SBC-LTER Long Term Experiment Methods

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Density of algae and invertebrates

Overview: These data are part of a larger collection of datasets associated with a long-term experiment designed to examine trajectories of change in the structure and ecological function of kelp forest communities in response to changes in the frequency and severity of disturbance to giant kelp. The experiment was motivated by previous findings demonstrating the important foundational role of giant kelp in structuring subtidal reefs and its high susceptibility to being removed by winter wave disturbance, which has been predicted to increase in frequency and severity due to ongoing anthropogenic climate change. The disturbance manipulations in this experiment included: (1) removing giant kelp from permanent plots once annually in winter to simulate increases in the frequency and severity of winter wave disturbance, and (2) removing giant kelp 1-2 times per season in permanent plots to examine the ecological consequences of the continuous loss of giant kelp from this system. The experiment was replicated at five reef sites in the Santa Barbara Channel and data for a variety of biological and physical variables associated with the experiment were collected from 2008-2023.

Study Sites: Time series data of reef biota (i.e., algae, invertebrates and fish), detrital accumulation, substrate type and topography, and surface and seafloor irradiance were collected at five reefs as part of a long-term experiment designed to evaluate the effects of disturbance to giant kelp (*Macrocystis pyrifera*) on the structure and productivity of the kelp forest community of algae, invertebrates and fishes. The five reefs (Arroyo Quemado 34^0 28.048'N, 120^0 07.031'W; Carpinteria 34^0 23.474'N, 119^0 32.510'W; Isla Vista 34^0 23.275'N, 119^0 32.792'W; Mohawk 34^0 23.649'N, 119^0 43.762'W; and Naples 34° 25.342'N, 119° 57.102'W) ranged in depth from 5.8 m to 8.9 m (MLLW) and were chosen to represent a range of physical and biological characteristics known to influence the structure and productivity of subtidal reef communities in the region. A ubiquitous (but not always persistent) feature on these reefs was the presence of giant kelp, which forms a dense canopy at the sea surface that alters the biomass, diversity and temporal stability of reef biota (Castorani et al. 2018, Miller et al. 2018, Lamy et al. 2020).

Beginning in 2008, giant kelp was removed once per year in winter from a 40 m x 50 m plot at three reefs (Arroyo Quemado, Carpinteria, and Naples) and a 30 m x 50 m plot at one reef (Mohawk) to simulate the effects of winter storm disturbance (referred to as "annual removal" treatment). An adjacent unmanipulated 40 m x 50 m plot at each site served as a control. Beginning in winter 2010, giant kelp was removed 1 to 2 times each season in a 10 m x 50 m area within (or in the case of Mohawk adjacent to) each of the annual removal plots to create a "continual removal" treatment. In fall 2011, a fifth site was established at Isla Vista with paired 40 m x 50 m annual removal and control plots (a 50 m x 10 m continual removal treatment was not established at this site). The reef community of algae (including giant kelp), invertebrates and fish were surveyed in annual removal and continual removal plots prior to each experimental removal of giant kelp. Thus, data collected on the date following the first kelp removal represents the first sampling period of the annual and continual removal treatments. The last experimental removals of giant kelp occurred in winter 2016 or winter 2017, depending on the site. The last sampling of reef communities under experimental conditions for annual and continual kelp removal treatments occurred ~12 months following the last kelp removal. Control, annual removal, and continuous removal plots continued to be sampled seasonally through spring 2023 to document the recovery of the reef community in the absence of experimental kelp removal. Dates of the initiation and cessation of kelp removal in the experimental plots are provided in Table 1.

Table 1: Dates (format yyyy/mm/dd) of the first and last experimental kelp removal for the annual and continual giant kelp removal treatments at the five reef sites.

Reef	Treatment	Date of First Removal	Date of Last Removal
Arroyo Quemado	Annual	2008/01/30	2017/03/02
	Continual	2010/02/04	2017/03/02
Carpinteria	Annual	2008/02/12	2017/02/15
	Continual	2010/01/29	2017/02/15
Isla Vista	Annual	2011/10/26	2016/02/18
Mohawk	Annual	2008/01/17	2017/02/13
	Continual	2010/05/05	2017/02/13
Naples	Annual	2008/01/10	2016/02/09
	Continual	2010/01/28	2016/02/09

Methods: Divers surveyed six 1 m^2 quadrats positioned at 8 m intervals along each 40 m transect and recorded the number of individuals species of common reef invertebrates and macroalgae (Figure 1). The abundance and average size of a select group of larger common algae and mobile invertebrates that are not easily counted in a 1 m^2 quadrats were counted in four contiguous 20 m x 1m quadrats positioned parallel and adjacent to the 40 m transect (Figure 2). Sampling entailed thoroughly searching the area within each quadrat for the targeted species without disrupting the bottom substrate or displacing organisms.

Within each 1 m^2 and 20 m^2 quadrat, divers also estimated the average value of a size-related measurement for each species, which was developed specifically for each species for the purpose of estimating its biomass. The metrics ranged from a specific dimension (e.g., length, width, diameter) to the number of specific morphological features (e.g., number of blades > a particular size). The size metrics used for each species and its relationship with biomass can be found at:

Estimating biomass from body size or percent cover for kelp forest species
https://portal.edirepository.org/nis/mapbrowse?scope=knb-lter-sbc&identifier=127

Figure 1. Schematic diagram showing the positioning of the 1 m^2 quadrats along the 40 m transect. Quadrats at 0 m, 16 m, and 32 m are positioned on the offshore side of the transect and quadrats at 8 m, 24 m and 40 m are positioned on the onshore side of the transect

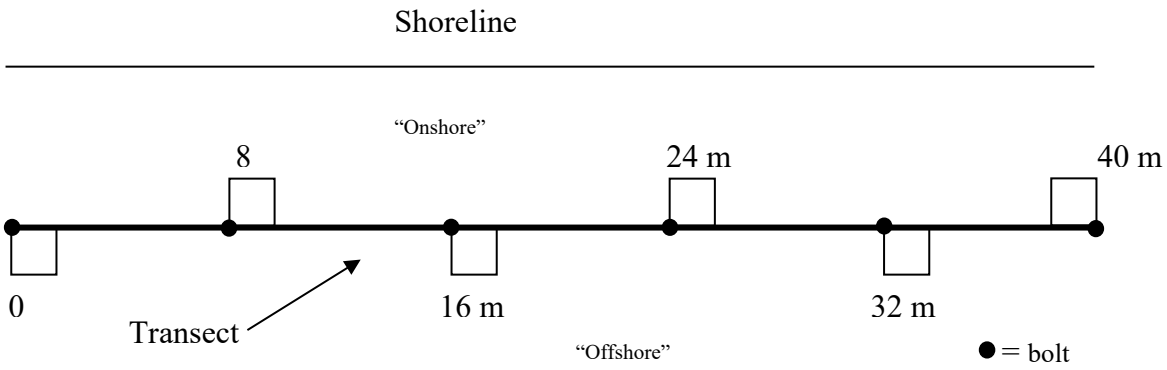

Figure 2. Schematic diagram showing the position of the four 20 m x 1 m quadrats relative to the 40 m transect.