MLPA Kelp Forest Monitoring Methods

Kelp forest surveys are conducted annually, generally from June to late October. Sites are surveyed for fishes and benthic organisms separately, with differing transect replication (described below) for the two methods. Transects are laid in a stratified random design with non-fixed transects at specified locations (sites) and targeted depth zones. Often, benthic sampling is conducted in the early part of the summer, with fish sampling commencing later in the summer and continues into the fall, in order to constrain the seasonality of sampling.

Fish surveys: The density of all conspicuous fishes (i.e. species whose adults are longer than 10 cm and visually detectable by SCUBA divers) are visually recorded along replicate 2m wide by 2m tall by 30m long (120m3) transects. In pairs, one diver surveys this volume along the reef surface (searching within cracks and crevices), while another surveys the same volume roughly one third to one half up into the water column (i.e. "mid-water") above the benthic diver, depending on visibility and bottom depth. Canopy transects of the same dimensions as the mid-water and bottom transects are surveyed at a subset of sites, mainly to target juvenile fish recruiting to the kelp canopy. Canopy transects are only done where kelp canopy extends to the surface and are usually completed separately from the bottom and midwater transects. On canopy transects, the fish counter swims 2m below the surface counting fishes in the top two meters of the water column. Typically, for each portion of the water column sampled, three 30m long transects are distributed end-to-end and 5-10m apart at each of the 5m, 10m, 15m, and 20m isobaths (with additional 25m transects conducted by VRG where habitat is available). Survey depths may vary based on reef topography. Counts on mid-water and bottom transects are eventually combined, thereby generating 12 replicate transects for each site for analyses. At sites with narrow kelp beds, particularly in parts of the Northern Channel Islands, only two zones are sampled, with four transects in each depth zone for a total of eight replicate transects. Fish transects are generally only conducted with at least 3m of horizontal visibility. The total length (TL) of each fish observed is estimated to the closest 1cm. For each transect, divers record the transect depth, horizontal visibility along each transect, water temperature, and sea state (surge), and percent of the transect volume occupied by kelp (PISCO only).

Benthic swaths for algae and invertebrate densities: The density of conspicuous, individually distinguishable macroalgae and macroinvertebrates (i.e. organisms larger than 2.5 cm and visually detectable by SCUBA divers) are visually recorded along replicate 2m wide by 30m long (60m2) transects. For select species (e.g., sea urchins), high densities are spatially subsampled to allow extrapolation to three separate $20m_2$ segments of the transect. Typically, two 30m long transects are distributed end-to-end and 5-10m apart at each of the 5m, 12.5m, and 20m isobaths (with additional 25m transects conducted by VRG where habitat is available). This usually generates six replicate transects for each site. At sites with narrow kelp beds, particularly in parts of the Northern Channel Islands, only two zones are sampled, with two transects in each depth zone for a total of four replicate transects. Giant kelp (*Macrocystis pyrifera*) and bull kelp (*Nereocystis luetkeana*) individuals are enumerated when they reach a stipe height of > 1m, and the number of giant kelp stipes for each individual are also counted. Size cut-offs for inclusion of other understory kelps and large macroalgae, and descriptions of size cut-offs for invertebrates are described in the taxonomic table.

Benthic point contact for algae and invertebrate percent cover: The percent cover of sessile non-individually distinguishable macroalgae and macroinvertebrates (e.g. colonial invertebrates, foliose macroalgae) are visually recorded along the same replicate 30m long transects used to conduct benthic swath surveys. Typically, two 30m long transects are distributed end-to-end

and 5-10m apart at each of the 5m, 12.5m, and 20m isobaths (with additional 25m transects conducted by VRG where habitat is available). This usually generates six replicate transects for each site. At sites with narrow kelp beds, particularly in parts of the Northern Channel Islands, only two zones are sampled, with two transects in each depth zone for a total of four replicate transects. At each meter mark along the 30m transect, the diver records the underlying substrate (bedrock, boulder, cobble, or sand), vertical relief (maximum vertical distance in a 0.5x1m box centered on the point, categorized into 0-10cm, 10cm-1m, 1-2m, and >2m bins), and cover (non-mobile primary space holding organism or bare substrate type). An additional category consisting of a small subset of specific organisms which may be ephemeral, and tend to create a layer over primary space holders are recorded, when present, as a superlayer. Examples include low-lying, very large-bladed macroalgae such as *Laminaria farlowii*, brittle stars, drift algae, and abalone in the Northern region. Superlayer classifications vary by survey region, and are further defined in the taxonomic table.

Size surveys for selected algae and invertebrates: Size frequency measurements of body size of targeted invertebrate species (e.g., red and purple urchins, abalone in the genus *Haliotis*, spiny lobsters, seastars) are recorded by divers both along benthic transects and at random locations within a study site. Organisms are generally measured by divers in situ, and measured sizes correspond with test diameter for urchins, length of longest arm for seastars, shell length for shelled mollusks, carapace length for lobsters, and total turgid length for sea cucumbers. In the case of urchins sampled by UCSB and VRG in Southern California, large numbers of individuals may be collected in bags and brought aboard the research vessel to facilitate measurement.