SBC-LTER Long Term Experiment Methods

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Percent Cover of Algae, Invertebrates and Bottom Substrate

Overview: One potential manifestation of climate change is an increase in the frequency of severe storms. Such changes are likely to have profound effects on giant kelp forest ecosystems because storms are a major source of disturbance that removes kelp and other biota. An increase in the frequency of severe storms would likely result in large losses of giant kelp every winter. Giant kelp is the foundation species of the ecosystem and our long-term monitoring shows that the dynamics of the benthic community of understory algae and sessile invertebrates are directly linked to the dynamics of giant kelp (Arkema et al. 2009. Ecology 90: 3126–3137).

Study Sites: Time series data of reef biota (i.e., algae, invertebrates and fish) and 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 benthic community. 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 from a 2000 m^2 plot once per year in winter at four reefs (Arroyo Quemado, Carpinteria, Mohawk and Naples) to simulate the effects of winter storm disturbance (referred to as "annual removal" treatment). An adjacent unmanipulated 2000 m^2 plot served as a control. Beginning in winter 2010, giant kelp was removed 1 to 2 times per season within a 600 m^2 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 2000 m^2 annual removal and control plots (a 600 m^2 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 continue to be sampled seasonally 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, in the format yyyy/mm/dd, of the first and last 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 and different types of bottom substrate. 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*). Additionally, the substrate type under each point is recorded and if the substrate is sand, then the depth of the sand is measured to the nearest cm. Mobile organisms occurring at a sampling point are not counted and are moved so that the species and substrate 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.