SBC-LTER Long Term Experiment Methods

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Percent Cover of Algae, 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: Uniform Point Contact (UPC) sampling is done to determine the percentage cover of algae and sessile invertebrates. UPC data are collected at 80 points uniformly positioned within a 1 m wide area centered along each 40 m transect (Figure 1). A diver records all organisms intersecting an imaginary vertical line passing through each point and species percent cover is determined as the fraction of points a species intercepts x 100. A species is only recorded once at a given point even if it intersects the imaginary line multiple times. Using this technique, the percent cover of all species combined on a transect can exceed 100%, but the percent cover of any individual species cannot. Species are recorded from top-down as they are encountered and are entered from left to right on the datasheet in such a way that primary space holders occupy the left side of the "SP_CODE" column. Species growing attached to other organisms are not counted, except those species growing on the ornate tube worm (*Diopatra ornata*). Mobile organisms occurring at a sampling point are not counted and are moved so that the species beneath them can be recorded. Only the holdfast is recorded to estimate the percent cover of the kelps *Macrocystis pyrifera*, *Pterygophora californica*, *Eisenia arborea* and *Laminaria farlowii*; the blades and stipes of these species, which extend into the water column, are ignored if they intersected a sampling point. Unlike the sampling of algal and invertebrate density done in fixed quadrats and swaths, the number of taxa sampled by UPC is not fixed; instead, all sessile species encountered are recorded. Species that are difficult to identify underwater are lumped into broader taxonomic categories (e.g., crustose coralline algae) to facilitate sampling.

Figure 1. Diagram of Uniform Point Contact Sampling showing 80 points sampled.