The Race to Restore Kelp:

How Scientists Are Working to Restore California's Kelp Forests

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Abstract

The recent surge in interest for restoring kelp forests in California has created a confusing and crowded landscape to navigate. Additionally, most existing resources are in the form of formal reports or journal articles, both of which rely heavily on specific terminology and can be physically locked behind a paywall. It is therefore unreasonable to assume interested members of the public and policy makers can reliably access or understand the intricacies of the kelp restoration landscape. To address these gaps, this project develops a multimedia web-based resource that provides unique access to kelp restoration projects happening in California. Through photos, videos, audio and maps, users can interact with the StoryMap and learn directly from stakeholders and learn how they are using various methodologies to restore kelp in California.

Introduction and Background

Threats to Kelp Forests

Worldwide, kelp forest coverage is predicted to contract due to the narrowing of suitable habitat. Kelp will continue to shift poleward, constrained by temperature and nutrient levels while remaining light limited in the higher latitudes (Steneck et al., 2002). Additional threats include marine heat waves, climate change, pollution, storms, and grazing pressure (Gorman et al., 2009; Holbrook et al., 2019; Laufkötter, et al., 2020; Leighton et al., 1966; McPherson et al., 2021; North, 1979; Parnell et al., 2010; Reed et al., 2016). Regional stressors, however, may play an even larger role in the health of kelp forests, highlighting the importance of region-specific knowledge of localized stressors and ecosystems (Krumhansl et al., 2016; Leichter et al., 2023). In 2013, sea star wasting syndrome decimated sea star populations, an important sea urchin predator along the west coast of North America, leaving urchin populations unchecked and free to graze on kelp (Galloway et al., 2023; Hewson et al., 2014; Kriegisch et al., 2019; Parnell et al., 2017). Additionally, starting in 2014, California encountered a series of warm water events including what has been coined, the Blob (Bond et al., 2015; Oliver et al., 2018; Zaba and Rudnick, 2016) and el Niño events, weakening kelp which favors cool, nutrient rich water (Wheeler and North, 1981). These compounding events severely altered California's kelp forests including reductions in kelp coverage by more than 95% in some regions of the state (McPherson et al., 2021; Rogers-Bennett and Catton, 2019 Ward, et al., 2022).

Historic Kelp Restoration and Information Gaps

Though global kelp restoration efforts were first documented in the 1700s in Japan, modern restoration efforts in California began in the 1900's (Eger et al. 2022; Ueda et al., 1963). These efforts began after natural and anthropogenic disturbances reduced kelp coverage in Southern California, where there was strong interest in maintaining healthy stocks for commercial kelp harvest (Foster and Schiel 2010). The kelp decline was triggered by a reduction of urchin predators due to fishing pressure, poor water quality from pollution, and warm water events (Wilson and North, 1983).

An extensive amount of literature and reports on kelp projects in California exist, overwhelming the field with information and data. Reports and journal articles are critical components in conveying findings, however relying solely on these documents fails to engage audiences outside of academia due to various accessibility issues including paywalls or niche scientific terminology. To address these gaps, this project provides a multimedia resource aimed at, and accessible to, interested members of the public to policy makers. The resource allows viewers to hear directly from restoration experts through audio clips and short videos, and allows users to engage with interactive features like maps and photo galleries, all while presenting the scientific information in an easily understood and consumable format.

Kelp Management in California

In California, kelp is managed by the California Department of Fish and Wildlife (CDFW) including permits for commercial harvest. Currently CDFW is working in partnership with the Ocean Protection Council (OPC) to develop a comprehensive statewide Kelp Restoration Management Plan (KRMP) to better address future loss of giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis luetkeana*). The KRMP will include an ecosystem-based management approach, adaptive kelp harvest framework, and a restoration toolkit. Additionally, in 2021, California Sea Grant and CDFW released a Giant Kelp and Bull Kelp Enhanced Status Report (California Department of Fish and Wildlife, 2021) and OPC released their Interim Kelp Action Plan (Esgro and Ray, 2021). Given the timing of these documents, additional supplemental resources explaining restoration efforts, provided in this project, seemed relevant and timely.

Restoration Stakeholders

Though the list of groups actively working in kelp forest restoration in California continues to evolve, at the time of writing, this project concentrates on three groups: The Nature Conservancy (TNC), Moss Landing Marine Labs (MLML), and The Bay Foundation (TBF). It is important to note that due to the collaborative nature of kelp restoration work, many times, no single group leads an effort, but rather collaborate on different elements of the project. Though the StoryMap developed for this project highlights specific groups, unless explicitly stated, does not indicate that respective groups are leading the project. For example, TNC is working on several collaborative projects in Northern California including ones at Albion Cove, Caspar Cove, and Noyo Harbor. The StoryMap developed for this project focuses on the work that TNC is doing at Caspar Cove, even though several other groups are working on this project including CDFW, OPC, Reef Check, and The Waterman’s Alliance.

Restoration Methodologies

Current restoration strategies center around three main pillars: artificial reefs, grazer suppression, and kelp out-planting (Eger et al. 2022). Artificial reefs involve the restoration or creation of new reef habitat that serve as substrate for kelp to grow on. Grazer suppression involves the reduction of herbivores, typically purple sea urchins (*Strongylocentrotus purpuratus*). This can be done by physically removing/culling urchins from a site or potentially reintroducing urchin predators. The literature suggests that reducing urchin densities to 2 per m^2 or less, reduces the grazing pressure enough for kelp to grow (Ford and Meux, 2010). Finally, kelp enhancement often involves growing kelp in a controlled environment and out-planting it on a site. This can be done at all kelp life stages using different mediums such as on rocks or line. Many times, methods are done in conjunction with one another to maximize the likelihood of success.

Project Objectives

Restoring kelp is not a new concept in California, efforts in Southern California began in the mid 1900's (North, 1958; Eger et al., 2022) and involved transplanting *Macrocystis pyrifera*. Later, other methodologies were tested including quicklime, urchin crushing and kelp out-planting (Wilson and North, 1983), the latter two are still used today (Williams et al., 2021). With so much work on kelp, there is no shortage of data or literature on the subject and yet little has been done to synthesize the historical restoration work or to share data, resources, or knowledge in a centralized location until CDFW and Eger et al. published a review and associated website on global kelp restoration efforts (California Department of Fish and Wildlife, 2021; Eger et al., 2022). More recently with regional declines in bull kelp following warm water events and the loss of sea stars (Hamilton et al., 2021; McPherson et al., 2021; Rogers-Bennett 2019), groups along California began working on kelp restoration efforts using strategies pioneered decades earlier (Eger et al., 2022). Groups often work on several different projects simultaneously, and some are using different restoration techniques at different sites. Adding to the complexity, many of the restoration projects are collaborative, meaning multiple groups are contributing to portions of a larger project. With the abundance of reports and journal articles, the constantly growing number of projects, the variation in restoration techniques, and the intermixing of groups on projects, the restoration landscape becomes very convoluted, even for those working in it. It's unrealistic to think that interested members of the public or policy makers are able to keep up with this overwhelming amount of information. Assuming interested parties are first able to access these reports or journal articles that many times are locked behind paywalls, they must then contend with extremely specific, long and jargon heavy content that may only be understandable to subject matter experts.

To address these accessibility issues, this project creates a multimedia, web-based resource aimed at synthesizing the kelp restoration landscape in California by highlighting several projects. This Esri StoryMap is not intended to replace reports or scientific literature on the subject, but rather provide a supplemental resource that can buttress the existing literature through multimedia elements. Viewers can experience restoration efforts by actively engaging with the various media elements which cannot be done through traditional scientific documents.

Methods

To understand and communicate the methodologies used for kelp restoration, it was critical to speak with stakeholders working on restoration projects in California. Every effort was made to include stakeholders from around the state and include a representative project for the varying restoration methodologies. Despite this, several groups declined invitations to participate or did not respond to initial invitations.

Stakeholder Selection

Throughout California, a substantial number of projects are working to restore kelp using a range of methodologies. Deciding which projects to highlight involved a teared approach. The first step was to divide California into three subregions; Northern, Central, and Southern California. These regions were divided following divisions used by CDFW and the OPC in their Interim Kelp

Action Plan (Esgro and Ray, 2021). The next step was to include projects that represented one of the three major restoration strategies; kelp enhancement, grazer suppression, and artificial reefs (Eger et al., 2022). Given the short 10-week period to conduct surveys and interviews, leveraging existing contacts was critical to accomplishing the project goals. After narrowing down the list, three targeted groups were chosen: The Nature Conservancy (TNC), Moss Landing Marine Labs (MLML), and The Bay Foundation (TBF). While many groups including some highlighted in this project work with multiple methodologies, for the sake of simplicity, each group was assigned a region and methodology. The Nature Conservancy represented Northern California and grazer suppression. Interviews were conducted with Tristin McHugh, Kelp Project Director. Moss Landing Marine Labs represented Central California and kelp enhancement. Interviews were conducted with Dr. Scott Hamilton, professor at MLML, Bennett Bugbee, graduate student at MLML, and Andrew Kim, research technician at MLML. The Bay Foundation represented Southern California and grazer suppression. Interviews were conducted with Tom Ford, CEO at TBF, Jillian Demeter, Ocean Resiliency Program Coordinator, and Mason Emery, Ocean Resiliency Program Coordinator. Going forward I will include an additional section highlighting artificial reefs, however at the time of writing, no group representing artificial reefs agreed to participate in this project.

Information Collection and Interviews

Interviews were conducted in April and May, 2023 with representatives from the three respective groups to understand their project goals, restoration locations, and methodologies. Interviews were recorded using an DSLR camera and digital sound recording device and were conducted on site. Filming experts in their field and allowing them to speak directly to viewers was an important element for the project to give viewers unique access, insight, and a personal connection with the projects. For TNC and TBF, dives were conducted to capture photographs and videos of the restoration sites. At MLML, photographs and videos were taken at the grow-out facilities. In addition to the formal interviews conducted with experts, informal interviews were conducted throughout the 2022-2023 academic year with various scientists, artists, and experts in the field.

Multimedia Elements

Multimedia elements included photographs, videos, audio, and maps and were integrated into Esri's StoryMap feature. Interviews and videos were edited using Adobe Premier. Photos were edited using Adobe Lightroom. Editing for all elements was minimal and intended to maintain the integrity of the original content. GIS Shapefiles for given restoration projects were provided by the respective stakeholders. Kelp coverage data for 1989 and 2016 were downloaded as shapefiles from the CDFW's website. Dates for kelp coverage were chosen based on availability and to provide viewers with a comparison between a relatively abundant kelp year (1989) and a post-disturbance year (2016).

Output

The final output is an interactive webpage hosted as an Esri StoryMap. The StoryMap is intended to be accessible to a wide audience including individuals or groups interested in kelp restoration, policy makers, and scientists. Relying on the visual elements allows for a wider audience that might otherwise be turned away by scientific language while maintaining the information at a level that scientists would be uninterested in. To describe the kelp restoration landscape, the StoryMap allows users to scroll down California to explore the three regions (Northern, Central and Southern California). Throughout the experience, users can feel as though they are participating in the process thanks to the integration of visuals and audio that they can elect to interact with. Users can experience the sights and sounds that they would not have access to due to diving, travel, or restricted access. Users can also see the people who are working on these projects which is aimed at creating an empathetic connection that is not possible through words alone. The StoryMap can be accessed using the following weblink and QR code: https://arcg.is/0b1euv.

Future Steps

Due to increased interest in restoring kelp, pilot restoration projects continue to grow in the state. Government agencies like CDFW are actively working on developing management plans for dealing with restoration projects so future kelp loss can be addressed in a quick and effective manner. Globally, increased interest in kelp restoration has spurred groups like Kelp Forest Alliance to develop an online resource that can aid in fostering collaborative efforts. Various researchers are developing techniques to leverage existing and cutting-edge technologies to develop new ways of monitoring kelp. Thanks to generous funding by the Edna Bailey Sussman Fund, this project will add additional elements including historical perspectives from past restoration projects and novel techniques for monitoring existing or restored kelp forests.

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