Briefing on Kelp Forests in Greater Farallones National Marine Sanctuary

State of the Resource

Condition Report Data (in preparation)

- Kelp habitat and ecosystem: Greater than 90% of kelp forest habitat in northern California has been lost since 2014 due to repeated warm water events lowering reproduction rates of kelp and disease events removing top predators of kelp forest grazers, red (*Mesocentrotus franciscanus*) and purple urchins (*Strongylocentrotus purpuratus*).
- There was widespread recruitment failure of kelp, resulting in habitat and food limitations for associated species within the ecosystem. In addition, purple urchin recruitment yielded populations that increased to greater than sixty times normal levels (Rogers-Bennett and Catton 2019) and shifted behavior from passive feeding on algal detritus to active grazing on kelp and other marine algae, effectively outcompeting other herbivores such as abalone and red urchin. Following the decimation of the benthic "fleshy" algae, purple urchins then began grazing on the long-lived and slow-growing crustose coralline algae, thus creating large swathes of bare rock, which are unsuitable for post-larvae settlement of abalone.
- Kelp canopy: A slight increase in kelp canopy cover was observed in 2021, but there has been no significant recovery of kelp forests in GFNMS as of 2022 (Bell et al., 2023). Historical kelp persistence, or areas where kelp canopy occurred more frequently than surrounding areas prior to 2014, was determined using remote sensing data such as Landsat and aerial plane-based surveys. From 2014–2022, kelp persistence was nearly nonexistent in the sanctuary due to extremely sparse growth (CDFW 2019; Bell et al., 2023).

Climate Vulnerability Assessment Findings

- Vulnerability is calculated from exposure to climate and non-climate stressors, sensitivity to those same stressors, and the resource's ability to adapt to the impacts. Ratings presented are from the original 2015 report and from 2023 revisions of some indicators.
- Kelp Forest habitat has a **high** vulnerability score based on sensitivity and exposure to sea surface temperature, turbidity, and disturbance regimes (MHW). The adaptive capacity is moderate due to low structural and functional integrity, limitations to recovery including herbivory, and lack of species diversity.
- Kelp forest-relevant species of interest:
    - Red and purple urchins have a **moderate vulnerability** score based on sensitivity and exposure to sea surface temperature, pH and DO, disturbance regimes (MHW), sensitivity to competition (for red urchins only) and high

dependence on forage. Urchins have high adaptive capacity, based on their ability to adapt to forage conditions, adjust behavior, and persist with lowered body condition.

- Red abalone have a **high vulnerability** score based on sensitivity and exposure to sea surface temperature, low oxygen and pH, disturbance regimes (marine heatwaves), dependence on forage, and harvest (when fishery is open). Red abalone have moderate adaptive capacity as evidenced from a lack of recovery from high losses in 2014, dependence on kelp forests, and competition from urchins.

Pressures on Kelp Forests

Human activities and natural processes can affect the condition of kelp forests through a variety of pathways. This section has been included to inform the public about the most significant overarching pressures, past, present, and potential, that may impact kelp forests. While some pressures are beyond the scope of what ONMS can address, the sanctuaries are monitoring and working on efforts to respond to pressures related to climate change.

Summary of Relevant Regulations

The following GFNMS prohibitions can prevent impacts to kelp from listed prohibited activities:

1. Exploring for, developing, or producing oil, gas or minerals.
2. Discharging or depositing from within or into the Sanctuary any material or other matter.
3. Discharging or depositing, from beyond the boundary of the Sanctuary, any material or other matter that subsequently enters the Sanctuary and injures a Sanctuary resource or quality.
4. Constructing, placing or abandoning any structure, drilling into, dredging, or otherwise altering the submerged lands of the Sanctuary.
5. Deserting a vessel aground, at anchor, or adrift in the Sanctuary.
6. Leaving harmful matter aboard a grounded or deserted vessel in the Sanctuary.

See links to full text, definition, exceptions, and exemptions on the regulations pages of the GFNMS website.

Summary of Relevant Sanctuary Projects

Conservation Science

- Since 2019, GFNMS, Greater Farallones Association (GFA), and our partners have been conducting research to inform kelp restoration along Marin, Sonoma and southern Mendocino counties. Depending on location, activities have included: kelp canopy mapping to identify areas of kelp persistence, environmental monitoring, ecosystem assessments, kelp propagation, outplanting methods testing, assessment of urchin removals, and kelp wrack surveys.

Resource Protection

- The sanctuary is a collaborative partner in multiple efforts to restore kelp habitat with an emphasis on kelp forests along the Sonoma coast at priority locations based on historic presence, persistence, and accessibility. Four suitable locations have been identified: Ocean Cove, Stillwater Cove, Timber Cove and Ft. Ross Cove. Gerstle Cove was identified as a suitable control site.
- The sanctuary reviews project proposals that could potentially violate sanctuary regulations or are likely to destroy, cause the loss of, or injure sanctuary resources in kelp forests.
- Through permitting actions the sanctuary manages, reduces, or eliminates injury to kelp forest habitat.
- The sanctuary works with NOAA's Office of Law Enforcement and the U.S. Coast Guard to document and enforce sanctuary regulations that protect kelp forests, works with NOAA's General Council to issue fines, conducts damage assessments, and works with responsible parties to address impacts to kelp forests.

Education and Outreach

- Fisherman in the Classroom and LiMPETS school programming supported by NOAA BWET and other funding sources delivered kelp-focused programming. Students participated in a Fisherman in the Classroom program led by sea urchin divers and visited bull kelp field sites (either Gerstle Cove or Fort Ross Cove) to learn about drone surveys to measure the extent of bull kelp canopy and to conduct intertidal urchin surveys. Students collected, dissected, and analyzed urchin data to increase understanding of the role of urchins in kelp disappearance.
- Public programming included the Sea Urchin Soirée and the Seaweed Soirée, bull kelp updates presented to Sanctuary Naturalists, and a Sanctuary Explorations Seaweed workshop at Shell Beach on the Sonoma Coast to increase community and stakeholder understanding of the kelp ecosystem.
- Web stories, print, TV, and social media on kelp were published as well as media days on the regional research vessel *Fulmar* and at the kelp lab space at Bodega Marine Laboratory were hosted. Multiple kelp-themed *Ocean Currents* radio programs are archived on the NOAA website including a program on the disappearance of bull kelp in sanctuary waters to increase target public awareness of kelp loss and the need for restoration.

Infrastructure and Vessels

Sanctuary infrastructure supports kelp work through through office space, at sea assets, and administrative, logistical, and operational assistance including:

- Meeting spaces for staff and partners to collaborate on kelp projects and storage for field equipment.
- Spatial analysis products and services
- Crissy Field Visitor Center as an exhibit and teaching space to deliver kelp related programs to educate the public about the importance of kelp.

- GIS to support kelp habitat mapping and conduct spatial analysis to plan and assess restoration activities.
- Government vehicles for transportation to and from marinas and field sites for kelp monitoring, research, and education projects.
- Vessel support for field operations to research, monitor, and restore kelp.

Summary

Greater than 90% of kelp forest habitat in the sanctuary has been lost since 2014. Since 2019, GFNMS, Greater Farallones Association (GFA), and our partners have been conducting research to inform kelp restoration, focused on bull kelp. The sanctuary is a collaborative partner in multiple efforts to restore kelp habitat at priority locations based on historic presence, persistence, and accessibility. Education projects inform students and adults about the importance of kelp forests through Fisherman in the Classroom and LiMPETS school programming, public programming, and radio, print, TV, and social media on kelp. Sanctuary infrastructure supports kelp research and education through providing office space, a visitor center, at sea assets, and administrative, logistical, and operational assistance such as GIS support for mapping and spatial analysis.

GFNMS Advisory Council Recommendations

These recommendations were provided during a GFNMS Advisory Council meeting on December 15, 2023. To view council discussion on this topic, please visit https://farallones.noaa.gov/manage/sac_meetings.html and view the meeting's highlights.

Conservation Science

- Actively partner and collaborate to continue research and analysis to inform kelp restoration efforts including: kelp culture and outplanting techniques, urchin removals, environmental and ecosystem monitoring, kelp canopy mapping, and methods for restoration effectiveness monitoring.
- Conduct analysis of status and trends of species and habitat metrics to understand and evaluate changes in this ecosystem in GFNMS. Maximize the use of kelp data to understand sanctuary habitat status and trends to inform management. Increase capacity for data management and analysis to support these activities.

Resource Protection

- Actively partner and collaborate on kelp restoration activities in the sanctuary.
- Review the effectiveness of regulations related to how humans use or control ocean resources that may impact kelp forests in the sanctuary and recommend changes if needed.

Education and Outreach

- Assess kelp education programming effectiveness in increasing student, stakeholder, and community awareness about the importance of kelp ecosystems and the need for restoration to ensure a healthy sanctuary.
- Support student, stakeholder, and community involvement in kelp research and restoration.
- Actively partner with organizations to communicate the importance of healthy kelp ecosystems in the sanctuary.
- Explore the recommendations of the Marine Protected Area National Advisory Council for sanctuaries to develop a Cultural Landscape Approach in pursuing its work to raise awareness and understanding and conservation of the resources of Greater Farallones and Cordell Bank National Marine Sanctuaries.

Infrastructure and Vessels

- Partner with Bodega Marine Lab to share space to conduct kelp ecosystem research.
- Maintain meeting space and offices in San Francisco and Point Reyes Station to facilitate collaboration among science, resource protection, education, and operations staff and partners.
- Provide spatial analysis products and services
- Expand Crissy Field visitor center to develop a kelp habitat exhibit and to develop teaching space to train teachers and deliver kelp habitat education programming about the importance of kelp habitat and stewardship.
- Ensure staff have vehicle and vessel access to kelp field sites to conduct research and monitoring.