

Kelp Recovery Recommendations
Greater Farallones National Marine Sanctuary Advisory Council

On January 10, 2018, the Greater Farallones National Marine Sanctuary Advisory Council (Council) approved the formation of the Kelp Recovery Working Group to develop research, education/outreach, and management recommendations for the recovery of bull kelp populations along the North-Central California coastline. These recommendations were presented to the Council on November 14, 2018 for discussion and approval and the final recommendations are included here. These recommendations have been forwarded to the Sanctuary for consideration and inclusion in a final Kelp Recovery Action Plan, to be completed by February 2019.

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Kelp Recovery Program Recommendations

Kelp Recovery Purpose Statement:

Our mission is to promote healthy bull kelp ecosystems along the northern California coast, foster collaborative kelp recovery and conservation efforts, and bring the best information and data to bear on adaptive management of this vitally important resource.

The Greater Farallones National Marine Sanctuary Advisory Council recommends that the Sanctuary, in partnership with the California Department of Fish and Wildlife, develop a *Kelp Recovery Program* and a Kelp Recovery Network, operated by a coordinator and working with existing citizen science programs, to implement the following recommendations, with initial priority to develop a consistent funding stream and best practices.

Recommendations for developing a “Kelp Recovery Program”:

- Designate and fund a full-time Kelp Recovery Program Coordinator with conflict resolution skills and connections to relevant groups and stakeholders.
- Develop a Kelp Recovery Network to ensure communication and connection across all relevant agencies, tribes, programs, organizations, etc. Consider the successful and effective model of the Seabird Protection Network when designing the Kelp Recovery Network.
- Create an advisory group to meet at regular intervals to inform implementation of the Program and the Network’s activities.
- Create a science team to collect and analyze data, and provide guidance to advisory group (consider support from a post-doc position).
- Engage the public at regular intervals regarding the Network’s activities via the Sanctuary Advisory Council.
- Consult with tribes on cultural sensitivities.
- Implement the following priority topic area recommendations:
 - Monitoring: *Develop a cost-effective, sustainable kelp monitoring program*
 - Community Engagement: *Leverage and grow community engagement; develop consistent messaging and a comprehensive outreach plan to increase participation and awareness.*
 - Restoration Site Selection: *Compile all criterion datasets in spatially explicit way for application to site-selection decision tree.*
- Immediately assess the efficacy and feasibility of the “Tier 1” active recovery options outlined in Appendix B, and pursue implementation.
- Reconvene the Kelp Recovery Working Group in one year to assess progress and evaluate recovery actions.

Monitoring and Research Recommendations

The scope of these recommendations is intended to speak only to the monitoring and understanding needed to inform kelp recovery management, and not the actions pertaining to management of bull kelp and the ecosystems they support. The recommendations focus more on the types of studies and key elements of those studies, but not to the specifics of study design or methods.

Priority: Develop a cost-effective, sustainable kelp monitoring and research program

1. Expedite the processing and analysis of satellite data for bull kelp along the Sonoma/Mendocino coast, annually at a minimum. These data are critical in understanding natural trends in changes to kelp canopy cover, and may eventually be used to: evaluate whether recovery efforts are appropriate, inform those potential recovery efforts, and evaluate the consequences of any recovery effort. CDFW should determine thresholds of concern that trigger investigations as to why bull kelp abundance is below levels of long-term natural variability (like now). Are levels below long-term trends the consequence of any human activities or reflect responses to abnormal environmental conditions? These data should also be used to inform management of resources reliant on bull kelp by indicating where declines in kelp have contributed to declines in other species, triggering appropriate management responses. Moreover, knowledge of kelp dynamics can be used to inform ecosystem-based management of coastal fisheries (e.g. forecasting change in abalone stocks and condition of red sea urchins).

- As funding allows, these data should be ground-truthed with aerial surveys

2. Develop a large-scale Unmanned Aerial Vehicle (UAV) monitoring program to complement satellite imagery. Because satellites don't provide the resolution and scale of data needed to ask some critical questions (particularly when assessing the efficacy of a kelp recovery action), UAV data is needed to ground-truth satellite data and provide finer spatial and temporal resolution. UAVs provide: improved spatial resolution, the ability to identify vulnerable areas that are not captured by satellite imagery (kelp refugia, urchin removals), the ability to identify areas that landsat can't capture, or in areas where you need more information, spatial heterogeneity of reef structure, the ability to identify persistent pockets of kelp for spore supply, and species-specific resolution data (i.e. bull kelp versus giant kelp).

These data would enhance the goals of recommendation #1. Specific actions should include:

- Develop best practices for data collection including required permits, specific track-lines, altitude, tidal information and:
 - Overflight restrictions from regulatory agencies including the SanctuaryClear guidance from the Sanctuary on UAV use
- Develop methods for image processing and analysis, and identify lead agency/researcher to undertake processing. Once methods are developed, consider a phased approach for locations so that the collection methods can be modified if needed.
- Identify the target UAV user/pilot (UC scientists/experts, contractors, UAV enthusiasts via crowd-sourcing, NGOs)

- Specify product outputs that are needed to manage for bull kelp – engage the managers (CDFW, ONMS)
- Run the three primary data collection methods in one year for calibration - UAVs, planes, satellite

The most effective way to gather UAV data would be to decentralize the data collection and leverage 1) Scientists and contractors (experts) OR 2) UAV enthusiasts (citizen science) to run specific tracks at a specified frequency. Scientists (e.g. Tom Bell, Kyle Cavanaugh) would provide best practices and methods to the users, and the users would submit their images on a drop box for analysis. This could be web-based to prioritize sites and contact pilots to submit their images. Tom Bell and his lab are already running the infrastructure – the desire is to scale up the collection. Track files can actually be sent to individuals with a log-in and the UAV can run on autopilot collecting and transmitting the data.

If the “enthusiast”/citizen science route is pursued, there are two options: 1) Create an organization like Reef Check to organize a UAV imagery program (i.e. outreach, training, image processing, data management, etc.); 2) A much less reliable approach, but not entirely separate of this first option, would include the development of a crowd-sourcing website – this would be much more hands-off, and involve less investment and less risk.

3. Investigate the key characteristics that confer persistence and resilience of kelp beds.

Understanding persistence and resilience is partly, and very importantly, informed by remotely gathered kelp dynamics (satellite data, UAVs- see recommendations #1 and #2) and oceanographic information. It can indicate how some attributes of forests (e.g., forest size, density, proximity to other forests) or particular environmental conditions (e.g., water temperature, clarity, wave exposure) confer persistence or resilience. But it doesn't describe how other aspects of the ecosystem (abundance of herbivores and their predators, invasive species, potential spore banks, interactions with seafloor features) might confer persistence or resilience. Ecosystem monitoring studies in MPAs would provide this additional information in evaluating the causes of persistence and resilience (or lack thereof) at no additional costs. The following actions will contribute to an understanding of bull kelp persistence:

- Identify MPAs with and without persistent kelp beds as priority locations for leveraging ecosystem monitoring studies, and pursue collaborative efforts to collect data (CDFW and ONMS should continue collaborative cruises yearly).
- Process landsat data since 1984 to establish a baseline and evaluate deviation from the baseline.
- Traditional Ecological Knowledge and sociological dimensions (OPC could lead this effort).
- Identify data to further contribute to an understanding of persistence (bathymetry, model reanalysis output (Edwards ROMS), nutrient sampling, temperature-salinity-oxygen moorings, HFR surface current, and buoy wave data).
- Understanding the potential role of a perennating “seed bank” of microscopic spores to the recovery of forests is another important element of a more spatially limited monitoring study. Development of methods and a study design to determine the extent

of these seed banks and to test whether they are sufficient to contribute to and explain patterns of recovery should be explored.

4. Explore the potential for MPA network monitoring and other ecological monitoring efforts (e.g. CDFW Kelp Ecosystem Monitoring Program, Reef Check, Humboldt State University) to fulfill science needs/objectives in understanding kelp dynamics and recovery. These data are particularly useful for decoupling whether bull kelp dynamics might be attributed to the human activities conducted outside the MPA (e.g., fishing) or by natural environmental variation and whether these effects are synergistic. Differences in patterns of resource and ecosystem dynamics in and out of MPAs suggest that human activities conducted outside MPAs may contribute to these differences, whereas similar patterns of resource and ecosystem dynamics in and out of MPAs suggest that human activities conducted outside MPAs are not contributing to those dynamics. This insight may lead to changes in management strategies, both in location and timing, and may guide how recovery efforts should move forward.

5. Monitor to inform recovery efforts (including sea urchin removals). All of this pertains to how monitoring studies inform the design and evaluation of recovery efforts. This underscores how monitoring data not only inform a particular recovery effort, but also inform future recovery efforts by determining how the design of a recovery program did or did not lead to a successful recovery of kelp and associated resources. The following activities are recommended to ensure monitoring can inform recovery efforts:

- Ensure pre and post monitoring of recovery actions
- Describe the purpose of the monitoring effort
- Thoroughly describe the sampling design and protocols as they pertain to the purpose of the monitoring effort
- Describe how the data will be managed and disseminated (raw data sets, analyses and results of analyses)
- Consider monitoring other aspects of the ecosystem that either (i) help explain the relative success of the recovery effort, (ii) inform the design of future recovery efforts, or (iii) identify how other species in the system, including other marine resources, influence and respond to forest recovery (How much algae was at the site when the recovery effort was initiated? Were there urchin predators or competitors around? Were environmental conditions conducive to success (water clarity and temperature)? What are the consequences of forest recovery for the recovery of other species (e.g., abalone, red sea urchins)?

6. Use high-resolution UAV canopy data to explore relationships of blade biomass with spore production (size of sori). These data will advance our knowledge of the biology of bull kelp and guide recovery planning by understanding sources (and sinks) related to spore

production, and possible dispersal. It is not clear if dense stands contribute disproportionately to colonization beyond that source area. Having an answer will guide where to apply effort.

- A coordinated approach that combines remote and ground truthing surveys would be required to test for these relationships.
- Develop methodology and identify lead researcher/agency to manage, process and interpret data

7. Leverage existing websites to help coordinate monitoring events and to disseminate the information gathered from monitoring studies. All existing and future non-sensitive data (excluding Personally Identifiable Information and sensitive tribal information) related to these recommendations should be publicly available on [CNRA Open Data](#). Other relevant websites (e.g. CDFW, [Noyo Center for Marine Science](#), and [Greater Farallones Association](#)) used to disseminate the information should be coordinated with explanations of the purpose of the monitoring programs and data, who was involved in collecting it, etc. For example, detailed explanations can be provided at one website that others can point to, or the same text can be shared and posted across the websites. Mixed messages from the various websites should be avoided. A separate website should be used to focus community removal events, so as not to confuse recovery efforts with monitoring efforts.

Community Engagement Recommendations

The community engagement recommendations reflect a broader view of opportunities to engage the public. Specific messaging will be tailored to specific audiences; this is further elaborated in the recommendations. Overall, messaging should include concepts of adaptive restoration and adaptive learning, noting that a goal of these projects is to understand the cause of the issue. It is important to be explicit with regulations. The community engagement recommendations are intended to break the barrier between the research (that is developing) and public accessibility of information.

Priority: Leverage and grow community engagement; develop consistent messaging and a comprehensive outreach plan to increase participation and awareness.

1. Engage with a range of community members, organizations, agencies, etc. to raise awareness about kelp recovery efforts with consistent messaging tailored to each target audience and their level(s) of engagement & areas of focus. Specific messaging should be crafted for public education, partner recruitment and monitoring outcomes. The list below outlines audiences and partnerships with identified organizations, members, or agencies that can be engaged.

- a. The general public: the following groups should be engaged to raise awareness and educate:
 - i) Kayak companies (e.g. WaterTreks Ecotours)
 - ii) Arts centers (e.g. Gualala Arts Center)
 - iii) Activist organizations
 - iv) Nature/Education Centers (e.g. Bay Model)
 - v) Libraries (e.g. Point Arena Library)
 - vi) Public facilities such as campgrounds, parks, and lighthouses
 - vii) Chambers of Commerce
 - viii) General public partaking in recreation
 - ix) Harbors and local boating communities
- b) Governments:
 - i) Tribal: Resource management departments, seaweed gatherers and indigenous harvesters, tribal water consortium in Northern CA, North Coast Resource Partnership tribal representatives
 - ii) State: California Department of Fish & Wildlife, Ocean Protection Council
 - iii) Federal: Greater Farallones, NOAA
 - iv) Local governments
 - v) Legislators
- c) Fundraisers
 - i) Funders (e.g. private, corporate funding opportunities)
 - ii) Foundations and associations (e.g. Greater Farallones Association, The Sea Ranch Association)
 - iii) Local, state, federal government grants

- iv) Opportunities for crowdfunding
- d) Resource stakeholders
 - i) Tribal groups (Tribes - Seaweed gatherers and indigenous harvesters, tribal water consortium in Northern CA, North Coast Resource Partnership tribal representative)
 - ii) Recreational fisherpeople
 - iii) Commercial fisherpeople
 - iv) Party boats
 - v) Commercial and recreational fleet captains
 - vi) Academic/science institutions
 - vii) Processors
 - viii) Abalone Divers
 - ix) Chambers of Commerce
- e) Potential users of urchins - groups to engage regarding novel urchin use:
 - i) Urchinomics: a Norway-based business that works worldwide to preserve kelp forests and boost rural communities by creating a lucrative market for sea urchins
 - ii) Composters
 - iii) Farms
 - iv) Craftspeople
 - v) Public input/crowdfunding: public challenge to crowdsource ideas regarding novel urchin use
 - vi) Chambers of Commerce via visitor centers
 - vii) Restaurants
- f) Research and scientific input
 - i) Monitoring groups/labs (e.g. Bodega Marine Lab)
 - ii) Citizen science groups
 - iii) Other (national/international) groups addressing urchin barrens
- g) Classroom education
 - i) LiMPETS
 - ii) Noyo Center for Marine Science
 - iii) GFNMS school-age programs
- h) Media and public outreach
 - i) Newspapers (SF Chronicle, NYT, Point Arena Light, Ukiah, Press Democrat, Marin IJ, do editorial, consistent messaging/story, educating the community as a whole)
 - ii) Magazines
 - iii) Radio
 - iv) TV

2. Develop meta-messaging with correct and consistent scientific elements of the story.

There are many levels of messaging depending on the audience and community engagement.

There should be one overarching message (“meta-message”) that shares four important aspects to this topic. We offer a four-step guideline for the meta-message, including:

1. **Place:** The Northern California bull kelp forest is an underwater community with ecological, historical, economic, and cultural significance on which our lives/our way of life depend.
 - a. Analogies/metaphors “what would California be without redwoods? Kelp forest?” (knowing a place because of significant natural elements, and history & culture with that nature)
 - b. Capturing historical environment/pre-dating written history
2. **Problem/Issue:** “Perfect storm”: wasting disease of sea stars, a major purple urchin predator, coupled with extremely warm ocean conditions (El Nino, “the blob” - a heat wave in our marine ecosystem) compounded by the negative impacts of climate change which have all resulted in an unprecedented, dramatic, and startling 95% decrease of bull kelp forest in the last five years. (The problem statement may need to be messaged in different ways to different audiences.)
 - a. An example of a problem statement that can be used as messaging for tribes: *Most ocean pollution begins on land. When large tracts of land are plowed, the exposed soil can erode during rainstorms. Much of this runoff flows to the sea, carrying with it agricultural fertilizers and pesticides. Eighty percent of pollution to the marine environment comes from the land. Coastal communities have seen these effects and how it has drastically changed the ocean.*
3. **Why it matters:** The health of the ocean matters because of all the sensitive marine species. Kelp provides a vital component necessary for a healthy coastal neighborhood. Marine species provide important ecosystem services such as the provision of food, medicines, and livelihoods. Kelp forest sustains and supports hundreds of species which Tribal people and fishermen rely on for subsistence.
4. **Action:** Support kelp recovery efforts and organizations through the following ways:
 - a. Get active: Volunteer with citizen science programs that contribute to kelp recovery: [Noyo Center for Marine Science](#), [Reefcheck](#)
 - b. Get giving: Donate to organizations that help fund recovery efforts
 - c. Get talking: Act as a messaging ambassador and share the story
 - d. Get clever: Think about innovative uses for the purple urchin
 - e. Learning: your impact on the land, consumption, water use, land use change
 - f. Climate impacts 5 things list/behavior change list

3. Communicate the need to find beneficial uses to address purple urchin barrens and highlight beneficial uses and opportunities for purple urchins. We need to be vigilant to not message purple urchins as a “villain”. They are a native species and we don’t want to create a situation of unintended consequences for when things cycle back to a more kelp-abundant mode. We recommend phrasing urchin removals as “urchin harvesting”. A case-specific and very targeted effort of “culling” may arise but this will be very coordinated and managed. This could include an incentive-based prize for the innovative use of urchins.

4. Create connections for key organizations with large membership bases that can leverage resources to understand how the kelp issue is connected or related to topics they care about. This could include drafting a statement about how the kelp issue impacts other species and habitats. For example, the Audubon Society has a large membership base and could become a key partner in sharing the message of the kelp issue as it pertains to birds.

5. Produce a range of informational outreach materials with consistent messaging. Outreach materials or presentations should be translated into various languages. Products could include the following:

- Talking points
- A shareable presentation
- A community list serve with upcoming events
- A laminated, weatherproof “Kelp Binder” with relevant information, photos, and visuals. This binder can be provided to docents, vessels, public facilities, libraries, etc. to share the story in a consistent manner. The Noyo Center has an example of a [presentation](#) they use.
- A shared information portal that is updated with community events. The organization that could own this portal would need to be identified; suggestion that GFNMS/Ocean Climate program could own. Cal Fish and Wildlife has started an open data portal/library where the assets could reside.
- A shared drive of visual assets or image and video library that includes iconic social media-worthy photos and videos. The Noyo Center has some images they can provide.
- A “traveling roadshow” presentation to public facilities. These presentations could have a target date or time frame. The goal of the traveling presentation would be to have a large number of people spreading the same message to different communities.
- Youtube channel to show/digital version of the presentation
- Informational cards and additional outreach materials. Consider where printed materials are necessary or appropriate.

6. Utilize partner social media channels to share consistent messaging and information, including videos. Various organizations maintain their own social media sites which can promote directly to their audiences.

7. Create means for commercial urchin divers to film what is happening underwater and stream through videos. The 3D element is powerful and shows the problem. Connect with existing partners such as MARE that may have ROV footage related to kelp.

8. Make a connection to anthropogenic environmental change as part of the problem, understanding climate change, and land development/uses as potential drivers of stressors to open-coast environments. We need to look at better practices here to minimize impacts. Identify that humans are contributing to local anthropogenic environmental change, which is an additional factor. In our storytelling we should try to get people to understand the larger picture

and interconnectivity of actions; not focus on purple urchins as the main villain. Encourage what people can do in their daily life/provide climate resiliency best practices. Meet people where they are and adjust topics for this variability in understanding.

9. Provide lists of behavior change recommendations that will reduce negative anthropogenic impacts. One list can include the top five actions the general public can take to help this project. Another list could include changes that people can make in their lives to address broader climate impacts on the ocean.

Site Selection Process Recommendations

The following recommendations outline the process by which sites should be selected for recovery action. Specific recovery actions for specific sites are not identified, and are not the intent of these recommendations.

Priority: Compile all criterion datasets in spatially explicit way for application to site-selection decision tree.

1. Site selection criteria should be grouped into three tiers of categories, within which site selection criteria are organized by prioritization (see Appendix D).

All of the criteria evaluated should be included in the site selection process, but they should be grouped and weighted using the following guidelines:

- **Tier 1:** Criteria that have ecological significance should be given priority. Within this group, historical and current persistence criteria should be given the greatest consideration.
- **Tier 2:** Areas where recovery efforts should be avoided should be considered next, such as MPAs and culturally sensitive areas.
- **Tier 3:** Positive additional aspects such as ease of public access, protection from wave exposure and sites of value to the recreational abalone fishery and the red urchin commercial fishery should be considered.

Criteria may be weighted differently within these three tiers on a case by case basis, in which case clear reasoning should be provided. Local and traditional knowledge should be incorporated whenever possible. If site selection criteria result in regional grouping, take additional positive aspects into greater consideration and/or apply higher weight to spread out sites. Determine why regional grouping may have occurred. The persistence criterion can be made less stringent if necessary. These criteria will determine ‘candidate areas’, or regions of the coastline where potential recovery efforts could be made, then specific sites should be chosen within these candidate areas, based on the recovery action being implemented.

- CDFW should consider leaving temporary markers on restoration/recovery sites.

2. Multiple layers of persistence of kelp canopy should be considered.

Both historical and current persistence of kelp canopy should be defined when looking at specific sites. Historical persistence is especially important for Sonoma, as there is very little current persistence. Define these “persistence” layers and use the same criteria for historical and current persistence across all sites, but acknowledge that persistence may occur at different sites for different reasons and take this into consideration when developing the type of recovery action.

- Historical persistence should be defined clearly.
- Consider scale of persistence (2m resolution from airplane-based surveys)

3. Priority should be given to sites where survey data is gathered, or has historically been gathered, and tiers should be assigned based on the resolution of that data.

Sites that have been surveyed by CDFW, Reef Check, PISCO, etc. will provide a better baseline for understanding ecosystem dynamics and responses to recovery efforts and should be prioritized after understanding candidate areas. The resolution of this data should be prioritized by two tiers. The first tier should include areas that have pre-disturbance, or pre-impact data, then the second tier should be sites that have current and ongoing data.

- A map of all monitoring and survey sites should be created and referenced when identifying candidate areas and sites.
- Resolution of each data set should be clear and informative to site selection for recovery actions at a specified scale.
- Further surveys within each chosen site should be conducted to determine specific restoration actions on a finer scale.

4. When specific recovery sites within candidate areas are chosen, a corresponding control site should be chosen at the same time.

Learning from the recovery process is essential and having control sites will allow more effective monitoring to determine success or failure. The potential for Marine Protected Areas to be considered control sites is high, so as to minimize the influence of commercial and recreational take on monitoring.

- Develop a clear process for determining what defines a “site”.
 - A “site” may be defined as a treatment site plus a control site.
 - The size of a site chosen will depend on the resolution of the data available and the work to be accomplished.

5. Different types of recovery actions should be identified for different sites depending on the criteria for which they were selected.

It is critical to understand what is going on underwater, in addition to what the aerial data reveals as “persistent”. These criteria should be used as a guide for areas that may be feasible and effective places to conduct restoration work, then once we’ve identified ‘candidate areas’ or larger regions to work in based on the criteria, there should be additional on-the-ground evaluation to determine the type of restoration action(s) and finalize specific sites.

- This work should be informed by the ongoing urchin removal efforts conducted in 2018.

Other major thoughts on site selection criteria:

Anthropogenic stressors will vary in type and magnitude depending on the region/site and should be evaluated separately for each candidate area and the sites within. Stressors may include pollution, oil spills and/or fishing. Oil spill impact reports should be consulted and lower priority should be assigned to sites in high-risk areas. It should be highlighted in this report that anthropogenic stressors are relatively low for the northern California coastline, as this report may influence decisions made in other regions. Additional data/information should be gathered on: areas of cultural significance and sensitivity, bathymetry, magnitude/type of sediment impacts.

Appendix A. Working Group Membership

Name		Affiliation	Contact
<i>Catton</i>	<i>Cynthia</i>	<i>Working Group Co-Chair; CDFW</i>	<i>Cynthia.Catton@wildlife.ca.gov</i>
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Appendix B. Active Recovery Options

At their September 13, 2018 meeting, the Kelp Recovery Working Group considered and evaluated a number of possible management actions to support the recovery of bull kelp beds along the north coast. This is not an exhaustive list of options. Recovery options are organized first by type of action (no action, enhance bull kelp, and reduce sea urchin) and second by the working group's recommendation for how each action should be approached moving forward:

Tier 1: Action should be investigated and assessed immediately (within 1-2 years). These actions are incorporated into the Working Group's recommendations.

Tier 2: Action should be considered at a future date, depending on conditions (due to the experimental nature of the action and/or significant information gap)

A number of actions considered were deemed to have consequences that could be too severe and were thus removed from the list of possible actions. These options are recorded at the end of this document, and should not be considered for implementation at any time.

No action:

Tier 2:

Do not take any active recovery actions

- This action should be assessed on a regular basis as an alternative course

Enhancing bull kelp:

Tier 1:

Active bull kelp zoospore seeding

- Need: source information, feasibility at scale
- Opportunity to explore resilient ecotypes to assist adaptation
- Agency lead: CDFW
- Scientific expertise: Mike Graham, MLML; Phillippe Alberto, UW

Tier 2:

Outplant sporophytes grown in the lab

- Need: feasibility at scale, suitability in coastal environment
- Opportunity to install artificial reefs as refuges in sandy habitat

Reducing starving urchins:

Tier 1:

Commercial urchin harvest

- Needs: ideally create a market for urchins, consider payment for collection, ensure coordinated and directed harvest informed by Kelp Recovery Program
- Benefit: skilled, effective, less limited geographically than rec divers
- Agency lead: CDFW, in collaboration with Kelp Recovery Network Partners

Recreational urchin harvest

- Needs: coordinated and directed harvest informed by Kelp Recovery Program
- Recognize utility of existing, individual efforts
- Benefit: capacity and enthusiasm
- Agency lead: CDFW, in collaboration with Kelp Recovery Network partners

Support [Seastar Wasting Disease Strategic Action Plan](#) recommendations

- Needs: review recommendations and identify potential synergies
- Lead: Greater Farallones Association
- Scientific expertise: Seastar Wasting Syndrome Task Force

Urchin culling

- In close partnership with Tribes and CDFW, investigate unintended consequences (i.e. induced spawning, damage to reef and other species)
- Needs: ensure communication around this action clearly portrays urchins as a native species important to a balanced ecosystem; coordinated, highly controlled approach in specific, focused areas

Tier 2:

Reintroduce sea otters

- Issues: barren urchins do not have enough calories to sustain otters (they do not even consume them), not a viable option now
- May be a viable option long-term

Underwater remotely-operated urchin predators

- Universities of Tasmania and Sydney, Australia, are testing this method

Actions Should Not be Pursued:

Urchin disease introduction

- Issues: full eradication of urchins not the desired result

Genetic modification of urchins (sterilization)

- Issues: full eradication of urchins not the desired result

Implement urchin barriers

- Issues: not cost-effective for an annual species and north coast conditions

Areas of Potential Future Research for Data Gaps & Site Selection

Genetically test bull kelp beds (eDNA) and the surrounding biological community selected for restoration

- Determine if local biome affects recovery of species in restoration efforts
- Genetic diversity in the future may be able to play a part in the selection of sites for restoration and recovery actions.

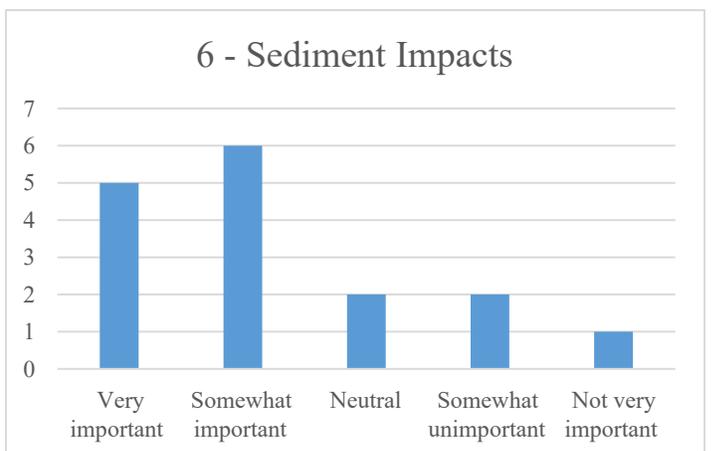
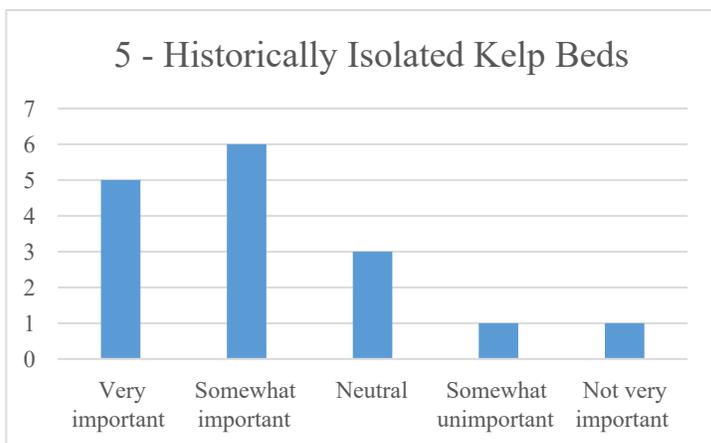
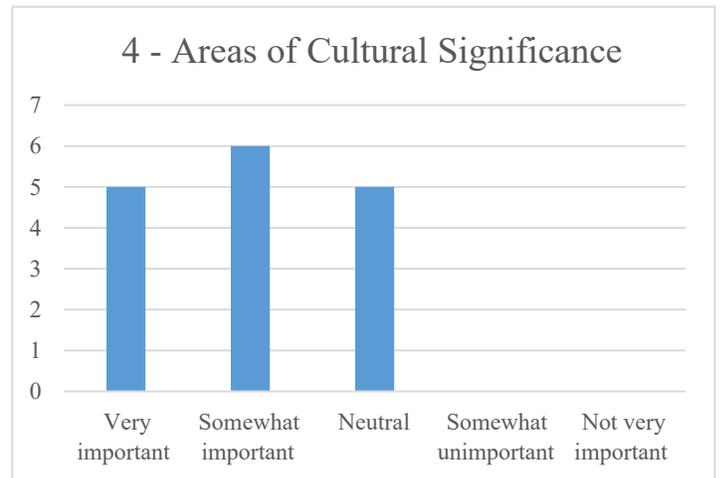
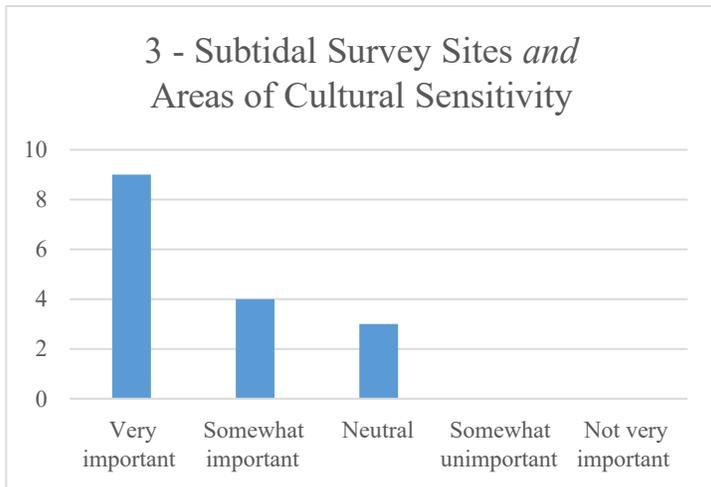
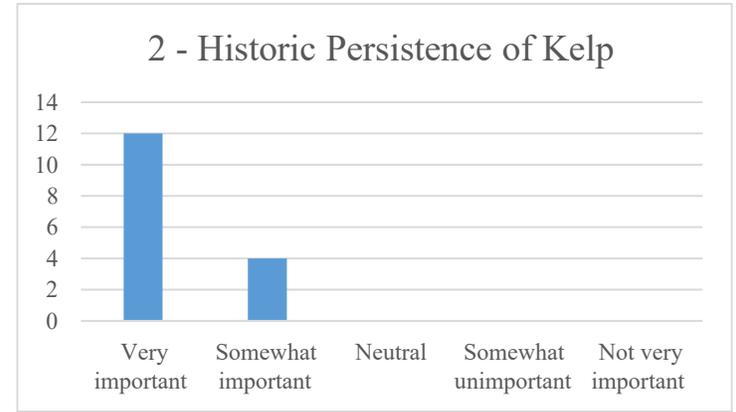
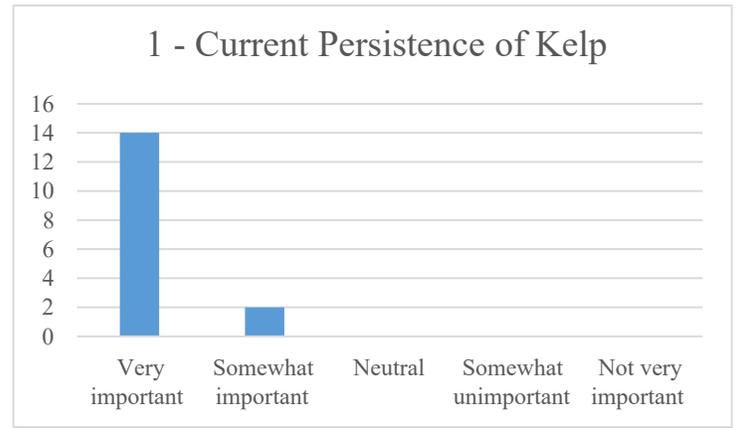
Appendix C: Established Partnerships

Listed below are the agencies, organizations, and stakeholder groups that should be engaged and leveraged in the development of a Kelp Recovery Program and Kelp Recovery Network. This list will be continually expanded as new partnerships are formed.

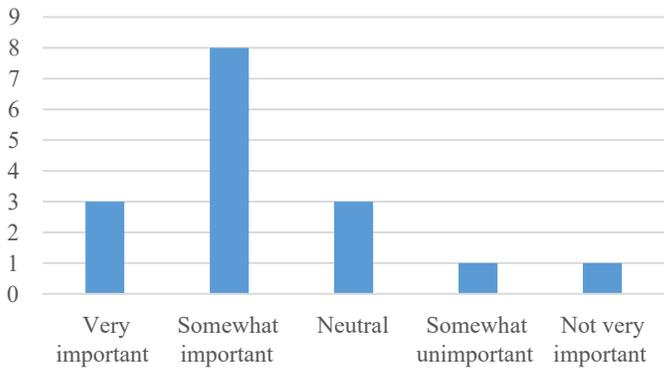
- California Department of Fish and Wildlife
- Greater Farallones National Marine Sanctuary
- Greater Farallones Association
- The Nature Conservancy
- North Coast Resource Partnership Tribal Representatives
 - Sherwood Valley Band of Pomo and Noyo Tribal Community
 - Round Valley Tribes
 - Coyote Valley Band of Pomo
 - Manchester/Point Arena Tribe
 - Potter Valley Tribe
 - Kashia Tribe
 - Inter-Tribal Sinkyone Council
- Noyo Center for Marine Science
- Urchinomics
- Surfrider Foundation
- Watermen's Alliance
- Get Inspired, Inc
- Reef Check California
- California Sea Urchin Commission
- University of California, Bodega Marine Lab
- Lift Economy
- Nutiva
- North Coast Brewing
- Fortunate Farm
- Humboldt State University
- University of Santa Cruz
- San Diego State University Coastal and Marine Institute
- Farallon Institute
- Waves of Compassion Association

Appendix D. Results of Restoration Site Selection Criteria Survey

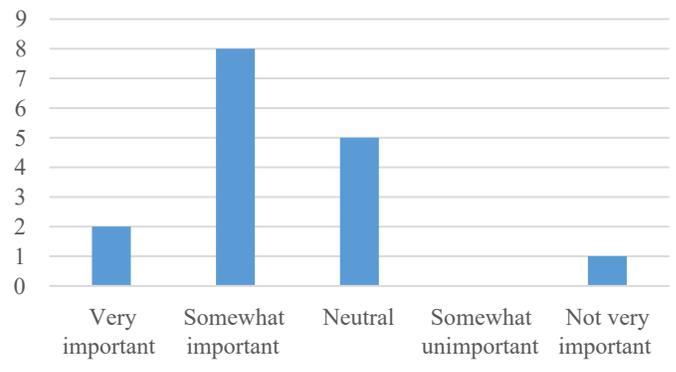
	Restoration Site Selection Criteria, in order of importance (n = 16)	Average Rating (1 = Very important; 5 = Not important)
1	Current persistence of kelp	1.13
2	Historical persistence of kelp	1.25
3	Subtidal survey sites	1.63
3	Areas of cultural sensitivity to be avoided	1.63
4	Areas of cultural significance to be recovered	2
5	Historically isolated kelp beds	2.19
6	Sediment Impacts	2.25
7	Presence of anthropogenic stressors	2.31
8	Sites of value to red abalone fishery	2.34
9	Proximity to public access points	2.44
10	MPAs where urchin harvest is allowed	2.56
11	Protection from wave exposure	2.63
11	Sites of value to red urchin fishery	2.63
12	MPAs where urchin harvest is prohibited	2.88
13	Freshwater output sites	3.25



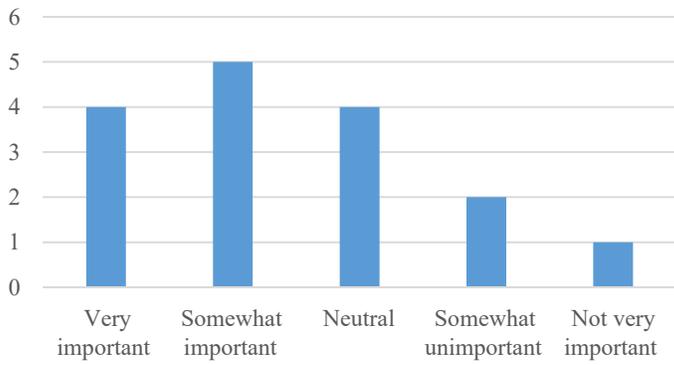
7 - Presence of Anthropogenic Stressors



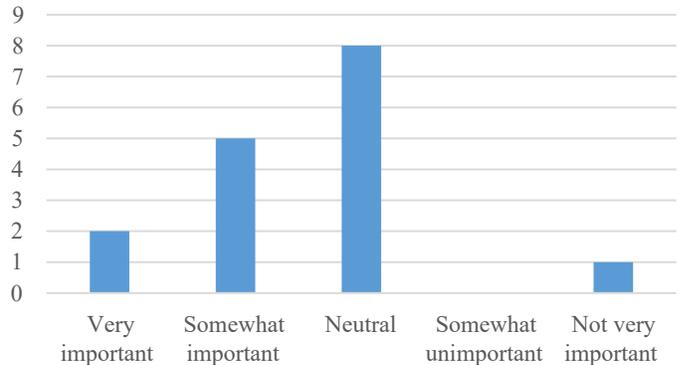
8 - Sites of Value to Red Abalone Fishery



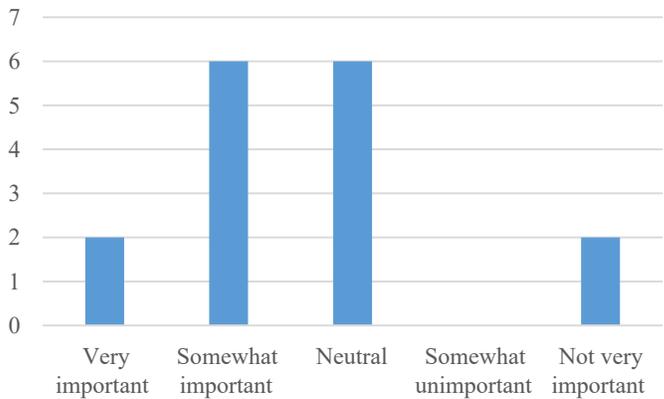
9 - Proximity to Public Access Points



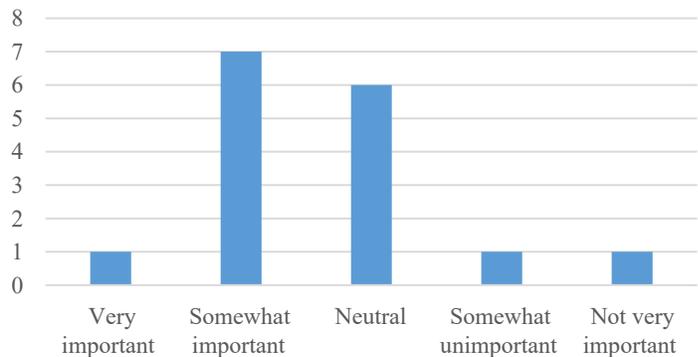
10 - MPAs: urchin harvest is allowed



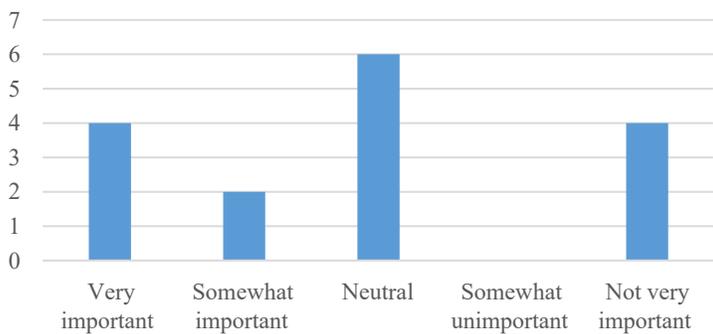
11 - Protection from Wave Exposure



11 - Sites of Value to Red Urchin Fishery



12 - MPAs: urchin harvest is prohibited



13 - Freshwater Output Sites

