COMMITTEE STAFF SUMMARY FOR NOVEMBER 16, 2023 MRC

4. KELP

Today's Item

Information 🛛

Action 🗆

- (A) Receive Department update on and discuss collaborative kelp restoration efforts and recovery tracking; and
- (B) Receive Department update on developing a kelp restoration and management plan (KRMP) for giant and bull kelp.

Summary of Previous/Future Actions

•	Commission referred kelp recovery and restoration tracking to MRC	October 9-10, 2019
•	MRC received overview of collaborative kelp recovery and restoration efforts	November 5, 2019; MRC
•	Department and California Ocean Protection Council (OPC) update on kelp recovery and restoration and release of interim action plan	March 16, 2021; MRC
•	Commission referred KRMP development to MRC	February 16-17, 2022
•	MRC received Department overview of a plan and process for KRMP development	March 24, 2022; MRC
•	Department presentation on kelp recovery and restoration tracking, and KRMP development	March 14 and 16, 2023; MRC
•	Today's Department update on kelp recovery and restoration efforts and KRMP development	November 16, 2023; MRC

Background

(A) Kelp Restoration Efforts and Recovery Tracking

In October 2019, the Commission received an update on the dramatic declines in bull kelp persisting across the northern California coastline and, based on interest in tracking kelp recovery and kelp restoration strategies and efforts, referred the topic to MRC. In November 2019, the Department provided MRC with an overview of collaborative kelp recovery and restoration efforts underway or under development by partners and the Department.

Department and OPC staff provided a joint presentation at the March 2021 MRC meeting, with an update on bull kelp conditions in northern California, in addition to highlighting efforts to track, coordinate on, and plan for kelp recovery, supported by *Interim Action Plan for Protecting and Restoring California's Kelp Forests* (interim action plan), released by OPC in February 2021. The interim action plan, developed in partnership with the Department, was intended to broadly serve as a starting point for discussions and planning amongst natural resource managers, the academic community, California tribes, coastal stakeholders, and members of the public.

The most recent update on the status of kelp canopy coverage was presented to MRC in March 2023, covering both bull kelp and giant kelp trends statewide. Trends reflected

persistent kelp loss in the north and different patterns of kelp loss and recovery across the remainder of the state. The Department also shared progress of collaborative projects exploring kelp restoration.

(B) Developing a Kelp Recovery and Management Plan

In February 2022, the Department reported that, consistent with the interim action plan, it was initiating a process to develop a statewide, ecosystem-based, adaptive KRMP for giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis luetkeana*), with the ultimate goal of adoption by the Commission. The Commission referred KRMP development to MRC as a work plan topic.

In March 2022, the Department presented an overview of its proposed approach for preparing a KRMP. Developed in partnership with OPC, the KRMP would include three core components: (1) a harvest management framework and other fishery management plan elements required by the Marine Life Management Act; (2) an innovative framework for ecosystem management of kelp forests; and (3) a restoration toolkit. The public engagement process was designed to include tribal engagement, a science advisory committee, and a community working group.

In July 2022, MRC requested that the Department prepare for today's meeting an update on progress pursuing a KRMP as well as more detail about kelp recovery tracking and the range of collaborative restoration projects.

Update

For today's meeting, the Department has provided a comprehensive report, prepared collaboratively with OPC, titled *Status of Research and Monitoring, Restoration Efforts, and Developing Management Strategies for Kelp Canopy Forming Species in California* (kelp report; Exhibit 1). The kelp report provides an update on KRMP development, an overview of bull kelp and giant kelp status and monitoring data, and an overview of research projects across the state exploring kelp restoration techniques.

Today, the Department will make a presentation (Exhibit 2), prepared in collaboration with OPC staff, that highlights key details from the kelp report and efforts to date in KRMP development, including initial outreach and meetings with tribes, the community working group, and a scientific advisory council.

Following today's meeting, the Department and partners will continue to conduct scientific, tribal, and stakeholder engagement; synthesize the state of the science; and identify and address key knowledge gaps.

Significant Public Comments (N/A)

Recommendation (N/A)

Exhibits

- 1. <u>Department and OPC report: Status of Research and Monitoring, Restoration Efforts,</u> <u>and Developing Management Strategies for Kelp Canopy Forming Species in</u> <u>California, dated November 2023</u>
- 2. <u>Department presentation</u>

Committee Direction/Recommendation (N/A)

Status of Research and Monitoring, Restoration Efforts, and Developing Management Strategies for Kelp Canopy Forming Species in California



(Photo Credit: CDFW)

California Department of Fish and Wildlife, Marine Region and

California Ocean Protection Council

November 2023



Citation: California Department of Fish and Wildlife (CDFW) and California Ocean Protection Council (OPC). 2023. Status of Research and Monitoring, Restoration Efforts, and Developing Management Strategies for Kelp Canopy Forming Species in California.

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LIST OF ACRONYMS

- CCR California Code of Regulations
- CSUMB California State University Monterey Bay
- CWG Community Working Group
- EBM Ecosystem Based Management
- ESR Enhanced Status Report
- FGC Fish and Game Commission
- FMP Fishery Management Plan
- F/V Fishing Vessel
- GFA Greater Farallones Association
- GFNMS Greater Farallones National Marine Sanctuary
- KRMP Kelp Restoration and Management Plan
- LTER Long Term Ecological Research
- MHW Marine Heat Wave
- MLML Moss Landing Marine Laboratories
- MPA Marine Protected Area
- NGO Non-Government Organization
- QAQC Quality Assurance Quality Control
- OPC Ocean Protection Council
- NOAA National Oceanic and Atmospheric Administration
- PISCO Partnership for Interdisciplinary Studies of Coastal Oceans
- SAC Scientific Advisory Committee
- SSU Sonoma State University

- SSWD Sea Star Wasting Disease
- TNC The Nature Conservancy
- UC University of California

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1. BACKGROUND

Two canopy forming kelp species, bull kelp (*Nereocystis luetkeana*) and giant kelp (*Macrocystis pyrifera*), occur in California and are regionally divided across the state. Bull kelp dominates the cooler waters of northern California, while giant kelp dominates southern California's nearshore waters. Central California provides a unique transitional environment where both species comprise a kelp forest ecosystem. In recent years, California has experienced climate-driven kelp declines along its coastline, with some regions and localized areas exhibiting severe and persistent loss that has led to significant negative impacts to biodiversity, coastal communities, and culturally and economically important fisheries.

Bull kelp forests in northern California, specifically in Sonoma and Mendocino counties, have been severely impacted by the North Pacific Marine Heat Wave (MHW) that emerged in 2014 and compounded with a strong El Niño in 2015, and an unprecedented increase in sea surface temperatures through 2016. Subsequent synergistic environmental stressors, including the loss of the predatory sunflower sea stars (*Pycnopodia helianthoides*) due to Sea Star Wasting Disease (SSWD) (Harvell et al. 2019) and increased densities of purple urchin (Strongylocentrotus *purpuratus*) of up to 60 times historical abundances (Rogers-Bennett and Catton, 2019), have led to a regime shift from kelp forest-dominated to urchin barrens over approximately 100 miles of the northern California coastline. For example, over 90% loss of observed bull kelp canopy has been documented in Sonoma and Mendocino counties, with little signs of recovery since 2014, which has had significant negative impacts to northern California's nearshore ecosystems resulting in the collapse of the commercial red urchin (Mesocentrotus franciscanus) fishery due to urchin starvation and lack of quality roe product forcing declaration for federal disaster regarding the fishery in 2015 and the closure of the iconic recreational red abalone (Haliotis rufescens) fishery in 2018 following extensive population declines.

In contrast to the region-wide devastation observed on the north coast, patterns in kelp canopy on California's central coast (San Francisco Bay to Point Conception) and south coast (Point Conception to U.S./Mexico border) are more complex. At the local scale in both of these regions, there are kelp beds exhibiting both long-term increases and decreases in kelp canopy. Kelp cover along the central coast region of the state has remained relatively stable, though localized areas along the Monterey Bay Peninsula have experienced significant declines since the 2014-16 MHW. While giant kelp and bull kelp co-occur in the central coast region, the Monterey Bay Peninsula has been predominantly composed of giant kelp. The giant kelp-dominated south coast region has also experienced declines since 2014, though not to the degree of loss observed on the north coast. The specific areas of concern

include Orange County, San Diego County, and San Miguel Island in the northern Channel Islands.

In an effort to address the catastrophic loss of kelp in key regions across the state, and to adaptively manage these vital marine ecosystems, the California Department of Fish and Wildlife (Department) and the California Ocean Protection Council (OPC) have prioritized the development of a Kelp Restoration and Management Plan (KRMP). The goal of the KRMP is to develop a robust, adaptive, climate-ready approach to managing, protecting, and restoring giant and bull kelp forest ecosystems statewide for consideration and adoption by the California Fish and Game Commission (FGC).

The state has also invested in the protection and restoration of kelp forest ecosystems, and the communities they support through grant funding opportunities aimed to fill critical knowledge gaps to advance the understanding of kelp restoration and research. As anthropogenic climate change is predicted to increase disturbances such as MHWs, and exacerbate stochastic events like El Niño Southern Oscillation, these research efforts provide a frontline defense for the protection and proliferation of these vital marine ecosystems and the associated fisheries they support.

This update consists of KRMP development, an overview of bull kelp and giant kelp status and monitoring data, and research projects across the state exploring kelp restoration techniques.

2. KELP RESTORATION AND MANAGEMENT PLAN DEVELOPMENT

2.1. Kelp Recovery and Management Plan Development Process

The Department, in partnership with OPC, is developing a statewide, ecosystembased, adaptive KRMP for giant kelp and bull kelp. The Department and OPC are using a multi-pronged approach, consisting of a Community Working Group, Science Advisory Committee, and Tribal Engagement to ensure the development of the KRMP is informed by the best available science and community perspectives across the state of California. The KRMP will include a cohesive kelp management strategy which consists of three core components: 1) a harvest management framework and other Fishery Management Plan (FMP) elements required by the Marine Life Management Act (MLMA); 2) an innovative framework for ecosystem-based management (EBM) of kelp forests; and 3) a Restoration Toolkit. The integration of EBM approaches and a Restoration Toolkit into the traditional FMP framework will facilitate a robust, adaptive, climate-ready approach to managing the State's kelp forest ecosystems in the face of changing ocean conditions. The KRMP development process is anticipated to occur over the course of three to five years. The KRMP will also reference and build off several guidance documents that have been developed for kelp recovery throughout the state including the Sonoma-Mendocino Bull Kelp Recovery Plan (2019), OPC Interim Kelp Action Plan (2021), and the Department's Giant Kelp and Bull Kelp Enhanced Status Report (2021).

The **Community Working Group (CWG)** is an informal advisory body composed of California Native American tribes, stakeholders, and interested members of the public established to help inform the design and development of the KRMP. The goals of the CWG are to advise on and inform the development of the core components of the KRMP. CWG members are tasked with sharing information about the KRMP development with their broader community networks, as well as gathering and sharing their communities' perspectives, interests, and feedback.

The **Science Advisory Committee (SAC)** is an independent body tasked with providing scientific expertise on all aspects of the KRMP to ensure the best available and most current science is directly integrated into the KRMP. The SAC is composed of experts in natural and social sciences, economics, and local and traditional knowledge, spanning a broad scope of disciplines and geographic areas.

Pathways for **Tribal Engagement** throughout the development of the KRMP include Tribal Roundtable Listening Sessions, government-to-government consultation, representation on the CWG and SAC. Additional pathways for engagement may be identified as the KRMP development process unfolds. A top priority for the State of California is to provide California Native American tribes the opportunity to inform the design and development of the KRMP's process and outcomes, including comanagement pathways, if this is identified as a priority by California Native American tribes.

2.2. Kelp Recovery and Management Plan Timeline

The KRMP development process is anticipated to occur over the course of three to five years. The early stages of KRMP planning began in 2022 and in 2023, the Department and OPC staff assembled the SAC and the CWG.

2022

- Fish and Game Commission Marine Resources Committee update (March)
- Notification of interested parties and stakeholders (ongoing)
- <u>Funding secured to support development of KRMP</u> (October)
- FGC Tribal Committee update (August)
- Project Management Team contracted to support development of the KRMP (December)

2023

- Fish and Game Commission Marine Resources Committee update (March)
- Solicitation and establishment of CWG (ongoing)
- Tribal notification (May) and consultation (ongoing)
- Tribal Roundtable Listening Sessions (June)
- CWG meeting (July)
- Establishment of SAC (ongoing)
- SAC meeting (September)

2.2.1. Community Working Group

To facilitate and bolster community and stakeholder engagement throughout the development of the KMRP, OPC has contracted Strategic Earth LLC. to work with OPC and the Department to coordinate and administer the CWG. The CWG, was

established in 2023 and is composed of 24 individual members spanning California's coast and representing non-governmental organizations (NGOs), local businesses, commercial harvesters, and tribal governments. The CWG is expected to hold eight virtual meetings and two 1.5 day hybrid meetings throughout the initial development of the KMRP (2023-2025).

2.2.2. Science Advisory Committee

In collaboration with the Department and OPC, California Sea Grant (CASG) is tasked with convening, administering, and facilitating the KRMP SAC. Composed of 11 professional scientists with representation from academia, agency, non-profit, and tribal governments, the SAC will provide expertise and perspectives for the KRMP's science needs assessment. The SAC is expected to meet quarterly for the initial development of the KRMP (2023-2025) virtually (three meetings per year) and inperson (two half day meetings per year). The SAC convened for the first time in Fall 2023 for a virtual orientation session and will meet again in December 2023 for a two-day in-person workshop.

2.2.3. Tribal Engagement

In June 2023, the Department and OPC, in collaboration with Strategic Earth LLC., held two virtual Tribal Roundtable Listening Sessions that were open to elected officials and representatives of California's native tribes. The purpose of these sessions was to solicit early feedback from tribal governments regarding their priorities for protecting, conserving, restoring, and managing kelp forest ecosystems, as well as pathways for effective and meaningful engagement with tribal governments. Representatives from several California tribal nations also sit on the CWG and SAC.

3. OVERVIEW OF GIANT AND BULL KELP STATUS

3.1. Monitoring of the Resource

Kelp is very dynamic and variable by nature therefore the availability of long-term data is fundamental for monitoring the resource and identifying trends and patterns of concern. The Department uses several monitoring sources to assess and inform kelp status throughout the state, these include data from remote sensing imagery, subtidal surveys, and the commercial kelp fishery.

3.1.1. Kelp Canopy Fishery-Independent Monitoring Data

Emerging technologies have provided additional sources of kelp canopy data at greater temporal and finer spatial scales, that the Department, OPC, and others use to understand and assess kelp canopy dynamics.

Landsat is a remote sensing satellite imagery tool that provides kelp canopy data at 30-meter resolution, dating back to 1984. These data provide the longest continuous time series of kelp canopy information statewide, are publicly available, sourced from the Santa Barbara Coastal Long-Term Ecological Research (SBCLTER) data portal, and can also be viewed on KelpWatch through an interactive mapping tool. The Department currently uses Landsat canopy data to assess broad region (Figure 1) and county (Appendix 1) spatial scales throughout the state.

OPC recently invested in a partnership among the Department and researchers at University of California Los Angeles to advance kelp canopy mapping techniques with PlanetScope imagery, including automation of image processing and production of high-resolution statewide kelp canopy maps (3-meter resolution). This will provide the State with the ability to analyze trends and variability in kelp canopy dynamics, with elevated focus on areas of special concern (e.g., the Mendocino and Sonoma Coasts). Project partners will use PlanetScope classification to document spatial patterns of recovery and identify potential drivers of resilience, including factors such as habitat quality, marine protected area (MPA) protection status, sea temperature, and nutrients, urchin dynamics, and kelp dispersal. This will allow for the characterization of the connectivity between refugia (i.e., areas where kelp canopy persisted from 2014-2020) and unoccupied habitat, with close examination of the relationship between connectivity and probability of recovery.

Kelp canopy data sourcing to date				
Survey Type		Primary Data Source	Spatial Resolution	Timeframe
≁	Piloted Aerial Survey	CDFW	2-meter	1989; 1999-2016
AD	Satellite Pomoto	PlanetScope	3-meter	2016-present
	Sensing	*Landsat	30-meter	1984-present
*	Unoccupied Aerial Systems (drones)	Variable	centimeters	Sporadic; Project- specific

Table 1: Spatial and temporal resolution of different remote sensing tools used to assess kelp canopy data. Highlighted row indicates the primary data source the Department is using to assess kelp canopy on relatively broad spatial scales. *Santa Barbara Coastal Long-term Ecological Research.

3.1.1.1. Regional Trends (North to South)

This report provides updates for canopy data through the end of 2022. The current timeline for quality assurance and quality control (QAQC) and processing remote sensing and satellite imagery data offsets the ability to report and update figures by approximately one to three quarters each year.

The north coast (Oregon-California border to San Francisco Bay) regional data (Figure 1; top panel) shows severe and persistent declines in kelp canopy following the 2014 MHW and associated cascading events. Sonoma and Mendocino County show the most severe declines (Appendix 1), with more than 95% and 90% loss in average kelp canopy cover in Sonoma and Mendocino counties respectively, since the 2014 MHW (Figure 2).

The central coast (San Francisco Bay to Point Conception) regional data (Figure 1; middle panel) shows trends within the normal variability of historical canopy cover. Looking at the county spatial scale, Monterey County also shows some indication of decline post-MHW, though trends look to be within normal range of historical coverage (Figure 2; Appendix 1). This pattern is largely driven by declines along the Monterey Peninsula. It is important to note that much of the coastline that makes up Monterey County is encompassed by Big Sur, which has maintained strong canopy cover through the post-MHW time period. Other areas in the central coast region,

such as San Mateo and Santa Cruz counties have increased kelp canopy cover since the 2014 MHW (Figure 2; Appendix 1).

The south coast (Point Conception to USA-Mexico border including the Channel Islands) shows some regional declines since the 2014 MHW. San Diego and Orange counties have both shown kelp canopy declines post-MHW (Appendix 1). However, kelp canopy cover in Santa Barbara County (Appendix 1) has exhibited some increases since the 2014 MHW (Figure 2). The Channel Islands have also experienced losses in kelp canopy since 2014 (Figure 2) with the most significant declines at San Miguel Island and Santa Rosa Islands (Appendix 1).



Figure 1. Landsat derived regional canopy data from 1984 through the end of 2022 (Q4). The red dashed line indicates the onset of the MHW in 2014. Data Source: SBCLTER et al. 2022.



Figure 2. Percent change in mean canopy cover by county (listed north to south) from 1984-2013 (pre-MHW) and 2014-2022 (post-MHW). Note that this figure excludes San Mateo County due to greater than 400% increase in kelp canopy cover and San Francisco County due to zero kelp canopy cover over time. Central blue line indicates 0% or no change; Red lines indicate 50% change (left: negative indicating a decrease; and right: positive indicating increase in mean canopy cover). Data Source: SBCLTER et al. 2022.

3.1.2. Subtidal Fishery-Independent Data

Subtidal monitoring of kelp forests using SCUBA divers has occurred for several decades and provides critical information on kelp density, community diversity, and ecosystem health. There are several subtidal monitoring programs collecting longterm data in kelp forest ecosystems throughout the state, including the Department's north coast (Mendocino and Sonoma counties) nearshore ecosystem dive surveys (est.1971). Other important subtidal monitoring programs include Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO; est. 1999), Channel Islands National Park Kelp Forest Monitoring Program (est. 1982), and Reef Check (2005present). The data collected by these monitoring groups are used directly by managers to make informed, science-based decisions regarding California's marine communities. While remote sensing and aerial surveys are useful tools to assess changes in kelp canopy abundance, diver surveys can provide critical in situ kelp and marine algae abundance and biodiversity data as well as important indicator species data that are used to quantify, model, and track ecosystem health (Figure 3). Further, these data help marine managers assess the efficacy of marine managed areas and provide updates for marine resource managers. An interactive map

showing the monitoring sites of many Sanctuary Integrated Monitoring Network (SIMoN) can be found on the <u>Kelp Ecosystem Monitoring Map webpage</u>. Additionally, MPA monitoring provides <u>baseline and long-term monitoring of kelp</u> <u>forest ecosystems</u>.



Figure 3: Giant kelp stipe counts (A), bull kelp counts (B), understory stipitate kelp counts (C), sunflower sea star counts (D), purple urchin density counts (E), and red urchin density counts (F). Data are provided by PISCO; figure provide by Dr. Jenn Caselle, UCSB. Due to sampling and data availability limitations, data for the north coast date back to 2014; only one site was surveyed in 2021 and 2022.

3.1.3. Commercial Kelp Harvest Fishery-Dependent Data

The Department manages commercial kelp and other marine algae harvest statewide. The commercial harvest of giant and bull kelp is managed and reported differently depending on use (for general use, i.e., including as feed for farmed abalone aquaculture or for human consumption as edible seaweed). The Department's commercial kelp harvest data for general use dates back to 1916 with the majority of kelp harvest likely being giant kelp. Edible seaweed harvest reporting for giant and bull kelp began in 2002. The FGC recently adopted amendments to the commercial harvest regulations that include more precise harvest location reporting for bull kelp, separating reporting weights for bull and giant kelp in the Commercial Kelp Harvester's Monthly Report (harvest for general use), and information on catch by unit effort. There are currently no reporting requirements for recreational kelp harvest.

3.2. Monitoring Next Steps

Historically, aerial surveys have been the primary method of monitoring kelp canopy off the California coast. However, aerial surveys are expensive and have considerable logistical constraints. Remote sensing, via satellite imagery, provides a more cost-effective and reliable strategy for long-term kelp canopy monitoring. Pilot work supported by OPC shows that maps of kelp canopy derived from highresolution PlanetScope satellite imagery match well with maps derived from aerial surveys. A recent investment by the State will support the next steps in the development of a novel approach for kelp canopy monitoring. This project will result in the creation of seasonal, statewide, high-resolution maps of kelp canopy from 2016-2023, the development of a fully automated approach for processing large amounts of satellite imagery, the use of satellite imagery to analyze kelp canopy dynamics, and the development of a method for monitoring kelp at very small spatial scales (0.5m - 3m) using very high-resolution imagery.

To further advance the implementation of emerging technologies to inform kelp forest management, the State has invested in the use of SkySat/Pelican, a high-resolution satellite dataset from PlanetScope, which will provide satellite imagery on a scale of 0.5m. These data are not suited for large-scale statewide maps but will be more cost effective and useful for site-based monitoring and evaluation at current kelp restoration sites, and for planning and monitoring future kelp restoration efforts.

In advance of their December 2023 meeting, OPC plans to recommend a \$9 million dollar investment for three years of MPA monitoring from 2024 to 2026 including rocky intertidal, kelp forest, estuary, sandy beach, and surf zone habitats. OPC staff are currently scoping further monitoring investments for their February 2024 meeting.

4. REGULATORY ACTION

4.1. Commercial Bull Kelp

Given the dramatic and persistent loss of bull kelp in Sonoma and Mendocino counties since 2014, and due to the lack of scientific data to explain whether commercial harvest does or does not have an impact on the current bull kelp population, the FGC adopted precautionary measures to protect and maintain the remaining bull kelp in the region. These regulatory actions included temporary closure of commercial bull kelp harvest in Sonoma and Mendocino counties, implementation of an annual bull kelp harvest limit of four tons wet weight in Humboldt and Del Norte counties combined (harvest is allowed for human consumption only), and closure of three lease-only administrative kelp beds in Mendocino, Humboldt, and Del Norte counties (see California Code of Regulations [CCR], Title 14, Section 165(c)(9) and Section 165.5(c)). These temporary commercial bull kelp regulations became effective on January 1, 2023, and are intended to sunset in three years (January 1, 2026) with the intent to allow time for the Department, Tribes, industry, and other stakeholders to develop the KRMP.

4.2. Recreational Purple Urchin

Amendments to the recreational purple urchin regulations were implemented in response to increased densities of purple urchin and over-grazing pressure on northern California kelp forests since the onset of the MHW and associated loss of the predatory sunflower sea star and impacts to local fisheries such as the closure of the red abalone fishery. In 2018, an emergency regulatory action was approved by the FGC, increasing the daily bag limit for (hand harvest) from 35 individuals to 20 gallons of purple urchin in Sonoma and Mendocino counties. In 2019, the daily bag limit of purple urchin was further increased from 20-gallons to 40-gallons in Sonoma, Mendocino, and Humboldt counties (CCR, Title 14, Section 29.06(b)), with no sunset date. The intent of the higher 40-gallon limit was to promote continued involvement of recreational divers in efforts to restore severely-impacted kelp forest ecosystems and contribute more greatly to urchin suppression efforts without adversely affecting the long-term health of the native purple urchin population. Separately, in 2020 a temporary regulation to remove the recreational bag limit for purple urchin was implemented at two specific locations in California, including unlimited take of purple urchin via hand harvest or culling at Caspar Cove, Mendocino County, and unlimited take of purple and red urchin via hand harvest or culling at Tanker Reef, Monterey County. The intended sunset date for both of these temporary site-specific regulations is April 1, 2024, however, a current regulatory process is underway that may allow one or both of the sites to extend regulations for an additional five years

(April 1, 2029) or modify the existing site boundaries for Tanker Reef (Department, 2023). The FGC adoption hearing for these proposed regulations is anticipated at their February 2024 meeting.

5. ADVANCING KELP RESEARCH

5.1. Kelp Research and Recovery Program

The Kelp Research and Recovery Program (KRRP) was created by OPC, CASG, and the Department to fill critical knowledge gaps and advance understanding of kelp research and restoration. In 2020, a combined total of \$1,800,000 was released to fund six KRRP projects as the first round of competitive kelp research and restoration projects. These projects filled critical knowledge gaps in applied restoration techniques for temperate rocky reefs in California and have helped establish protocols for future kelp forest restoration.

A team of researchers from UC Santa Barbara and UC Santa Cruz created the first of its kind decision tree to inform agency managers, funders, and other restoration practitioners about where and when to focus kelp restoration efforts. Concomitant with the generation of this model, a multi-faceted team from UC Davis, UC San Diego and Sonoma State University investigated the synergistic factors that influence bull kelp loss. Specifically, this team sought to understand bull kelp's vulnerability to heat, the decline in sunflower sea stars, which has contributed to an overabundance of purple urchins on the north coast, and the efficacy of different protocols for removing urchins. While canopy-forming kelps persist exclusively on subtidal rocky reefs (in California), purple urchins spawn in both subtidal and intertidal ecotones. Researchers from CSU Monterey Bay (CSUMB) and Reef Check surveyed the urchin populations at nine intertidal sites across the Monterey Peninsula and discovered that intertidal areas are a far more important source for urchin populations than previously thought. The results from these projects directly inform critical spatiotemporal knowledge gaps surrounding restoration success and help ensure the direction and efficacy of future projects.

The urgency to restore the staggering loss of kelp forests in key areas across the state has suggested human intervention may be necessary to ensure success on manageable timelines. Scientists from Moss Landing Marine Laboratories (MLML) and San Jose State University developed a novel, low-cost technique for culturing bull kelp year-round. When scaled, these methods will greatly inform the feasibility and success of future bull kelp outplanting. Separately, a team from UC Irvine adapted a giant kelp outplanting technique for use in California. The use of an inoculated gravel substrate, in conjunction with laboratory-rearing experiments to breed heat-tolerant kelps, will influence how projects can "future-proof" restoration efforts to ensure efficacy under climate change-induced ocean warming. Finally, a consortium of researchers from the University of Wisconsin-Milwaukee, UC Santa Cruz, and University of Southern California developed a "seed bank" of more than

1,700 bull kelp genotypes from 14 sites across the state. This collection, the first of its kind, will help preserve the genetic diversity of bull kelp, and may be used in captive rearing and outplanting restoration projects.

5.2. 2024 Kelp Research and Restoration Program Request for Proposals

To advance the KRRP and fill critical knowledge gaps, OPC, CASG, and the Department announced a second round of competitive funding with a combined total of \$5,000,000 in Summer 2023. Building on the success of the KRRP, this second round of funding is intended to specifically support solutions-oriented projects that directly contribute to the recovery of California's kelp ecosystems and coastal communities, and to inform management approaches for protecting and restoring kelp ecosystems. Over 40 Letters of Intent were submitted to CASG in Summer 2023; OPC, CASG, and the Department will be participating in the full proposal review and selection process with an external panel of scientific experts in Fall 2023. The final suite of recommended projects will be brought to the OPC at their December 2023 meeting for consideration of funding. Upon approval, the three-year research awards are expected to begin in February 2024.

5.3. Non-State Funded Research

Due to its ecologic and economic importance, many academic institutions, NGOs, and other interested entities are engaged in cutting edge kelp research. One such project is the Kelp Restoration as an Integrated Socio-Ecological System (Kelp RISES) consortium hosted by UC Davis, which aims to understand how different management approaches account for ongoing climate change in relation to California's kelp forest communities. Other notable consortia include the Pycnopodia Working Group facilitated by The Nature Conservancy (TNC), which is leading efforts to explore the recovery of a key kelp forest predator (the sunflower sea star; see below).

6. EFFORTS INFORMING THE DEVELOPMENT OF THE KELP RESTORATION AND MANAGEMENT PLAN

6.1. Building a Science-based Kelp Restoration Toolkit

Kelp forest restoration has been practiced in California since the late 1950s, with most historical efforts occurring in southern California (Eger et al. 2022b). Projects have included removing urchins, removing competitive and invasive algae, outplanting kelp, transplanting reproductive material, and providing substrate. More recent kelp restoration and recovery projects have been focused on the northern California region due to the dramatic loss of the resource particularly in Sonoma and Mendocino counties. Much of the restoration work occurring in California is aimed to identify restoration tools or a combination of methods that can be used strategically to defend restoration sites from overgrazing and facilitate kelp growth and persistence. Kelp restoration work is extremely labor intensive and logistically challenging (e.g., variable weather, remoteness of sites, etc.), therefore many of the restoration projects are being implemented through partnerships and coordination with several other state and federal agencies, researchers, non-profits, tribal, and coastal communities.

Restoration tools that are currently being implemented include urchin suppression such as commercial hand harvest, recreational hand harvest (increased bag limit in Humboldt, Mendocino, and Sonoma; CCR, Title 14, Section 29.06(b)), recreational culling (Caspar Cove; CCR, Title 14, Section 29.06(d)(1) and Tanker Reef; CCR, Title 14, Section 29.06(d)(2)), commercial culling (via Scientific Collecting Permit), and boat-based urchin trapping. Several restoration projects have also explored using commercial urchin divers to remove purple urchin via hand harvest and landing purple urchins where they are sold or donated for use as soil amendment in compost. These projects have been mutually beneficial to restoration practitioners and the commercial urchin fishery due to the collapse of the red urchin fishery and need for experienced urchin divers to clear restoration areas.

Some restoration projects are also exploring methods of kelp enhancement to facilitate kelp growth and persistence in areas that have been recently cleared of urchin including, outplanting of cultured substrates such as green gravel and inoculated biodegradable substrates (including seeded twine). Other more passive methods of kelp enhancement being tested are transplanting reproductive material via introduction of spore bags and pumping concentrated spore solution onto the benthos.

6.2. Current and Ongoing Restoration Projects

Below is a summary of current restoration projects, from north to south, including a brief background, project goals, approximate timeframe, initial take-aways and next steps, and key partners and contributors.

6.2.1. Noyo Bay, Mendocino County: Coordinated Grazer Suppression via Commercial Hand Harvest of Purple Urchin to Support Kelp Recovery

Background: In 2020, the first State-supported bull kelp restoration effort was initiated in Mendocino County. Noyo Bay and Albion Cove (see "Albion Cove" section below) were selected as restoration sites based on several criteria, including logistics, proximity to extant bull kelp patches, and encroachment of purple urchin into these kelp refugia locations (Eger et al. 2022a, Ward et al. 2022). Restoration began at Noyo Bay; commercial divers systematically harvested purple urchin from August through November in 2020, during which time they completed the initial clearing of the site to the target threshold density of ≤ 2 purple urchin target density was maintained until project completion in December 2021 (Ward et al 2022). Increases in bull kelp density were observed at the restoration site in Noyo Bay in comparison to the control site and reached approximately 20% of historical densities (Eger et al 2022a, Ward et al 2022).

Goals: Evaluate the feasibility and efficacy of coordinated grazer suppression via commercial urchin diver hand harvest to a maintained threshold density (2 urchin/m²) as a bull kelp restoration tool in the north coast region.

Timeframe: 2020 - 2021

Take-aways: Commercial urchin divers demonstrated a coordinated approach in reducing urchin densities to the target density in the restoration area of Noyo Bay. This project was co-managed by state agencies and nonprofit entities and established successful engagement with local commercial divers impacted by the loss of the kelp forest. This project provided mutual benefits for the fishing community by providing supplement income and fiscal support for the recovery of the red urchin fishery. Restoration practitioners gained vital local knowledge, experience, and equipment to effectively reduce urchin densities (Ward et al. 2022, Eger et al. 2022a). The work at Noyo initiated strong partnerships and collaboration that continues to evolve in the region.

Next Steps: Though grazer densities were reduced, and initial bull kelp growth was detected at Noyo Bay (Figure 4), the project timeframe (two-years) did not allow

consecutive seasons to facilitate expansion or self-sustaining kelp recovery (Ward et al. 2022). The outcomes of this work necessitate the need for continued research and exploration of grazer suppression paired with novel bull kelp enhancement techniques over longer periods of time for ecosystem recovery. Outcomes from this state-supported project have led to ongoing research and exploration of grazer suppression and kelp enhancement techniques, supported by TNC, at Noyo Bay and Albion Cove.

Partners and Contributors: OPC, the Department, Reef Check, TNC, Waterman's Alliance, Noyo Center for Marine Science, and commercial urchin divers and processors.



Figure 4. [Left-Photo] Commercial urchin diver hand harvesting purple urchins at the Noyo Bay restoration site. [Right-Photo] Bull kelp stipes observed at the Noyo Bay restoration site following purple urchin removals. Photo Credit: Tristin McHugh (TNC).

6.2.2. Caspar Cove, Mendocino County: Evaluating Efficacy of Recreational Diver Participation in Kelp Recovery

Background: Leading to the closure of the recreational red abalone fishery at the end of 2017, there was high public interest and momentum to reduce detrimental purple urchin grazing pressure on bull kelp recruitment and growth in Sonoma and Mendocino counties. As such, emergency regulations were initiated in 2018 to increase the daily bag limit of purple urchin for the recreational diving community. For divers with valid fishing licenses, bag limits increased from 35 individuals per day to 20 gallons, and most recently to 40 gallons in Mendocino, Sonoma, Humboldt, and Del Norte counties. However, due to logistical challenges, and safety and efficiency considerations, public interest remained to reduce urchin densities *in situ*. In 2020, the FGC adopted a temporary emergency regulation to remove the recreational bag limit for purple urchins and allow unlimited take by hand and

handheld tools inside the boundary area of Caspar Cove, Mendocino County (Figure 5).

Goals: Provide a science-based assessment of in-water purple urchin culling at a focused location by recreational divers as a potential bull kelp restoration tool in the north coast region.

Timeframe: 2018 to present

Take-aways: Though regulations allowing for *in situ* recreational culling efforts at Caspar Cove began in February 2020, engagement was minimal due to the COVID-19 pandemic, which imposed significant challenges such as site accessibility, limited local resources, and other logistical constraints. Despite the unique setbacks that impacted the rural coastal community of Mendocino County, the recreational dive community, led by The Waterman's Alliance, remained engaged and motivated to conduct urchin removals. The Watermen's Alliance and partners have since identified solutions to many of these local challenges, such as working with Sonoma County Sheriff and Mendocino Fire Department to secure SCUBA cylinder fills for monthly recreational diver events, which has resulted in increased diver effort. As of July 2023, 241 self-reported dives have been logged by 110 unique divers, resulting in an estimated removal of 130,758 purple urchins. Recreational divers have been able to successfully coordinate within a one-acre restoration focal area established in 2022 inside Caspar Cove (Figure 5) that was developed between The Waterman's Alliance, TNC, and the Department. Within this area divers have been able to effectively reduce purple urchin densities detectable via subtidal monitoring by Reef Check and patchy kelp canopy has been detected through Unoccupied Aerial Vehicle (UAV, e.g., drones) surveys (Figure 5).

Next Steps: The temporary regulation allowing culling *in situ* at Caspar Cove is under consideration by the FGC to extend past the original sunset date of April 1, 2024, for an additional five years (April 1, 2029). Due to the early disruptions that caused delays in recreational diver effort, extension of this regulation would allow continued engagement and monitoring needed to inform whether urchin culling by recreational divers represents a viable tool for bull kelp restoration in northern California.

Partners and Contributors: The Department, Waterman's Alliance, TNC, Reef Check, Cal Poly Humboldt State University, Sonoma County Sheriff, Mendocino Fire Department, California State Parks, Caspar Campground and Store, and the recreational dive community



Figure 5. Map of Caspar Cove restoration site including the regulation boundary, site zones, and one-acre Targeted Restoration and Monitoring Area (inside site zone A). Layered OAV kelp canopy data from 2014-2016 was sourced from the Department and Sandoval & Associates, LLC (30cm resolution) and UAV kelp canopy data from 2020-2023 was sourced from TNC (3cm resolution). Map cartography by TNC.

6.2.3. Albion Cove, Mendocino County: Identifying Scalable Kelp Enhancement Techniques Alongside Urchin Suppression via Commercial Hand Harvest

Background: Suppression of purple urchins by commercial urchin divers began at Albion Cove in 2021 in the year following the initiation of restoration at Noyo Bay (see "Noyo Bay" above). The first in-water testing of bull kelp enhancement techniques in California were initiated alongside the effort to reduce urchin densities below the 2 urchins per m² threshold. This limited spatial-scale kelp enhancement study was part of the state's first Kelp Recovery and Research Program and sought to identify optimal methods for outplanting juvenile bull kelp for the north coast region (2020-2021). Considerations for scaling (2022-2023) were continued and managed by TNC.

Goals: Leverage best practices and lessons learned in kelp enhancement at Albion Cove to identify scalable and regionally appropriate bull kelp enhancement techniques. Multiple kelp enhancement techniques are being tested alongside grazer suppression via commercial urchin diver hand harvest.

Timeframe: 2020 to present

Take-aways: Results from 2020-2022 suggest that grazer densities can be reduced to the desirable threshold by commercial urchin divers. In addition, spore bags and seeded lines are likely to be the two most viable bull kelp enhancement strategies to test at larger spatial scales (Graham et al. 2023). In 2023, leading kelp enhancement techniques (spore bags, seeded lines and *in-situ* inoculation) were implemented by researchers at MLML and Sonoma State University (SSU) in Albion Cove to further develop kelp enhancement methods and approaches that can be used to boost productivity in a limited kelp recovery environment. Commercial urchin divers were able to effectively maintain threshold urchin densities with coordination support by Reef Check. Initial findings in 2023 demonstrated that spore bags support kelp recruitment on the reef and subsequent recruitment, growth, and increased survivorship of outplanted kelp on suspended lines (Figure 6). For the first time in California, researchers have observed bull kelp growth from "seed" to reproductive adult on outplanted lines on an open coast environment.

Next Steps: Continuation of urchin suppression to support assessment of kelp enhancement techniques at Albion Cove is planned through 2023, and monitoring for kelp enhancement successes will continue through 2024. Future restoration studies have proposed techniques that deviate from horizontal lines in the water and instead use smaller-profile vertical infrastructure.

Partners and Contributors: TNC, the Department, MLML, SSU, Reef Check, Albion River Campground, and commercial urchin divers and processors.



Figure 6. [Left-Photo] Researcher surveying bull kelp recruits on lines at the Albion Cove restoration site. [Right-Photo] Close-up of bull kelp growing on suspended seeded lines in Albion Cove. Photo Credit: Abbey Dias (SSU).

6.2.4. Fort Ross and Timber Cove, Sonoma County: Implementing Urchin Suppression via Commercial Hand Harvest of Purple Urchin Supplemented with Kelp Outplanting Techniques

Background: The Greater Farallones National Marine Sanctuary (GFNMS) is a federally marine-managed area that encompasses nearshore ecosystems from its northern boundary just north of Point Arena in Mendocino County, to its southern boundary, near Rocky Point in Marin County. To address the severe loss of kelp forests in GFNMS, The Greater Farallones Association (GFA) launched the Kelp Recovery Program in 2017 in partnership with GFNMS. GFA-GFNMS have conducted research to investigate strategies for kelp forest restoration, with a focus on strategically restoring bull kelp forest refugia, or 'oases', along GFNMS's northern coastline to serve as source populations to supply spores for surrounding areas that may be suitable as kelp forest habitat. Sonoma County, located within the GFNMS has suffered the greatest kelp loss (over 95%) in the state of California since 2014. In response, the first large-scale effort to restore bull kelp forest habitat at key sites within GFNMS was initiated by the Greater Farallones Kelp Restoration Project, led by GFA and GFNMS.

Goals: Restore resilient kelp habitat by establishing a network of kelp forest oases in GFNMS and facilitate broad-scale sustainable kelp recovery. The primary restoration tools being implemented in Sonoma County are urchin suppression via large scale hand harvest of purple urchin by experienced local commercial urchin divers. In sites with reduced grazing pressure, natural bull kelp recovery will be supplemented with seasonal outplanting techniques.

Timeframe: 2023-present

Take-aways: Commercial divers began conducting purple urchin hand harvest in early September at Fort Ross and Timber Cove. As of October 2023, five local divers have removed approximately 16,000 pounds of urchins from both sites over a total of 30 dive days. Concurrently, researchers from SSU and MLML conducted kelp enhancement via spore bags and seeded substrates at Fort Ross. NOAA divers from GFA-GFNMS conducted restoration assessment surveys of both sites, and ten sites along Sonoma County were mapped by staff from CSUMB to capture data on kelp canopy extent.

Next Steps: Restoration work in the form of commercial hand harvest and supplemental kelp enhancement is anticipated at Fort Ross and Timber Cove through November 2023 and is planned to restart and expand to Ocean Cove in Spring of 2024. Stillwater Cove (Sonoma County) is proposed as a future restoration site as restoration work expands in GFNMS.

Partners and Contributors: GFNMS, GFA, CSUMB, MLML, SSU, the Department, and commercial urchin divers.

6.2.5. Drakes Bay, Marin County: Investigating (Non-diver) Bull Kelp Enhancement Techniques to Support Natural Recovery of Kelp Forest Habitat

Background: In 2022, GFA-GFNMS launched a pilot restoration study in Marin County, also located within the GFNMS to help preserve the nearshore bull kelp spore bank and facilitate natural recovery of kelp forest communities.

Goals: Investigate kelp enhancement techniques for establishing bull kelp refugia along the Point Reyes National Seashore (Marin County) and characterize interconnectivity between coastal habitats.

Timeframe: June 2022-present

Take-aways: This project piloted kelp enhancement techniques at Drakes Bay and Double Point in Marin County. The two vessel-based (non-diver) kelp outplanting techniques conducted at this site include: (1) the use of twine seeded with bull kelp sporophytes wrapped around biodegradable substrate (Figure 7); and (2) pumping concentrated bull kelp zoospore solution to the benthos via the "reef duster" method (Figure 7). Drones are being used to monitor and map kelp canopy at fine scales and a Remotely Operated Vehicle (ROV) is being used to check substrate type and survey previous outplanting locations. Moorings have also been deployed at these sites to track oceanographic conditions at depth. **Next Steps:** Kelp canopy in Drake's Bay and Double Point will be surveyed again in the spring of 2024 and findings will be coalesced into a report in the summer of 2024. The project may be extended another two years pending funding.

Partners and Contributors: GFNMS, GFA, SSU, FishBio, Monterey Bay Seaweeds (MBS), CSUMB, and the Department.



Figure 7: [Left-Photo] Researchers prepare reproductive bull kelp samples for "reef duster" kelp enhancement method. [Right-Photo] Researchers carefully wrap inoculated twine around clay bricks to be deployed at the Drakes Bay restoration site. Photo Credit: Rietta Hohman (GFA-GFNMS; NOAA Affiliate).

6.2.6. Tanker Reef, Monterey County: Evaluating Recreationally-led Urchin Suppression to Aid in Kelp Recovery

Background: In 2020, the FGC adopted an emergency regulation to remove the recreational bag limit for Caspar Cove (Mendocino County). In August 2020, the FGC authorized notice to initiate a regular rulemaking to continue the take provisions for a period of three years. Additionally, in response to a petition regarding concerns of giant kelp declines along the Monterey Bay Peninsula, the FGC authorized notice to remove the bag limit for purple and red urchins and allow unlimited take by hand and handheld tools at Tanker Reef (Monterey County) for the same three-year period.

Goals: The exemption for unlimited recreational take of purple and red urchin at Tanker Reef was designed to provide an assessment of the efficacy of the recreational diver community to self-organize and implement *in situ* urchin culling, which would later be evaluated as a potential tool in support of kelp restoration by facilitating natural recovery. Data gathered from the three-year Tanker Reef effort would be analyzed and evaluated in terms of feasibility and efficacy, to inform the state's response to kelp loss via future management and restoration strategies.

Timeframe: 2021 to present

Take-aways: Culling efforts at Tanker Reef were initiated in April 2021 and led through the efforts of the petitioner. As of July 27, 2023, the petitioner reported 1,369 dives conducted by 187 unique divers, resulting in an estimated removal of 633,211 purple and red urchins. Actual counts of urchins culled were not made but estimated based on average rates of culling per minute of diver effort multiplied by diver bottom time. Of the estimated 633,211 urchins removed, approximately 219,733 (34%) were removed from the 100-meter squared focal restoration area ("grid"). Between Spring and Fall 2021 monitoring surveys revealed that urchin densities were reduced below a target threshold of \leq 2 urchins per m² within the grid and remained around the threshold density through Summer of 2023 (Figure 8). Beginning in Spring of 2022, densities of giant kelp individuals increased in the grid and reached a maximum in Summer of 2022 (Figure 9). Through Summer 2023 giant kelp individual and stipe densities have remained higher in the grid as compared to the control site, an adjacent area of similar size where culling is not supposed to occur.

Next Steps: The temporary regulation allowing culling *in situ* at Tanker Reef is under consideration by the FGC to extend past the original sunset date of April 1, 2024, for an additional five years (April 1, 2029). To date, data have been collected by the Department and Monterey Bay National Marine Sanctuary (MBNMS) scientists ("targeted monitoring" of urchins and kelp only), Reef Check volunteer citizen science divers ("ecosystem monitoring", including kelp and marine algae, invertebrates (including urchins), and fishes), and the petitioner (e.g., culled urchin estimates, diver effort). These data sets have not yet been combined into a synthesized report that can serve as the basis for understanding the dynamics at Tanker Reef, whether it can be scaled up, and feasibility and application to other parts of the state. Depending on the outcome of the ongoing regulatory process, the Tanker Reef site may enter a post-restoration phase. This phase of post-restoration monitoring would be conducted at the grid and control sites to characterize the resistance and resilience of the newly established kelp patch in the absence of ongoing diver intervention.

Partners and Contributors: Giant Giant Kelp Restoration Project (G2KR), Reef Check, MBNMS, the Department, and the recreational dive community.



Figure 8. Purple urchin (top) and red urchin (bottom) density (urchin/m²) during each subtidal survey timepoint (2021-2023). Filled points indicate densities at the restoration focal area (100x100m) and open points indicate urchin densities at the control area (comparable 100x100m area). Data source: the Department and MBNMS (circles) and Reef Check (triangles).



Figure 9. Giant kelp individual density (per/m²) during each subtidal survey timepoint (2021-2023). Giant kelp individuals are defined as individuals >1m off the bottom. Filled points indicate kelp densities at the restoration focal area (100x100m) and open points indicate densities at the control area (comparable 100x100m area). Data source: the Department and MBNMS (circles) and Reef Check (triangles).

6.2.7. Palos Verdes, Los Angeles County: Systematic Urchin Suppression via Commercial Diver Culling Results in Minimal Maintenance of Restoration Sites

Background: The Palos Verdes Peninsula, located between Los Angeles and Long Beach, has one of the longest documented declines in kelp forests along the California Coast. Subtidal surveys in 2010 revealed an estimated 62 hectares of the peninsula's rocky reefs were described as persistent urchin barrens. Building on previously successful kelp restoration in the Santa Monica Bay via the removal of urchins, The Bay Foundation (TBF) partnered with NOAA, Vantuna Research Group (VRG, Occidental College), Montrose Settlements Trustees, and commercial urchin fishermen in one of the longest running subtidal restoration projects in California.

Goals: TBF seeks to restore the Palos Verdes Peninsula to a kelp-dominated state through culling purple urchins *in situ* with the use of hand tools by commercial divers. At select sites along the coast of the Peninsula, adjacent to the Point Vicente and Abalone Cove State Marine Conservation Areas, TBF conducts pre- and post-urchin removal surveys to comprehensively determine the initial and post removal densities of purple urchins. These efforts ensure a restoration target of approximately 2 purple urchins per m² is achieved throughout a restoration site. In conjunction with project

partners, TBF also conducts surveys in adjacent reference sites. TBF's methods of systematically delineating and clearing urchins along band transects has resulted in minimal maintenance of restoration sites. VRG has and continues to conduct annual Cooperative Research and Assessment of Nearshore Ecosystems surveys across selected restoration sites and in neighboring rocky reef/kelp forest habitats to contextualize and describe trends resulting from these efforts.

Time Frame: 2013-present

Take-Aways: TBF has implemented large-scale restoration via a core team of commercial urchin divers systematically culling purple urchins, reducing densities from an average of ~30/m² to ~2/m². A total of 58 acres of kelp forest has been restored since 2013, with minimal maintenance needed. Increases to giant kelp, invertebrates, fish diversity and biomass, and increased red urchin gonad weight have been documented in restoration sites along the Palos Verdes Peninsula (Figure 10).

Next Steps: As this is an ongoing project, TBF and VRG continue to monitor preand post-culling, and reference sites as it expands its efforts across the southeast coast of the Peninsula.

Partners and Contributors: TBF, VRG, NOAA, Montrose Settlement Trustees, and commercial urchin harvesters.





Figure 10: [Left-Photo] Before and after [Right-Photo] systematic commercial urchin culling at TBF restoration site in Palos Verdes. Photo Credit: TBF.

6.2.8. Urchin Trapping: A Non-diving Opportunity for Urchin Suppression

Background: Urchin trapping is a novel urchin grazer suppression technique that may provide an alternative and cost-effective approach for reducing purple urchin

populations that does not require divers to get in the water. This is a key consideration for the north coast where the ocean conditions often constrain the hand harvest of urchins. A novel approach to testing urchin traps in Mendocino County was initiated in 2021 by TNC alongside the Department and a commercial urchin diver. During Phase 1 (2021), the project team refined trap design, tested bait types (drift kelp, fish carcass, produce), and explored viable soak times to maximize catch and streamline logistics for deployment on the north coast. In Phase 2 (2022) the project team sought to understand trap performance in urchin barrens on reefs with differing urchin densities to evaluate performance under differing restoration scenarios. Currently, in Phase 3 (2023), the project team is testing trapping to protect kelp refugia and, at an exploratory scale, developing techniques to maximize catch per unit effort (CPUE) and reduce cost to help guide potential expansion of this work to additional participants and geographies.

Goals: Identify best methods and approaches for urchin trap deployment to maximize CPUE, reduce costs of restoration, provide equitable solutions for grazer suppression (non-diving options), and thereby serve as an effective kelp restoration tool

Timeframe: 2021 to present

Take-aways: During Phases 1 and 2 over 23,000 purple urchins were caught using traps. Although questions of efficiency compared to other methods remain, there is strong interest to explore grazer suppression methods that do not require humans to get in the water. Urchin trapping study results identified the following for maximum trap performance: kelp beach wrack as bait distributed evenly across the trap, soak time of less than 48 hours, and trap catch is greater in higher density urchin barrens (McHugh et al. in prep). However, in lowered urchin density scenarios, traps have been observed to "attract" wandering urchin and aggregate them to a focal area. Urchin traps can be an effective urchin suppression tool and may provide increased catch capacity if coupled with commercial diving, allowing divers to soak traps while hand-harvesting urchins.

Next Steps: Expand opportunity to more commercial urchin harvesters to test urchin traps in other geographies within California to maximize CPUE, reduce restoration costs, and provide equitable opportunities for non-diving participants. Further, questions remain regarding their efficiency in defending recovering restoration areas with low urchin density, especially in scenarios where urchins are inhibiting kelp recovery and persistence of kelp refugia.

Partners and Contributors: TNC, UC Santa Barbara, F/V *Crazyhorse* (Commercial Sea Urchin Diver), Reef Check, the Department, and Urchin Processors at Noyo Harbor.

6.2.9. Sunflower Star: Restoring Ecosystem Balance Following the Loss of an Apex Predator

Background: The sunflower sea star (*Pycnopodia helianthoides*) is a significant predator in Northeastern Pacific nearshore ecosystems and can impose top-down pressure on urchins, thus promoting kelp proliferation (Heady et al., 2022). Beginning in 2013, sunflower sea star populations along the West Coast were significantly affected by SSWD, ultimately reducing populations by over 99% in California waters, resulting in the functional extinction of this species (Gravem et al. 2021). Numerous entities through the range of sunflower sea stars have been investigating the ecology and epidemiology of SSWD and are developing a pathway for the recovery of this species.

Goals: Identifying key steps necessary for recovery, securing funding, and developing strong partnerships and coordination for action.

Take-aways: The 2022 *Roadmap to Recovery for the Sunflower Sea Star*, was developed through TNC convening a working group of West Coast experts and managers and provides an overview of the species, status, and threats as well as identifies knowledge gaps and priority objectives and actions for informing recovery of the species. Unfortunately, since the onset of SSWD, the sunflower sea star has exhibited little natural recovery in California, necessitating the need for continued research and redundant captive breeding programs. The first subtidal sighting on the north coast since 2014 was in December of 2022 in Mendocino County by F/V *Crazyhorse*, and since, there have been a total of at least four recent (2022-2023) individual sightings of sunflower sea stars in Mendocino County.

Next Steps: Current studies are investigating the ecology and behavior of sunflower sea stars, SSWD and disease mitigation, expansion of captive breeding and rearing of the sunflower sea star and identifying best methodology for potential translocation.

Partners and Contributors: TNC, University of Washington, University of Oregon, the Department, Aquarium of the Pacific, California Academy of Sciences, Sunflower Sea Star Lab, and many others.

7. LOOKING AHEAD

The Department and OPC continue to explore novel tools and techniques to restore, enhance, protect, and manage California's kelp forest ecosystems. These efforts include the ongoing support in monitoring the kelp resource as well as urchin suppression and kelp enhancement practices, and the strategic release of competitive funds to catalyze research that will fill vital knowledge gaps and inform current and future regulatory actions and adaptive management. In addition, OPC and the Department anticipate releasing an update to the Kelp Action Plan in early 2024, which directly supports the development and implementation of the KRMP. Throughout KRMP planning and development, OPC and Department staff will continue to engage with California Native American tribes, KRMP SAC and CWG, FGC, stakeholders, and the ocean community to ensure that expert knowledge, and community perspectives support and inform the KRMP.

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Figure 11. Non-exhaustive list of entities engaged in current kelp monitoring, research and recovery efforts in California.

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APPENDIX 1: Kelp Canopy Data by County

Landsat derived canopy data by California County from 1984 through the end of 2022 (Q4). The red dashed line indicates the onset of the MHW in 2014. Data Source: SBCLTER et al. 2022. Please note that San Fransico County is not included due to zero kelp canopy data over time.



Del Norte

Mendocino



Sonoma



Marin



San Francisco: no kelp canopy data for San Fransico county



San Mateo





Monterey



San Luis Obispo



A-4

2010-

 



Orange







Channel Islands (all)







Agenda Item 4: Kelp Restoration Update

16 November 2023

Presented to:

Marine Resources Committee Fish and Game Commission Presented by:

Dr. Kristen Elsmore Senior Environmental Scientist Specialist Marine Region

Overview

- Kelp Canopy Status and Trends
- Overview of Select Research and Restoration Efforts
- Upcoming Opportunities for Kelp
- Development of Kelp Restoration and Management Plan (KRMP)





Exploring Tools for the Restoration Toolkit

- Urchin suppression techniques
 - Urchin culling by commercial divers
 - Urchin culling by recreational divers
 - Experimental traps
- Kelp enhancement techniques
 - -Spore bags
 - -Seeded substrates and lines
 - Concentrated spore solution





Urchin Suppression: Commercial Hand-Harvest

- Sites: Noyo Bay
- Goal: Efficacy of commercial harvest to maintain less than 2 urchin/meter² density
- Takeaways:
 - Strong partnerships and collaboration
 - Urchin densities reduced
 - Initial bull kelp regrowth
 - Timeframe (< 2 yrs) was short-lived
- Next Steps:
 - Continued research



Urchin Suppression: Recreational Culling

- Sites: Caspar Cove and Tanker Reef
- Goal: Efficacy of urchin culling via recreational divers
- Takeaways:
 - Successful coordination of recreational divers
 - Caspar: Delayed effort due to COVID-19
 - Increased diver effort in 2022
 - Tanker: Urchin densities reduced; initial kelp regrowth
- Next Steps:
 - Pending regulatory decision process





Urchin Suppression & Kelp Enhancement

- Sites: Albion Cove (Mendocino); Fort Ross (Sonoma)
- **Goal:** Test kelp enhancement techniques alongside urchin suppression efforts
- Take Aways:
 - Albion: Bull kelp recruitment through spore bags and seeded lines
 - Fort Ross: Outplanting of spore bags and seeded substrates
- Next Steps:
 - Continue urchin suppression and monitoring of kelp recruitment

Kelp Enhancement

- Site: Drakes Bay (Marin County)
- Goals: Establish bull kelp refugia and characterize interconnectivity between coastal habitats
- Takeaways:
 - Outplanting of seeded twine on substrate and "reef dusting"
 - Drone + ROV monitoring
- Next Steps:
 - Monitoring of kelp recruitment







Commercial Urchin Culling (SCP)

- Site: Palos Verdes (Los Angeles County)
- Goals: Restoration via urchin culling by commercial divers
- Takeaways:
 - -58 acres of kelp forest restored since 2013
 - Minimal maintenance of restoration sites
 - Increases in giant kelp, inverts, fish diversity and biomass, and red urchin gonad weight
- Next Steps:
 - Continued monitoring pre/post-culling and reference sites





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CALIFORNIA OCEAN PROTECTION COUNCIL

Sunflower Sea Stars (Pycnopodia helianthoides)

- Status of Sunflower Star in CA
 - Little-to-no recovery
 - First subtidal sightings since initial loss (Mendocino County, Dec. 2022)
- Roadmap to Recovery (2022)
 - Overview of the species, status, and threats
 - Identifies knowledge gaps
 - Priority objectives and actions for informing recovery









• \$5 million for state-funded Accelerating Kelp Research and Restoration in California



Kelp Restoration and Management Plan

Goal:

To develop a robust, adaptive, climate-ready approach to managing, protecting, and restoring giant and bull kelp forest ecosystems statewide for consideration and adoption by the Fish and Game Commission

Core components:

- Ecosystem-based management approach
- Adaptive kelp harvest framework
- Restoration Toolkit

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CALIFORNIA OCEAN PROTECTION COUNCIL

Kelp Restoration and Management Plan Timeline

- Tribal Engagement
- Community Working Group
- Scientific Advisory

Committee





Conduct scientific, Tribal, and stakeholder engagement Synthesize state of the science Identify and address key knowledge gaps

Kelp Restoration and Management Plan Milestones

2023 KRMP Milestones

- Community Working Group (CWG): Solicitation and establishment
 - First Community Working Group meeting (July)
- Establishment of Science Advisory Committee (SAC)
 - First SAC meeting (September)
 - Second in-person SAC meeting (December)
- Tribal Roundtable Listening Sessions (June)
 - Representatives from several California tribal nations to sit on the CWG and SAC

CALIFORNIA OCEAN PROTECTION

Summary

- Kelp Canopy Data
 - -Persistent kelp loss in the north coast
 - Different patterns of loss and recovery across the state
- Research and Recovery Efforts
 - -Broad suite of collaborative efforts across the state
 - -Will inform KRMP development
- Kelp Restoration and Management Plan
 - Plan development funded by OPC
 - -Initiating science, tribal, and stakeholder engagement

Thank You!



- <u>https://wildlife.ca.gov/Conservation/Marine/Kelp</u>
- <u>https://marinespecies.wildlife.ca.gov/kelp/true/</u>
- <u>https://www.opc.ca.gov/webmaster/ftp/pdf/agenda_item</u>
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