Photo: Chad King/NOAA

Giant kelp (*Macrocystis pyrifera*). Photo: Libby Mohn/NOAA

A science diver swims through a kelp forest at the "Pescadero downcoast" dive site in Monterey Bay. Photo: Steve Lonhart/NOAA

Table of Contents

- Section 1: Introduction 1**
- Section 2: Strategies and Activities 9**
 - Strategy 1: Education and Outreach 9
 - Strategy 2: Agency Coordination and Project Streamlining 11
 - Strategy 3: Research and Monitoring 12
 - Strategy 4: Pursue Science-Based Kelp Restoration that Moves Beyond the Pilot Scale 13
 - Strategy 5: Engagement with Indigenous Peoples, Governments, and Tribes (Indigenous Communities) 14
 - Strategy 6: Support Kelp Plan Strategies 15
- Section 3: Performance Measures Table 17**
- References 19**
- Appendix – Research Activity Panel Kelp Memo 23**



Giant kelp reaching the surface. Photo: Steve Lonhart/NOAA

Section 1: Introduction



Light filtering through the kelp forest canopy at Breakwater Cove along the Coast Guard Pier off San Carlos Beach. Photo: Libby Mohn/NOAA

Goal: Address the regional loss and long-term health of kelp forest ecosystems in the sanctuary through education, coordination with partners, research, restoration, and community engagement.

How the Iconic Kelp Action Plan Became a Sanctuary Priority

Kelp forest research, conservation, and education are Monterey Bay National Marine Sanctuary (MBNMS or sanctuary) priorities. At the December 2022 MBNMS Advisory Council meeting, the council requested the research activity panel (RAP), a standing working group of the advisory council, “evaluate suggested/proposed options for science to inform monitoring, recovery, and restoration of kelp forests in MBNMS.” The RAP response memo, including regional research needs for addressing kelp loss, was approved at the February 2023 advisory council meeting (see [Appendix](#)). During the November 2023 meeting, the council moved to establish a working group specifically to advise MBNMS on the development of an Iconic Kelp Action Plan, to determine the role of MBNMS staff in ongoing and developing multi-agency kelp related projects. MBNMS staff utilized the Sanctuary Advisory Council input to develop the strategies and activities in this document. The Iconic Kelp Action Plan is an addendum to the [MBNMS management plan](#).

Monterey Bay National Marine Sanctuary and Kelp

Monterey Bay National Marine Sanctuary (MBNMS or sanctuary) encompasses an extensive and diverse marine environment along California's central coast, stretching from Rocky Point in Marin County to Cambria in San Luis Obispo County. This federal marine protected area was established in 1992, spans 276 miles of shoreline, and encompasses more than 6,000 square miles of ocean. It was designated to better understand and protect its natural and cultural resources for future generations.

This planning document focuses on kelp forest ecosystems, and what activities MBNMS staff will undertake to advance science, facilitate education, protect kelp ecosystems, and ensure human benefits from these healthy ecosystems. The sanctuary's kelp forests have recently been affected by ocean warming events and biological changes, resulting in patchy yet significant kelp loss. This Iconic Kelp Action Plan was informed through a Sanctuary Advisory Council working group process and aims to protect and restore these vital habitats through a combination of science-driven strategies and community collaboration. These efforts will be carried out in collaboration with scientists, conservation organizations, commercial businesses, and community members to promote kelp resilience and ensure the ecosystem health provided by these habitats are protected.

Importance of Kelp Forests

Kelp forest ecosystems within the sanctuary are essential to the ecological, economic, and cultural health of coastal California. They are acknowledged as one of the planet's most prolific marine ecosystems, offering habitat to a diverse array of marine animals and acting as vital nurseries for several fish species. High levels of biodiversity, including endangered and threatened species, are fostered by the structural complexity of kelp forests, which provide both food and habitat. The overall health of the marine environment is linked to the biological state of kelp forests, which affects primary productivity and nutrient cycling. Kelp forests also sequester carbon, removing carbon dioxide from the atmosphere and storing it, therefore helping to mitigate the effects of a warming ocean.

The immediate economic and cultural importance of kelp forests is significant as well. Central California's kelp forests are vital ecosystems that support both commercial and recreational fisheries, while providing food for abalone aquaculture. Recreational use of kelp forests includes activities such as scuba diving, kayaking, artwork, and wildlife observations.

The Biology of Large Kelp

Kelp is classified as brown algae, typically growing in cold, nutrient-rich water where the seafloor is composed of shallow (< 98 feet) rocky reefs or large boulders. Kelp forms dense

underwater forests, and the larger kelps reach surface waters to form floating canopies. Numerous marine creatures rely on kelp species for their habitat, food, and shelter, making them one of the planet's most productive ecosystems. Other functions of kelp include converting sunlight, carbon dioxide, and water into sugar and oxygen (known as photosynthesis). Notable species of large kelp include the giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis luetkeana*), which can be found throughout coastal rocky habitats in Monterey Bay National Marine Sanctuary.

While different kelp species have different morphologies, almost all kelps are made up of the following components: a holdfast (a root-like structure that anchors kelp to the seafloor), a stipe (a stem-like structure that makes up the body of the kelp), and blades (similar to leaves). Some kelp species such as the giant and bull kelp possess the additional feature of pneumatocysts, or air bladders. The bull kelp's pneumatocyst is a single, enormous bulb that keeps the algae afloat, supporting its long, whip-like stipe that gives the kelp its common name. This annual species' life cycle is shorter than that of giant kelp, and it usually thrives in rougher, colder waters such as northern San Francisco to Alaska, but is also found throughout MBNMS. Conversely, the perennial giant kelp has pneumatocysts at the base of each blade and a much larger range spanning across the northern Pacific coast.

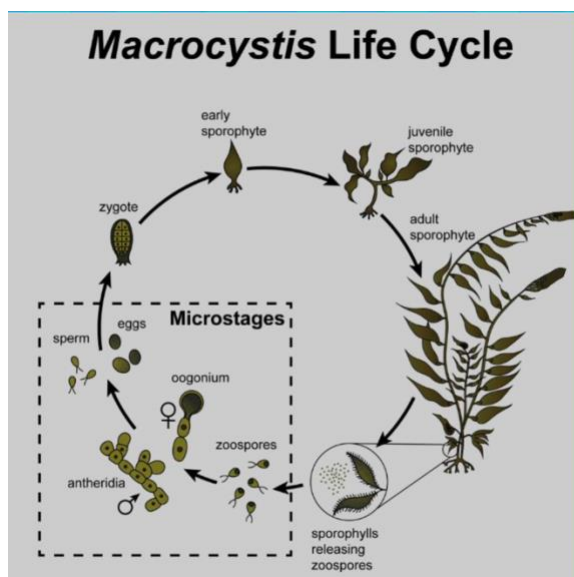


Figure 1. Illustration of alternating generations of kelp life cycle, including both macroscopic stages (sporophyte stages) and microscopic stages (gametophyte stages). The mature sporophyte releases zoospores, which develop into male (antheridia) and female (oogonium) gametophytes. Figure by: Dr. Adi Khen/Scripps Institution of Oceanography

The reproduction of kelp occurs through a complex life cycle with two main stages: the sporophyte (visible) and the gametophyte (microscopic) generations (see Figure 1). The kelp more commonly seen, the sporophyte, releases spores (small reproductive units) that settle on the

seafloor and grow into tiny gametophytes. Gametophytes are microscopic, and they make male and female reproductive cells, which come together to create a new visible sporophyte, completing the cycle.

Giant kelp, aptly named for its size, is one of the largest and fastest-growing types of algae. It can grow up to two feet a day in ideal conditions and reach heights of 98 to 173 feet. This rapid growth creates a dynamic habitat that provides refuge for various fishes, invertebrates, and other marine life, making kelp forests crucial for supporting marine biodiversity and healthy ecosystems.

Status of Kelp in Monterey Bay National Marine Sanctuary

Kelp thrives in nutrient-rich, cold waters and requires abundant sunlight for optimal growth. It is sensitive to a variety of physical factors, including water quality, water temperature, nutrient availability, turbidity (water cloudiness), large waves, and overharvesting at a commercial scale. These factors can lead to significant declines in kelp growth making kelp forests a crucial indicator of broader marine ecosystem health.

The kelp forests of northern and central California have experienced noticeable declines in recent years. Over 90% of the northern bull kelp forests from Van Damme in Mendocino County to Fort Ross in Sonoma County have been lost. This is potentially due to a combination of the [2014–2016 marine heatwave](#) (warm water event), unusually high recruitment of sea urchins, and the loss of the sunflower sea star (*Pycnopodia helianthoides*), a key predator of kelp-eating urchins. Kelp forests in Monterey Bay have also experienced a drastic reduction in recent years, which has profound ecological implications for the overall composition of coastal ecosystems.

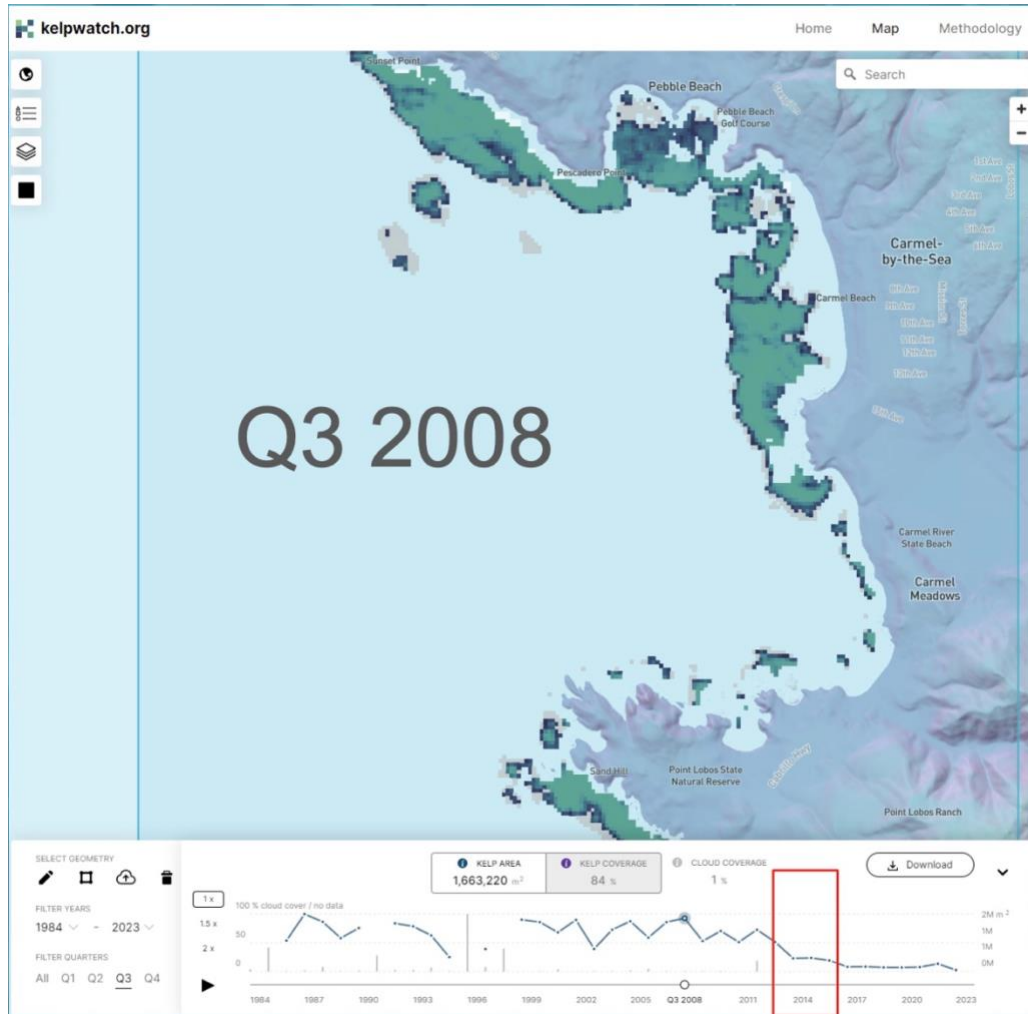


Figure 2. Kelp coverage in quarter three of 2008 from Sunset Point to Point Lobos State Natural Reserve. Data source: KelpWatch.org

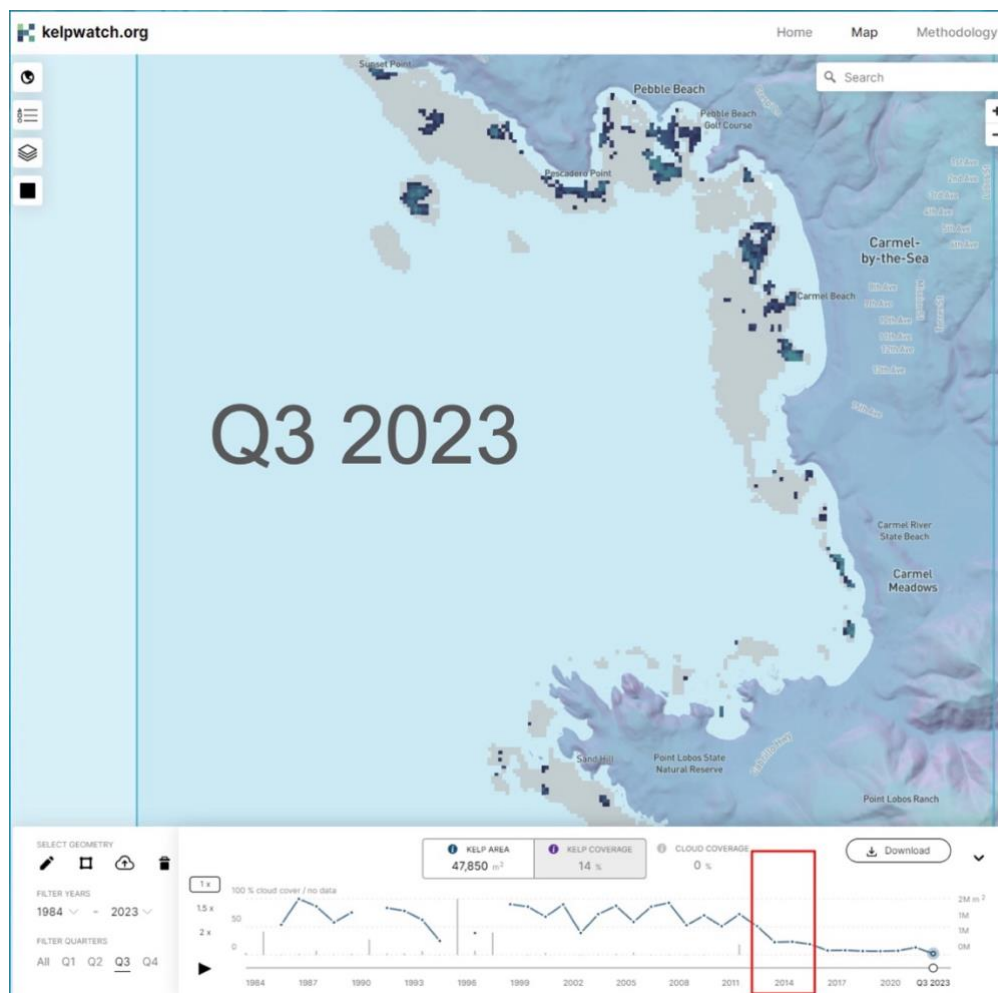


Figure 3. Kelp coverage in quarter three of 2023 from Sunset Point to Point Lobos State Natural Reserve. Data source: KelpWatch.org

The decline in kelp abundance can be traced to a combination of factors such as herbivore overgrazing and marine heatwaves, which have become more frequent and severe over time. Starting in the fall of 2013, a marine heatwave known as “The Blob,” which lasted for 711 days, showed maximum sea surface temperature anomalies of much as [43°F](#) along the U.S. west coast. A [2014–2016 El Niño](#) event and a lingering high-pressure ridge contributed to the unusually high water temperatures experienced in northern and central California. Hopkins Marine Station in Monterey Bay recorded six marine heatwaves in 2015, with 151 total days of marine heatwaves that year. Figures 2 and 3 show the change in kelp coverage south of the Monterey Peninsula from 2008 to 2023, with a red box around the dip in kelp coverage in 2014. The map in 2008 shows a thriving kelp forest with dense growth and canopy coverage, while the 2023 map reveals a significant decline in kelp abundance, characterized by sparse coverage and diminished canopy structure. Because they depend on nutrient-rich upwelled waters for their productivity, kelp forest abundance and distribution is strongly correlated with changes in ocean temperatures. Long-term environmental stresses can delay the recovery of these ecosystems.



An urchin-dominated community in Monterey Bay National Marine Sanctuary. Photo: Steve Lonhart/NOAA

A biological cause of kelp forest loss is overgrazing by herbivores, including red urchins (*Mesocentrotus franciscanus*) and purple urchins (*Strongylocentrotus purpuratus*). When drift algae is scarce, these urchins will leave protected crevices and roam freely, grazing on bull and giant kelp. If the number of urchins is very high due to large numbers of new individuals being added to the population at one time, predators such as sea otters and sea stars cannot limit their population size. Overgrazing by urchins creates deforested areas or “urchin-dominated communities,” which are regions mostly devoid of larger brown algae and populated by crustose red algae. These low-productivity areas are an alternate stable state to lush kelp forests and their associated upper canopies. Whereas a kelp-dominated community supports diversity among marine life, urchin-dominated areas show an increase in urchin presence and decrease in drift algae and all other associated biota typically found with a lush kelp forest, among other factors (see Figures 4 and 5).



Figure 4. In a series of different states of kelp forest communities, a kelp-dominated area has characteristics of normal to low water temperature, abundant drift algae, and urchins staying in crevices. Artwork by: Lila Luthy

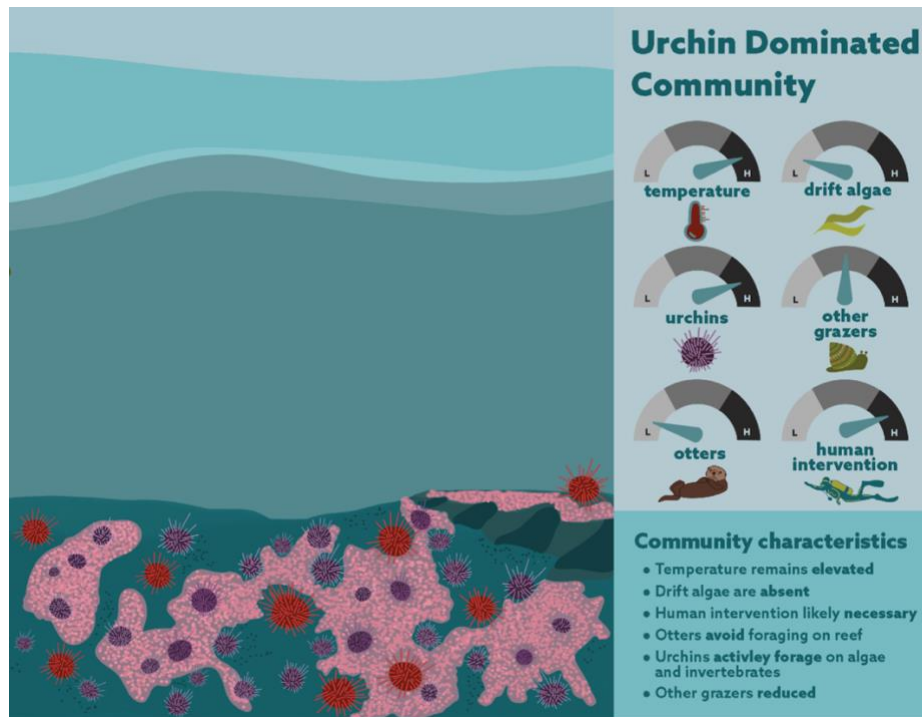
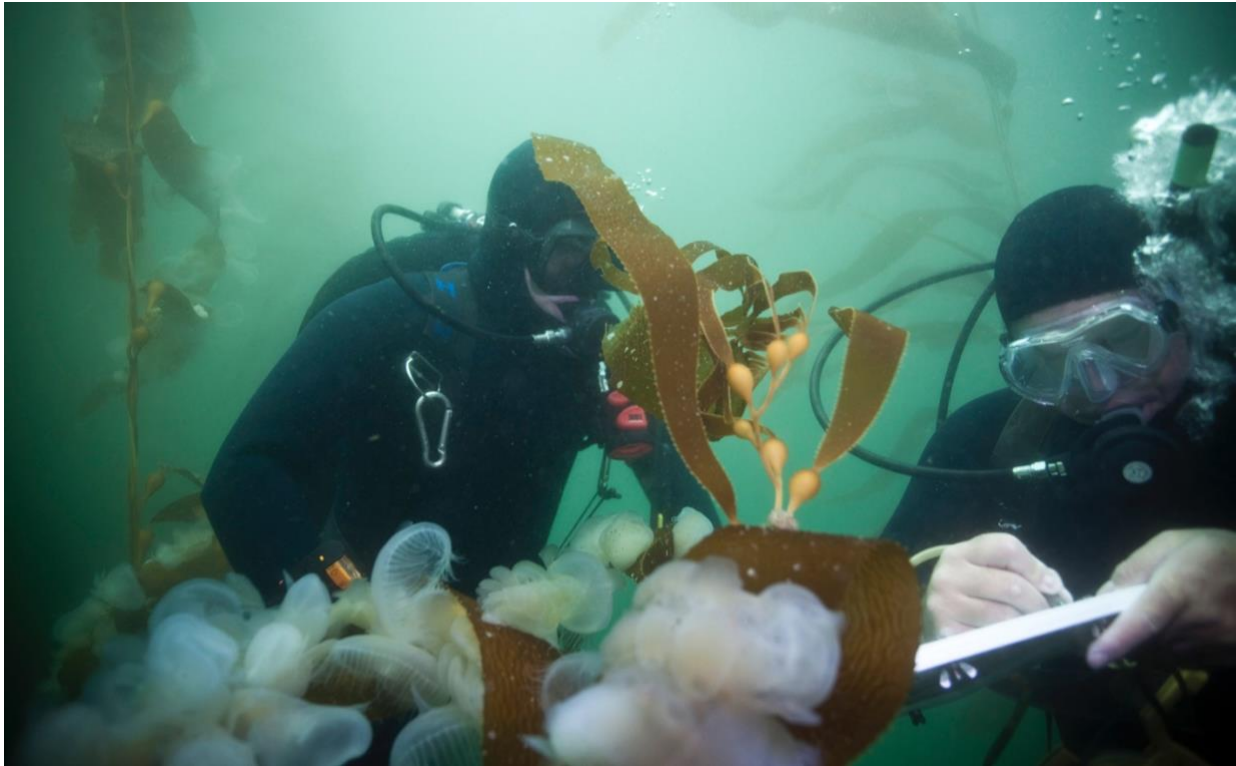


Figure 5. In a series of different states of kelp forest communities, an urchin-dominated area has characteristics of elevated water temperature, absent drift algae, and urchins actively foraging on algae. Artwork by: Lila Luthy

Section 2: Strategies and Activities



Research divers take notes on the hooded nudibranch (*Melibe leonina*), which were found on dozens of giant kelp between a depth of 15 and 30 feet offshore of Pfeiffer Big Sur State Park. Photo: Chad King/NOAA

Strategy 1: Education and Outreach

Education and outreach are one of the main pillars of MBNMS management to help fulfill its overarching mission “to understand and protect the coastal ecosystem and cultural resources of Monterey Bay National Marine Sanctuary.” Strategy 1 of the Iconic Kelp Action Plan focuses on education and outreach relative to the sanctuary’s iconic kelp. For inclusive outreach to be effective, activities need to value individuals and groups from diverse backgrounds, as it is important for everyone to realize their own connection to kelp.

Activity 1.1: Identify key audiences for kelp-related information from the sanctuary. Audiences could include, but are not limited to, kayaking and whale watching businesses, resource managers, teachers and students, sanctuary volunteers, the general public, and news outlets.

Activity 1.2: Develop key messages and talking points that address, the biology of kelp; the status of kelp within MBNMS; importance of kelp to diverse groups, acknowledging their

relationship with the coast; human benefits from a healthy kelp ecosystem; and how the public can volunteer in kelp-related activities. Talking points should be specific for various audiences identified in Activity 1.1.

Activity 1.3: Incorporate key messages and talking points into existing K–12, college, and public programming at sanctuary visitor centers.

Activity 1.4: Incorporate key messages and talking points into sanctuary volunteer training programs, specifically for visitor center docents and Bay Net and Team OCEAN naturalists, to increase interpretation to the public.

Activity 1.5: Incorporate key messages and talking points for sanctuary media engagement opportunities and social media efforts. Develop and share a kelp social media toolkit for partners and other social media influencers to broaden audience reach.

Activity 1.6: Enhance kelp interpretation at the Sanctuary Exploration Center by incorporating key messages and talking points into the existing kelp forest gallery exhibit signage. Work with partners to develop kelp signs along coastal access areas, where appropriate (e.g., Capitola Wharf Enhancement Project).

Activity 1.7: Incorporate kelp talking points (see Activity 1.2) into existing and new platforms for outreach such as: booths at large events (e.g., Whalefest), Blue Minute with KRML, and other public events (e.g., Rotary, Tap talks, food events).

Relevant strategies/activities located within the [MBNMS management plan](#)

Activity IK-1.3 → Education, Outreach, and Communication Activity EOC-1.1

Activity IK-1.4 → Education, Outreach, and Communication Activity EOC-2.1

Activity IK-1.5 → Education, Outreach, and Communication Activity EOC-6.5

Activity IK-1.6 → Education, Outreach, and Communication Strategy EOC-4

Activity IK-1.7 → Education, Outreach, and Communication Activity EOC-2.4;

Education, Outreach, and Communication Strategies EOC-5, 6

Potential Partners: California Department of Fish and Wildlife, City of Capitola, City of Monterey, City of Santa Cruz, Giant Giant Kelp Restoration Project, kayaking and whale watching vendors, KelpWanted, local Chambers of Commerce, local social media influencers, Monterey Bay Aquarium, Monterey Bay National Marine Sanctuary Foundation, Ocean Protection Council, O’Neill Sea Odyssey, rotary clubs, Sunflower Star Laboratory, Western Flyer Foundation.

Strategy 2: Agency Coordination and Project Streamlining

Numerous agencies, organizations, and individuals actively work on kelp projects within MBNMS. For the sanctuary to be most effective, coordination is critical to ensure kelp research and restoration projects are neither duplicative nor overlooked. Creating a common understanding of regional kelp projects will facilitate efficient progress in addressing kelp related issues.

Activity 2.1: Develop a summary of existing regional kelp research and restoration efforts in central California to facilitate effective collaboration. Information on community efforts, funded grants, student research, permitted activities, strategic planning efforts, etc. will be compiled and made publicly accessible on the SIMoN website.

Activity 2.2: Describe the agency permit processes and coordinate among interested parties to determine if kelp research and restoration can be streamlined. This will include providing an overview of resource management agency regulatory roles for addressing kelp and identifying any management and regulatory constraints on research and restoration efforts, particularly within state marine protected areas (MPAs). Information could include, for example, any limitations to out-plant kelp, the duration of research and restoration efforts (e.g., pilot efforts, long-term adaptive management), and special considerations for Indigenous Communities (see Strategy 5). As outlined in the most recent California Department of Fish and Wildlife (CDFW) [MPA Decadal Management Review](#), the Ocean Protection Council's Restoration and Mitigation Policy could be used to develop a framework for evaluating and approving restoration and mitigation actions. Research results from restoration studies will inform permit considerations, and permit authorizations may be a useful tool.

Activity 2.3: Participate in the integration of partner planning processes related to kelp management plans, including direct coordination and periodic updates provided to the MBNMS Advisory Council. Some kelp planning processes include: CDFW's Kelp Restoration and Management Plan; CDFW's MPA Decadal Management Review; Greater Farallones National Marine Sanctuary Kelp Restoration Plan; MBNMS' Climate Adaptation Plan; MBNMS' Iconic Kelp Action Plan; MBNMS' Management Plan; Monterey Bay Aquarium's Conservation and Science Programs.

Relevant strategies/activities located in the [MBNMS management plan](#)

Activity IK-2.1 → Research and Monitoring Strategy RM-2

Activity IK-2.2 → Resource Protection Strategy RP-3

Activity IK-2.3 → Operations and Administration Activity OA-2.5, Resource Protection Strategy RP-1

Potential Partners: California Department of Fish and Wildlife, California Ocean Science Trust, California Sea Grant, California State University Monterey Bay, Central and Northern California Ocean Observing System, Hopkins Marine Station, Kelp Forest Alliance, Middlebury Institute of International Studies at Monterey, Monterey Bay Aquarium, Monterey Bay Aquarium Research Institute, Moss Landing Marine Laboratories, Ocean Protection Council, Reef Check Foundation, U.S. Geological Survey, University of California at Santa Cruz.

Strategy 3: Research and Monitoring

Research and monitoring is a key component of the sanctuary program, including physical assets (e.g., boats, drones), personnel support for research, and staff expertise. The MBNMS research activity panel wrote a memo that details kelp research needs in the sanctuary region (see [Appendix](#)). Strategy 3 addresses what the sanctuary staff should focus on with its operational and staff resources.

Activity 3.1: Develop a study on the economic, social, and cultural values of healthy kelp forests. Research should involve: 1) a socioeconomic study on kelp and healthy kelp forests, and 2) the identification of high priority areas including ecologically, socially, and culturally relevant kelp bed locations. This information will guide where restoration efforts should be focused, in concert with CDFW.

Activity 3.2: Develop visual and conceptual tools (i.e., infographics, web-enabled condition report) of MBNMS kelp forests that will include key kelp messaging and talking points (see Activity 1.2). The product will help identify research information gaps to understanding kelp ecosystems and restoration. A draft of this conceptual model is already completed and was presented as background information to the kelp working group, and a related infographic on the kelp habitat in sanctuary condition reports will also provide useful information on critical scientific parameters to be monitored.

Activity 3.3: Improve fine-scale mapping of kelp forest canopies through time. While broad regional trends in kelp forest canopies have been demonstrated by satellite data, individual kelp forest information is needed to inform local changing and restoration options. This work is most likely best informed through surveys conducted by uncrewed aircraft systems/drones.

Activity 3.4: Support research, restoration, and monitoring of kelp forests with MBNMS boating and dive operations. MBNMS boats and dive programs are well suited to support collaborative agency and academic studies. For example, MBNMS staff participate in Partnership for Interdisciplinary Studies of Coastal Oceans monitoring training; boat access to research sites with CDFW and University of California Santa Cruz; dive studies on restoration method effectiveness; and long-term monitoring of Big Sur kelp forests. The research activity panel has

provided a list of kelp related research needs, which could be supported with extramural funds and MBNMS boat and diving operations (see [Appendix](#)).

Relevant strategies/activities located in the [MBNMS management plan](#)

Activity IK-3.1 → Resource Protection Strategy RP-2

Activity IK-3.2 → Research and Monitoring Activity RM-5.7

Activity IK-3.3 → Research and Monitoring Activity RM-1.1

Activity IK-3.4 → Research and Monitoring Activities RM-3.7, 3.8, 3.9

Potential Partners: California Department Fish and Wildlife, California Ocean Science Trust, California Sea Grant, California State University Monterey Bay, Central and Northern California Ocean Observing System, Channel Islands National Marine Sanctuary, dive clubs, Greater Farallones National Marine Sanctuary, Hopkins Marine Station, kayaking and whale watching vendors, Middlebury Institute of International Studies at Monterey, Monterey Abalone Company, Monterey Bay Aquarium, Monterey Bay Aquarium Research Institute, Moss Landing Marine Laboratories, Ocean Protection Council, Partnership for Interdisciplinary Studies of Coastal Oceans, University of California at Santa Cruz.

Strategy 4: Pursue Science-Based Kelp Restoration that Moves Beyond the Pilot Scale

There have been a number of kelp restoration efforts around the globe and a few pilot-scale kelp restoration efforts within MBNMS. This strategy explores how and if the sanctuary should consider the development of larger scale projects.

Activity 4.1: Develop a list of considerations to address before implementing a kelp restoration project. This list will inform permitting decisions (see Activity 2.2) and research needs (see Activity 3.4). Important concepts to consider might include previous success of the proposed method; purpose relative to specific user groups; project longevity, project geographic scale; available human resources and financial support; and monitoring to assess method efficiency, efficacy, and ecological success. Decisions should be science-based.

Activity 4.2: Evaluate the costs associated with different restoration approaches. Some kelp restoration efforts have been effective, but an assessment of their cost is necessary before scaling these efforts up to select kelp beds or regional and sanctuary-wide scales.

Activity 4.3: Clarify among academic institutions, community scientists, and fishermen how efforts can be more feasible to support collaboration. These groups would like to work together more, however, there may be institutional, financial, and legal roadblocks to address.

Activity 4.4: Continue providing support for underwater field work that advances our understanding of kelp restoration and supports its application, with considerations developed in Activity 4.1.

Relevant strategies/activities located in the [MBNMS management plan](#)

Activity IK-4.1 → Resource Protection Strategy RP-3

Activity IK-4.3 → Research and Monitoring Activity RM-4.4

Activity IK-4.4 → Research and Monitoring Activity RM-3.8

Potential Partners: California Department of Fish and Wildlife, California Sea Grant, California State University Monterey Bay, Central and Northern California Ocean Observing System, Giant Kelp Restoration Project, Hopkins Marine Station, Kelp Forest Alliance, Middlebury Institute of International Studies at Monterey, Monterey Bay Aquarium, Monterey Bay Aquarium Research Institute, Moss Landing Marine Laboratories, Ocean Protection Council, Reef Check Foundation, University of California at Davis, University of California at Santa Cruz.

Strategy 5: Engagement with Indigenous Peoples, Governments, and Tribes (Indigenous Communities)

Indigenous Communities are the original stewards of their homelands, which align with areas within and adjacent to MBNMS. With respect for and appreciation of the unique knowledge held and for their continued caretaking of these areas, MBNMS staff will work to equitably and meaningfully engage and collaborate with Indigenous Communities within MBNMS regarding the topic of kelp. This strategy is building off of [Imila-alpa Commitments](#) from an April 2024 Cross Pacific Indigenous Exchange meeting, the MBNMS process for engaging with Indigenous Peoples on the advisory council, and related relationship building initiatives.

Activity 5.1: Work with Indigenous Communities to understand their cultural needs and other interests related to kelp in general and specific kelp beds. MBNMS will take advice from Indigenous partners on the best way to address this activity (see Activity 3.1).

Activity 5.2: Engage with Indigenous Communities adjacent to MBNMS to support their kelp related access, cultural activities, and other ocean conservation interests (see Activity 4.3).

Relevant strategies/activities located in the [Imila-alpa Commitments](#)

Activity IK-5.1 → Imila-alpa Commitment 8

Imila-alpa Commitment 8: Continue to support, and where possible, expand the inclusion of Indigenous approaches to conservation, including cultural and language conservation and revitalization (e.g., supporting cultural activities, access, inclusion of Indigenous

worldviews in sanctuary processes, inclusion of Indigenous languages in outreach, place names).

Activity IK-5.2 → Imila-alpa Commitment 10

Imila-alpa Commitment 10: Enhance involvement and collaboration with Indigenous governments and organizations whose homelands align with National Marine Sanctuary System sites.

Relevant strategies/activities located in the [MBNMS management plan](#)

Activity IK-5.1 → Maritime Heritage Activity 1.4

Activity IK-5.2 → Operations and Administration Activity OA 6.4

Indigenous Governments, Organizations, and Communities Adjacent to MBNMS (alphabetical order)

Amah Mutsun Tribal Band (and/or Amah Mutsun Land Trust); Association of Ramaytush Ohlone; Chumash Indian Council of San Luis Obispo; Costanoan Rumsen Carmel Tribe; Esselen Tribe of Monterey County; Federated Indians of Graton Rancheria; Northern Chumash Tribal Council; Ohlone Costanoan Esselen Nation; Salinan Tribe of Monterey & San Luis Obispo Counties; Xolon Salinan Tribe; yak titʷu titʷu yak tilhini (ytt) Northern Chumash Tribe of San Luis Obispo County and Region.

Strategy 6: Support Kelp Plan Strategies

To implement the Iconic Kelp Action Plan strategies and activities, MBNMS will require additional financial and other resources from a diverse group of parties and organizations. This strategy addresses opportunities for how MBNMS can acquire additional resources to implement the Iconic Kelp Action Plan.

Activity 6.1: Identify the staffing and other financial resource needs for each activity within the kelp plan. Having an estimated budget for each activity will facilitate requests for support by MBNMS and partners.

Activity 6.2: Identify and apply to potential sources of funding for kelp plan priorities. Respond to agency requests for funding proposals and work with partners, foundations, and individual donors to acquire additional resources to address strategies and activities.

Activity 6.3: Provide talking points and kelp restoration updates to Sanctuary Advisory Council members, so they can reach out to potential funders directly or through their constituents (see Activity 1.2 and 1.5). The advisory council may also decide to write letters of support for proposals developed under Activity 6.2.

Relevant strategies/activities located in the [MBNMS management plan](#)

Activity IK-6.2 → Operations and Administration Activities OA-1.1, 2.4

Potential Partners: California Marine Sanctuary Foundation, MBNMS Advisory Council, Monterey Bay National Marine Sanctuary Foundation, National Marine Sanctuary Foundation, NOAA's Office of Response and Restoration, Ocean Protection Council, philanthropists.

Section 3: Performance Measures Table

Iconic Kelp Action Plan Goal: Address the regional loss and long-term health of kelp forest ecosystems in the sanctuary through education, coordination with partners, research, restoration, and community engagement.

Performance Measures Table

MBNMS will use the performance measures identified below to evaluate progress of the Iconic Kelp Action Plan. Performance measures tables assist in tracking the implementation of action plans.

Strategy Title	Desired Outcome (Objective)	Output Measure	Who Measures	Timeline
Strategy IK-1: Education and Outreach	Increase awareness and protection of kelp forests by building greater public understanding, engagement, and stewardship in our highly diverse coastal ecosystems	Key audiences for kelp-related information identified	Education and Outreach Team	Year 1
		Talking points and key messages developed for each audience	Education and Outreach Team	Year 1
		Talking points and key messages incorporated into appropriate outreach channels	Education and Outreach Team	Year 2, Ongoing
Strategy IK-2: Agency Coordination and Project Streamlining	Sanctuary and other agencies collaborate on and prevent duplication of kelp-related projects	Summary of regional kelp efforts in MBNMS completed and updated by the end of each calendar year	Research Team	Year 1, Ongoing
		Overview of resource management agency regulatory roles for kelp developed, including the identification of constraints	Resource Protection Team	Year 1
Strategy IK-3: Research and Monitoring	Continue to contribute to kelp forest ecosystem understanding and health through research and monitoring	Socioeconomic study on kelp conducted, including the identification of high priority kelp bed locations for restoration	Research Team	Year 1 and 2, Ongoing

Strategy Title	Desired Outcome (Objective)	Output Measure	Who Measures	Timeline
		Drone footage continually taken of select kelp forest canopies	Research Team	Quarterly
		Include infographic of kelp forests in web-enabled condition report	Research Team	Year 2
		Support field monitoring of kelp	Number of DAS and monetary value each year vessels <i>Tegula</i> and <i>Fulmar</i> are used for kelp monitoring, including number of divers and monetary value	Research Team
Strategy IK-4: Pursue Science-Based Kelp Restoration that Moves Beyond the Pilot Scale	Explore clearly defined, science-based kelp restoration in the sanctuary	List of restoration considerations developed. Coordinate with state KRMP to develop MBNMS specific restoration considerations	Coordinators and Superintendent	Year 2
		Costs of restoration approaches evaluated	Research or Resource Protection Team	Year 2
Strategy IK-5: Engagement with Indigenous Peoples, Governments, and Tribes (Indigenous Communities)	Engage with Indigenous Communities on kelp-related needs	Garner advice from Indigenous partners on how best to proceed with conversations on kelp-related needs	Superintendent and Indigenous Engagement Coordinator	Ongoing
Strategy IK-6: Support Kelp Plan Strategies	MBNMS has the resources to implement the Iconic Kelp Action Plan's strategies and activities	Funding and staffing needs identified annually for each activity	Coordinators and Superintendent	Year 1, Ongoing
		Potential funding sources identified	Coordinators and Superintendent	Ongoing

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Appendix – Research Activity Panel Kelp Memo

January 27, 2023 MEMORANDUM FOR:

FROM: SUBJECT:

Brian Nelson, Chair

Monterey Bay National Marine Sanctuary Advisory Council

Lisa Wooninck, PhD, Superintendent Monterey Bay National Marine Sanctuary

Steven Haddock, PhD, Acting Chair

Monterey Bay National Marine Sanctuary Research Activity Panel

Response to request from MBNMS AC on iconic kelp

Kelp (*Macrocystis pyrifera* and *Nereocystis luetkeana*) form an iconic habitat in Monterey Bay National Marine Sanctuary (MBNMS). Kelp canopies have declined drastically in Northern California and there has also been a noticeable decline within MBNMS, where kelp supports valuable economic and cultural resources. The Research Activity Panel (RAP) has discussed the issue at several meetings and received additional insight from internationally recognized kelp experts. On December 9, 2022, the MBNMS Advisory Council (AC) approved a motion requesting the RAP, “evaluate in MBNMS suggested/proposed options for science to inform monitoring, recovery, and restoration of kelp forests.” Below, please find a series of RAP-endorsed related science projects that need to be addressed; though numbered, the items are not prioritized. Potential MBNMS contributions to these efforts include: staff support (subject matter experts; field operations); use of MBNMS research vessels; facilitating coordination with other kelp interest groups; and supporting funding efforts to address the research.

1) Monitoring the natural recovery of giant kelp forests

Monitoring the natural recovery of kelp forests is necessary to identify the environmental and ecological conditions that are conducive to forest recovery. The objective is to monitor and compare kelp forests that exhibit early phases of recovery with those that do not, to identify those conditions that facilitate recovery. The information would inform when and where restoration efforts might be most successful, as well as what can be done to expedite recovery (e.g., urchin removal, kelp out planting). This type of information is also necessary for accurate MBNMS Condition Reports. Methods to address this topic could include modifications to ongoing PISCO/MPA diver surveys, additional surveys, and aerial drone canopy surveys.

2) Determining sea urchin behavior in kelp forests of various conditions

By determining the size distribution, movement, relative abundance of exposed and concealed urchins, and associated levels of live and drift algal cover, this project would inform conditions needed to facilitate kelp forest recovery (e.g., altering sea urchin behavior or reducing their

numbers). It is also possible that kelp and urchins interact differently in deep reefs, at the limits of standard SCUBA diving depths, providing some sort of kelp refuge. Methods to address this topic could include academic and community scientist diver surveys, and use of the recently developed autonomous camera system BOSS (Benthic Observation Survey System).

3) Determining the role of sea otters in persistent boundaries of healthy kelp forests. Sea otters feed preferentially on sea urchins that have healthy gonads, and these may be associated with access to drift algae at the boundaries of healthy kelp forests. By assessing biomass of urchins (concealed and exposed) and frequency of otters in healthy kelp forests, there will be an improved understanding of whether otters actively protect forest boundaries or whether intervention with urchin removal is necessary to protect and expand remnant forests. The Monterey Bay Aquarium has initiated this project with UC Santa Cruz.

4) Determining the effects of urchin density on urchin condition and kelp recruitment and survival

This study would assess the effect of the separate and combined densities of both red and purple urchins on kelp settlement and post-settlement survival. Red and purple urchin densities would be manipulated in cages while associated kelp recruitment and gonad conditions would be measured. Related experiments could be done by creating urchin clearings of different sizes at different frequencies to determine thresholds for kelp recovery. This project not only informs efforts to facilitate recovery, but also evaluates the effect of purple urchin numbers on the marketability of red urchins (*foruni*) in northern California.

5) Evaluating the areal extent of kelp spore dispersal “shadow”

The objective of this study would be to determine what dispersal patterns can be expected from kelp. Methods to address this question could include measuring recruitment on settling plates at different distances from naturally persisting kelp or placed spore sources (e.g., bags of sporophylls or translocated kelp) of giant and/or bull kelp. Knowledge of the distance of spore dispersal will inform where restoration efforts can leverage natural spore dispersal or require out planting.

6) Evaluating the required frequency of urchin removal to maintain or expand forests. For protecting remaining forests or restoring kelp through expansion of those forests, it is important to understand: the relationship between the width of an urchin removal border and frequency of urchin removal to maintain reduced urchin densities; how that relationship differs with the rugosity of the reef; how the relationship varies with the density of urchins in the adjacent barrens; how the density of other herbivores (e.g., gastropods, herbivorous crabs) alter the effect of urchin removals on the maintenance of forest boundaries; what the recruitment rate of kelp plants is relative to urchin density; what the overall effort (number of visits and number of divers) per unit length of a removal area is required to maintain urchin removals; and what the costs (e.g., divers, time, vessels) are associated with the overall effort. Carefully designed experiments could be addressed through a professional and community scientist collaboration.

These questions are already being addressed, in part, at “Tanker Reef” by CDFW, MBNMS and community scientists.

7) Evaluating the effects of environmental conditions on the foraging rate of purple sea urchins and kelp production

Mesocosms (large outdoor tanks at marine labs) can be used to determine relationships between water chemistry and temperature on urchin feeding and kelp growth. If grazing rate increases with water temperature, it may explain the outbreak of urchins associated with the marine heatwave. If grazing rates decline with cold temperatures, it might suggest recovery will coincide with cold water events/locations (upwelling) and years; these would also be favorable conditions for restoration projects. This project has been initiated by a UC Santa Cruz PhD student.

8) Evaluating the effects of water temperature, density and starvation on disease in the purple sea urchin

Recovery of kelp may be determined by a decrease in density of sea urchins, and sea urchin densities in southern California have declined with disease outbreaks. Knowing what conditions are conducive for disease outbreaks would allow for predictions of whether outbreaks will naturally control urchin numbers. This study would involve laboratory experiments where temperature, urchin body condition and urchin density are manipulated to assess the infection rate and mortality from black spot disease.

9) Developing an understanding of the economic and social values of healthy kelp forests

Kelp forests have value for a number of human uses like: providing critical habitat for dozens or hundreds of key species; recreational diving opportunities; food for abalone aquaculture; habitat that supports commercial and recreational fisheries; decreasing coastal erosion; scenic value, including bird and sea otter watching; and cultural activities, including for indigenous groups. An academic study on the social/cultural and monetary value of MBNMS kelp forests would inform the need to protect and restore this iconic habitat.

10) Taking advantage of remote sensing technology

Satellites are able to make large scale assessments of changing kelp cover, and lower altitude drones can provide higher resolution imagery. LIDAR from planes can be used to distinguish between the canopies of different species of kelp and to assess the health of plants. Monterey Bay Aquarium Research Institute (MBARI) is developing a drone program with long-range capabilities and CSU Monterey Bay already has a short-range drone program (partly funded by NOAA). Datasets generated by these surveys could be integrated with other data sharing products being developed by the Central and Northern California Ocean Observing System (CeNCOOS).

11) Developing a visual, conceptual model of MBNMS kelp forests

This model would include: environmental causes for growth and decline; anthropogenic causes for growth and decline; biological interactions impacting kelp abundance; and effects of different restoration methods. A visual (graphic) model would highlight how science questions around

kelp are interrelated and the role of different restoration methods. The model would also have heuristic value in interpreting this complex system to decision makers.

12) Assessing the potential of solutions from aquaculture

Conservation aquaculture has been used in marine systems to outplant impacted species for restoration (e.g., white abalone); to select for individuals that are resistant to problematic pressures (e.g., heat resistant populations); to grow and release predators that reduce problematic species (e.g., sea stars that eat urchins); and to enhance the commercial value of harvested species (e.g., feed collected urchins until they are valuable for human consumption). While not necessarily in the purview of MBNMS, NOAA has been promoting aquaculture as a necessary component to addressing the increasing need of seafood for human consumption.

13) Developing a historical perspective

Using tools of historical ecology (e.g., old photographs, media interviews) it would be valuable to develop retrospective knowledge on variability in MBNMS kelp canopy cover through time. This would help provide targets for kelp restoration, could determine if kelp has decreased and recovered before (to what levels and over what time periods), and therefore provide guidelines on the urgency of MBNMS resource management actions.



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