Reef Fish Density

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).

Experimental design: We initiated a long-term experiment (LTE) at four kelp forest sites (Arroyo Quemado, Naples, Mohawk, and Carpinteria) in 2008 to investigate the ecological consequences of regular kelp loss during winter to the structure and function of kelp forest communities in the Santa Barbara Channel (a fifth site, Isla Vista, was added in 2011). Paired 40 m x 40 m plots were established at each site and giant kelp is removed once per year in winter from one of the plots in each pair to simulate the effects of increased frequency of storm disturbance on giant kelp. The other plot in each pair is subjected to only natural disturbance and serves as a control for the experimental removal of kelp. Changes in the structure (e.g. species abundance, diversity) and function (e.g. primary production of understory algae, detrital accumulation) of the benthic community are being followed over time with seasonal monitoring in permanent 40 m x 2 m transects centered within each plot. To evaluate the effects of the constant removal of giant kelp on the benthic community we established a second 40 m x 2 m transect in the kelp removal plots at each site within which giant kelp is continually removed throughout the year. Transects are oriented parallel to shore in an eastward direction and are marked with six bolts placed at distances of 0, 8, 16, 24, 32, and 40 meters. Before each survey, divers swim a fiberglass meter tape along the transect and clip it to each permanent bolt before pulling it taut. All transects were sampled every six weeks (twice per season) from 2008 through 2012 and have been sampled once per season since then. Seasonal sampling is conducted midmonth in February, May, August, and November. Giant kelp is removed from the experimental plots immediately after the first survey of each year is completed.

Methods: The number, size and species identity of reef fish are recorded within a 2 m wide swath centered along each transect extending 2 m off the bottom. A diver swims the length of the 40 m transect approximately 1m above the bottom at a constant deliberate speed and records all fish passing through the sampling area. Fish size is measured as total length (TL) estimated to the nearest cm. Care is taken by the diver to not count the same individual more than once if it leaves and re-enters the sampling area. Surveys are carried out by only a select number of highly trained divers whose sampling techniques have been standardized in order to minimize observer bias. The horizontal visibility along the transect is measured and recorded for each sampling event. The number of fish taxa sampled is not fixed as all species of reef fish encountered in the sampling area are recorded. Species that are difficult to identify underwater are lumped into broader taxonomic categories (e.g., flatfish in the family Bothidae) to facilitate sampling.

Several species of small bottom-dwelling fish are difficult to accurately count and size during the reef fish survey due to their cryptic appearance and behavior. Individuals in a select group of these species are counted and sized in a separate survey done in the four contiguous 20 m x 1 m swaths that centered on the 40 m transect (Figure 1). A diver carefully searches the area within each swath taking time to look on the undersides of ledges and in crevices, and within understory

vegetation for select species of small cryptic fish that are purposely not counted in the reef fish survey. Understory algae are brushed aside during the search, but no organisms or boulders are physically moved. Size is recorded as total length (TL) to the nearest cm. The species of small cryptic fish counted in this survey are listed in Table 1.

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

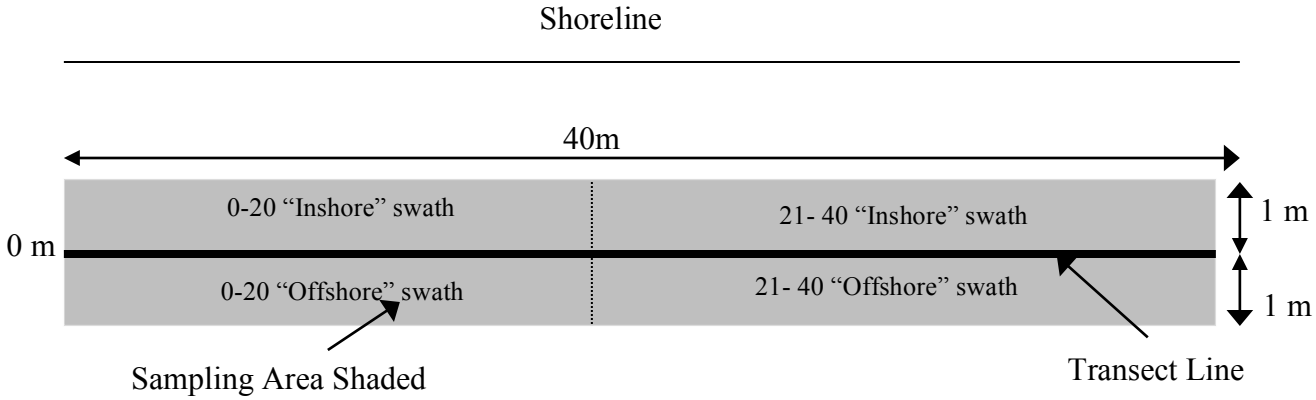

Table 1. Species list of small cryptic fish surveyed.

SP_CODE	GENUS	SPECIES	COMMON_NAME
AHOL	Alloclinus	*holde*r	Island kelpfish
CLIN	Gibbonsia	spp.	Crevice kelpfish
CNIC	Rhinogobius	*nicolsii*	Blackeye goby
COTT	Cottid	spp.	Sculpins
CSTI	*Citharicthys*	*stigmaeus*	Pacific sanddab
LDAL	*Lythrypnus*	*dalli*	Bluebanded goby
LHIR	*Leiocottus*	*hirudo*	Lavender sculpin
NBLA	*Neoclinus*	*blanchardi*	Sarcastic fringehead
OPIC	*Oxylebius*	*pictus*	Painted greenling