California MLPA Master Plan Science Advisory Team

Methods Used to Evaluate Marine Protected Area Proposals in the MLPA North Coast Study Region

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Executive Summary

This document provides the guidelines for design and methods used to evaluate alternative marine protected area (MPA) proposals for the California Marine Life Protection Act (MLPA) North Coast Study Region (NCSR). The MPA proposals are being developed through California's MLPA Initiative, a public/private partnership designed to assist the State of California in implementing the MLPA [California Fish and Game Code, Section 2853]. Developing and evaluating alternative MPA proposals is one component of an iterative process designed to "reexamine and redesign California's MPA system to increase its coherence and its effectiveness at protecting the state's marine life habitat and ecosystems," as mandated by the MLPA.

The MLPA North Coast Regional Stakeholder Group (NCRSG) creates alternative MPA designs that integrate a variety of scientific and personal knowledge. Evaluations of these alternative MPA proposals are conducted relative to the MLPA goals (Table 1-1 in Chapter 1), scientific guidelines described in the *California Marine Life Protection Act Master Plan for Marine Protected Areas* (hereafter called the *Master Plan*) and developed by the MLPA Master Plan Science Advisory Team (SAT), California Department of Fish and Game (DFG) feasibility criteria and California Department of Parks and Recreation guidelines. Potential impacts to commercial and recreational consumptive users also are evaluated. Evaluations are conducted by the SAT, MLPA Initiative staff, and contractors to the MLPA Initiative.

In addition to the guidelines for MPA design and associated evaluation methods, a discussion of the analysis and identification of bioregions in the NCSR is also included in this document. Bioregions are areas of the ocean with reduced population connectivity or distinct biological communities due to specific conditions such as ocean circulation and habitat. The consideration of bioregions in the design and evaluation of a network of MPAs is critical in ensuring that the diversity of marine communities is adequately represented in MPAs.

Evaluations conducted by the SAT to address the scientific guidelines in the *Master Plan* include levels of protection, habitat representation and replication, and MPA size and spacing. Additional analyses conducted by the SAT include birds and mammals, bio-economic modeling, and water quality. MLPA staff evaluate recreational, education and study opportunities while an MLPA contractor, Ecotrust, conducts an analysis of potential commercial and recreational fishery impacts.

The California Department of Fish and Game (DFG) conducts a feasibility analysis where alternative MPA proposals are evaluated against a set of feasibility criteria developed by DFG. The California Department of Parks and Recreation (State Parks) conducts an analysis where alternative MPA proposals are evaluated against a set of guidelines for MPA proposals developed by State Parks.

Bioregions

To help ensure that MPAs established under the MLPA include adequate representation of the marine communities and species diversity representative of California, MPAs must be distributed across biogeographically distinct areas. Both the MLPA and the *Master Plan* identify two biogeographic regions: 1) Point Conception north to the California-Oregon border and 2) Point Conception south to the U.S.-Mexico border. These biogeographic regions are delineated by their broad differences in species assemblages, and are widely recognized by marine scientists.

In each study region, the SAT has conducted analyses to determine if the study region should be divided distinct "bioregions." Bioregions are regions of distinct biological assemblages distinguished by different community compositions, the presence or absence of certain key species, or disruptions to population connectivity among habitats. The establishment of bioregions recognizes that although

species assemblages within a study region might be broadly similar, there are subtle differences among communities that should be captured in an MPA array.

Due to a variety of data on population connectivity, oceanography, geology, and hydrology, the SAT identified two bioregions that characterize the MLPA North Coast Study Region. The North bioregion extends from the mouth of the Mattole River to the Oregon border, while the South bioregion extends from the mouth of the Mattole River to Alder Creek in Mendocino County. It should be noted that although the bioregions stop at the study region boundaries for planning purposes, their biological relevance likely extends beyond those boundaries.

The SAT recommends including representation of all key habitats in each bioregion (see habitat representation). Representation of key habitats in each of the bioregions in the NCSR will be considered as part of the habitat representation evaluation for alternative MPA proposals. Replication of habitats will also be evaluated for each bioregion and the entire NCSR.

Levels of Protection

Types of activities that may be allowed within the three types of marine protected areas (state marine conservation area, state marine park, and state marine reserve) differ in the level of protection they provide to marine ecosystems. To facilitate comparisons among alternative MPA proposals, the SAT assigns a “level of protection” to each MPA based on the uses allowed within its boundaries.

Levels of protection are based upon the potential impacts of proposed activities to the ecosystems within an MPA. Conceptually, the SAT seeks to answer the following question in assigning levels of protection: “How much might an ecosystem differ from an unfished or unharvested ecosystem if one or more proposed activities are allowed?”

State marine reserves (SMRs) are, by definition, unharvested ecosystems, therefore they receive the highest protection level, “very high”. MPAs that allow extractive activities receive levels of protection ranging from “high” for low-impact activities, to “low” for activities that alter habitat and thus have a potentially large impact on the ecosystem. Both direct impacts (those resulting directly from the gear used or the removal of target or non-target species) and indirect impacts (ecosystem-level effects of species removal) are considered in the levels of protection analysis. Table ES-1 summarizes levels of protection assigned to various targeted species and gear types. As the need arises, the SAT will evaluate additional targeted species and gear types.

Table ES-1. Levels of protection and associated activities

Color Code	Level of Protection	MPA Types	Activities Associated with this Protection Level
	Very high	SMR	No take
	High	SMCA SMP	Salmon and other pelagic finfish[a] (H&L or troll in waters >50m depth); pelagic finfish[a] except salmon (spearfishing) coastal pelagic finfish[b] (H&L, round-haul net, dip net, cast net, hand); Pacific lamprey (H&L, hand harvest, spear, bow and arrow, dip net); eulachon (dip net); non-living shells (hand)
	Mod-high	SMCA SMP	Dungeness crab (trap, hoop-net, diving, hand); salmon and other pelagic finfish[a] (troll in water <50m depth); surf and night smelts (dip net, a-frame net, cast net); sharks, skates, and rays (spear, harpoon, bow and arrow in non-estuarine waters); trout except steelhead rainbow trout (H&L); California halibut, flounders, soles, turbots, and sanddabs (spearfishing); market squid (H&L, round-haul net, dip net cast net, hand);
	Moderate	SMCA SMP	Redtail surfperch (H&L from shore); surfperch (H&L from shore); California halibut, flounders, soles, turbots, and sanddabs (H&L); coonstripe shrimp and spot prawn (trap); clams (intertidal hand); nori/laver and sea lettuce[c] (intertidal hand); salmon and other pelagic finfish[a] (H&L in waters <50m depth); white sturgeon (H&L); sharks, skates, and rays (H&L);
	Mod-low	SMCA SMP	Pacific halibut (H&L); rockfishes, cabezon and other sculpins, lingcod and other greenlings, California moray eel, wolf eel, and monkeyface and rock prickleback (H&L, spearfishing, trap, hand, bow and arrow); red abalone (free-diving); urchin (diving), surfperch (H&L); shiner surfperch (H&L, dip net, cast net); unspecified finfish (H&L, spearfishing); sharks, skates, and rays (H&L, spear, harpoon, bow and arrow in estuarine waters); limpets and turban snails (hand); octopus (H&L, hand); crabs (trap, hoop net, hand); Turkish towel and Mendocino grapestone[d] (intertidal hand);
	Low	SMCA SMP	Rock scallop (diving); mussels (hand); bull kelp (hand); ghost shrimp (hand); sea palm (intertidal hand); canopy-forming algae[e] (intertidal hand); native oysters (hand); unspecified shrimps (hand); unspecified marine invertebrates (hand); unspecified marine algae (hand)

Notes: SMR = state marine reserve SMCA = state marine conservation area SMP = state marine park
H&L = hook and line m=meters

The SAT is currently reviewing the level of protection for numerous activities; this table will be updated as activities are reviewed and approved by the SAT. It should be noted that staff is working with the SAT to coordinate terminology for particular gear types that is consistent with both the activities being proposed by the NCRSG and as defined in regulations under California Fish and Game Code. Thus the descriptions here may change in a future version of this document.

[a] *The grouping "pelagic finfish" includes: northern anchovy (Engraulis mordax), barracudas (Sphyraena spp.), billfishes* (family Istiophoridae), dolphinfish (Coryphaena hippurus), Pacific herring (Clupea pallasi), jack mackerel (Trachurus symmetricus), Pacific mackerel (Scomber japonicus), salmon (Oncorhynchus spp.), Pacific sardine (Sardinops sagax), blue shark (Prionace glauca), salmon shark (Lamna ditropis), shortfin mako shark (Isurus oxyrinchus), thresher sharks (Alopias spp.), swordfish (Xiphias gladius), tunas (family Scombridae), and yellowtail (Seriola lalandi). *Marlin is not allowed for commercial take.*

[b] *The grouping "coastal pelagic finfish" includes: Northern anchovy (Engraulis mordax), Pacific herring (Clupea pallasi), jack mackerel (Trachurus symmetricus), Pacific mackerel (Scomber japonicus), and Pacific sardine (Sardinops sagax).*

[c] *Porphyra spp. (Nori, Laver), Ulva spp. (Sea Lettuce),*

[d] *Chondrocanthus/Gigartina exasperata (Turkish Towel), and Mastocarpus spp. (Mendocino Grapestone).*

[e] *The grouping "canopy-forming algae" includes the following harvested groups: Alaria spp. (Wakame), Lessonioposis littoralis (Ocean Ribbons), Laminaria spp. (Kombu), Saccharina/Hedophyllum sessile ('Sweet' Kombu), Egregia menzeisii (Feather Boa), and Fucus spp. (Bladder wrack or Rockweed).*

The level of protection assigned to an MPA that allows multiple uses is the lowest level of protection designated for any of the uses. The SAT acknowledges that multiple uses within an MPA may have cumulative impacts on the ecosystem that exceed those of the individual activities, but such cumulative impacts are difficult to predict and the SAT has not addressed this concern in assigning levels of protection. The levels of protection assigned by the SAT are used in all subsequent SAT analyses. Only MPAs at the three highest levels of protection, "moderate-high," "high," and "very high," contribute toward replication and are considered as part of the size and spacing analysis.

Habitat Representation

The SAT recommended that "for an objective of protecting the diversity of species that live in different habitats and those that move among different habitats over their lifetime, every 'key' marine habitat should be represented in the MPA network[1]." California's key marine habitats are described in the MLPA and have been further subdivided by the SAT to reflect important ecological differences at different depths. This habitat classification yields a total of 22 key habitats for which habitat representation is assessed contingent upon habitat map quality: rocky shore, sandy beach, surfgrass, coastal marsh, tidal flats, estuarine waters, eelgrass, kelp, hard and soft substrates in four depth zones (0-30 meters, 30-100 meters, 100-200 meters, and greater than 200 meters), submarine canyons, pinnacles, upwelling centers, retention zones, river plumes, and oceanographic fronts.

In evaluating habitat representation the SAT considers:

- The availability of habitats across the entire NCSR
- The availability of habitats within the two bioregions of the NCSR
- The percentage of available habitat protected in MPAs across six levels of protection
- The distribution of habitat protection across the two bioregions

Habitat Replication

Habitat replication within broad biogeographic regions is required by the *Master Plan*. The *Master Plan* identifies just two biogeographic regions in California: 1) Point Conception north to the California-Oregon border and 2) Point Conception south to the U.S.-Mexico border. The *Master Plan* recommends three to five replicates of each key habitat type within marine reserves in each biogeographic region. The northern biogeographic region encompasses three open coast study regions, including the NCSR. The guideline of three to five replicates will be applied at this scale and account for replication in all study regions north of Point Conception. Considering the physical and biological gradients across the NCSR, the SAT has additionally recommended at least one replicate of each key habitat be included in each of the two bioregions of the NCSR.

To count as a replicate of any given habitat, a MPA must contain enough habitat to encompass 90% of the biodiversity associated with that habitat. The minimum area to encompass 90% of the associated biodiversity varies by habitat and is determined from biological surveys. A summary of the minimum areas for replicates of key habitats in the NCSR is in Chapter 5 (and in Table ES-2.).

[1] *California Marine Life Protection Act Master Plan for Marine Protected Areas*

Table ES-2. Amount of habitat in an MPA necessary to encompass 90% of local biodiversity

Habitat	Amount of habitat needed to encompass 90% of biodiversity	Data Source
Rocky shores and offshore rocks	0.55 linear miles	PISCO Biodiversity
Nearshore rocky reefs and kelp forest (0-30 m)	1.1 linear miles *including the full 0-30m depth zone*	PISCO Subtidal
Rocky reef 30-100 m	0.13 square miles	Starr Surveys
Rocky reef 100-3000 m	0.13 square miles	Starr Surveys
Beaches	1.1 linear miles	*See below*
Soft bottom 0-3000 m [a] *(includes replicates of 0-30m, 30-100m and >100m soft bottom)*	10 square miles total mapped soft bottom Distributed across depth zones including at least: 1.1 mi 0-30m 5 sq mi 30-100m 1 sq mi >100m	NMFS trawl surveys, 1977-2007
Soft bottom 0-100 m [a] *(includes replicates of 0-30m and 30-100m soft bottom)*	7 square miles total mapped soft bottom Distributed across depth zones including at least: 1.1 mi 0-30m 5 sq mi 30-100m	NMFS trawl surveys 1997-2007
Soft bottom 0-30 m *when not combined with other depth zones*	1.1 linear miles *including the full 0-30m depth zone*	*See below*
Soft bottom 30-100 m *when not combined with other depth zones*	7 square miles	NMFS trawl surveys 1997-2007
Soft bottom >100 m *when not combined with other depth zones*	17 square miles	NMFS trawl surveys 1997-2007
Estuarine Habitats [b]	0.12 square miles (77 acres) total estuarine area Distributed across estuarine habitats including at least: 0.04 sq mi coastal marsh (25 acres) 0.04 sq mi eelgrass (25 acres)	SONGs sampling

[a] *Trawl survey data indicate that large amounts of soft bottom habitat are required to encompass 90% of biodiversity if each depth zone is replicated independently. Since soft bottom associated species tend to utilize multiple depth zones, the SAT recommends that soft bottom habitats across multiple depth zones are included in the same MPA or MPA cluster.*

[b] *Estuarine habitat replication thresholds are based upon data from small coastal estuaries in the south and central coast regions and may not be applicable to the large estuarine areas in Humboldt Bay.*

In evaluating replication of key habitats, the SAT:

- combines contiguous MPAs at or above the three highest levels of protection into "MPA clusters." Replication analyses are conducted at three different levels of protection: "moderate-high," "high," and "very high" and include all MPAs at or above the stated level of protection.
- considers whether there is a minimum amount of each key habitat present within an MPA cluster, and whether the MPA cluster meets the minimum size threshold, as described below.

- tabulates the number of replicate MPA clusters for each habitat within the biogeographic region (Point Conception to the California-Oregon border) relative to the guideline of three to five replicates per biogeographic region
- tabulates the number of replicate MPA clusters for each habitat within both of the NCSR bioregions relative to SAT guidance to include at least one replicate of each habitat per bioregion.

MPA Size

The *Master Plan* recommends that "for an objective of protecting adult populations, based on adult neighborhood sizes and movement patterns, MPAs should have an alongshore span of five to ten kilometers (3-6 [statute] miles) of coastline, and preferably 10-20 km (6-12.5 [statute] miles). Larger MPAs would be required to fully protect marine birds, mammals, and migratory fish[2]."

The SAT recommended that MPAs extend from intertidal to offshore areas for an objective of protecting the diversity of species that live at different depths and to accommodate the movement of individuals to and from shallow nursery or spawning grounds to adult habitats offshore. The recommended offshore span is from the mean high tide line to the offshore state waters boundary, generally a distance of 3.45 statute miles (3 nautical miles), except in some areas (e.g., offshore rocks) where state boundaries may extend farther.

Taking into account these two guidelines, the SAT recommended a minimum area of 9 to 18 square statute miles for each MPA, and preferably 18 to 36 square statute miles. The recommendation of a minimum area of 9 square statute miles is a simplified combination of the along-shore and offshore size guidelines and allows for the possibility that the alongshore span may be less (or greater) than three statute miles or the offshore span may be less than 3.45 statute miles. The guidelines for minimum and preferred areas of proposed MPAs will receive priority above the individual guidelines for alongshore and offshore spans. Additionally, the SAT recommends consideration of the configuration of proposed MPAs. Configurations with maximum area-to-perimeter ratios (e.g., 3 x 3 statute miles) are more likely to achieve greater protection for a variety of adjacent habitats and associated species than narrow and long MPAs (e.g.,1 x 9 statute miles).

In evaluating the size of MPAs, the SAT:

- combines contiguous MPAs at or above the three highest levels of protection into "MPA clusters." Size analyses are conducted at three different levels of protection: "moderate-high," "high," and "very high" and include all MPAs at or above the stated level of protection.
- tabulates the number of MPA clusters in each size range (below minimum, minimum size range, preferred size range).

MPAs containing estuarine habitat are not evaluated against the general rule that replication of habitat needs to be within an MPA cluster that is at least nine square miles.

MPA Spacing

The *Master Plan* recommends that "for an objective of facilitating dispersal of important bottom-dwelling fish and invertebrate groups among MPAs, based on currently known scales of larval

[2] California Marine Life Protection Act Master Plan for Marine Protected Areas

dispersal, MPAs should be placed within 50-100 km (31-62 [statute] miles) of each other" along the coast. Neighboring MPAs placed closer than 50 km (31 statute miles) apart also meet the guideline for spacing for the goal of designing a network of MPAs.

In evaluating the spacing of MPAs along the coast, the SAT:

- combines contiguous MPAs at or above the three highest levels of protection ("moderate-high," "high," and "very high") into "MPA clusters" that include all MPAs at or above the stated level of protection.
- considers MPA clusters of sufficient size (minimum MPA cluster size of nine square miles), with sufficient amounts of key habitats included to constitute a habitat replicate.
- determines the distance between replicates of key habitats within MPAs relative to the minimum spacing guideline of 31-62 statute miles.
- estimates the distance between MPAs that protect patches of the same key habitat.
- analyzes distances between neighboring MPAs separately for each key habitat.

Modeling

Two spatially-explicit bioeconomic models were developed, vetted, and utilized to evaluate alternative MPA proposals in the north central coast study region (NCCSR) and south coast study region (SCSR) planning processes of the MLPA Initiative; both models were extended for use in the NCSR. The models are the University of California, Davis "Spatial Sustainability and Yield" model (UCD model) and the University of California, Santa Barbara "Flow, Fish, and Fishing" model (UCSB model). Two models were developed to confirm that model outputs were reasonable and consistent. Since both models report consistent results, the SAT modeling work group determined that a single model (UCSB model and hereafter referred to as "the model") could be used to evaluate MPA proposals, with two sets of assumptions that reflect the key differences between the UCSB and UCD models.

The model uses spatial data on habitat, fishery effort, and proposed MPA locations and regulations to simulate the population dynamics of fished species. It then generates predicted spatial distributions of species abundances, yields, and profits for 7 representative species for each alternative MPA proposal. Importantly, the model incorporates the population dynamic consequences of spatially explicit fishing regulations.

The two original models (UCD and UCSB) differed in details regarding, for example, how specifically population dynamics are modeled, how the steady-state impacts of fisheries outside of protected areas are parameterized, and what units are used to express conservation and economic values. Despite these differences, the two models gave closely agreeing results in the SCSR and the first round of evaluations for the NCSR. A key structural difference in the models leading to slightly different results is the method for simulating the movement of adult fishes and invertebrates. Therefore, the UCSB model is currently run in a second mode that emulates the UCD approach to simulating home range movement (the UCD home range formulation); these model runs are identical to the original UCSB model in every other respect.

The model includes the following structural elements: (a) larval connectivity across patches driven by ocean currents, pelagic larval duration, and spawning season, (b) larval settlement regulated by species density in available habitat, (c) growth and survival dynamics of the resident (adult) population, (d) reproductive output increasing with adult size, (e) adult movement (e.g., home ranges), and (f) harvest in areas outside of MPAs.

Model outputs from the evaluation of alternative MPA proposals must be compared to each other to understand the potential impacts of changes to the design because outputs are not expressed in terms of minimum or maximum threshold values. For the modeling evaluation of alternative MPA proposals, the SAT provides:

- maps of biomass for each of 7 representative species and an average of all modeled species, region-wide and for individual MPAs
- maps of fishery yield for each of 7 representative species and an average of all modeled species, region-wide and for individual MPAs
- maps of spatial fishing intensity for each of 7 representative species and for an average of all model species
- plots showing the trade-offs between biomass and fishery yield for each alternative MPA proposal
- diagrams that illustrate the level of connectivity between different places in the NCSR for the suite of 7 representative species
- tables showing biomass and self-recruitment for individual MPAs in each alternative MPA proposal

Birds and Mammals

MPAs may benefit marine birds and mammals by potentially reducing human disturbance at breeding colonies or rookeries and at roosting and haul-out sites. Species foraging nearshore may also benefit from increased prey availability. To evaluate the protection afforded by alternative MPA proposals to birds and mammals, the SAT:

- identifies proposed MPAs or special closures that contribute to protection of birds and mammals.
- identifies focal species likely to benefit from MPAs and for which data are available.
- identifies important breeding and foraging hot spots for marine birds and mammals.
- estimates the proportion (of total numbers of individuals) of breeding birds at colonies and the number of rookeries potentially benefiting by proposed MPAs.
- estimates the number and size of marine bird roosts sites and proportion (of total numbers of individuals) of mammals at haulouts potentially benefiting by proposed MPAs.
- estimates the proportion of available near-colony foraging areas protected by proposed MPAs, defined by evaluating protection of buffered areas around colonies.
- estimates the number of available neritic foraging ‘hot spots’ protected by proposed MPAs, defined by at-sea densities of marine birds and mammals.
- estimates the proportion of estuarine and coastal beach habitats protected and density and diversity of shorebirds and waterfowl protected by proposed MPAs.

Water Quality

While water quality is not subject to management under the MLPA, it may be important in designing alternative MPA proposals. Where water quality is significantly compromised, marine life may be affected. Impaired water quality may lead to changes to population rates (growth, reproduction, and

mortality), population abundance, and ecological community composition through a variety of interactions (e.g., decreased diversity, loss of sensitive species and abundance of tolerant species).

For MPA network design, the SAT recommends including areas already designated as areas of special biological significance (ASBSs) because these areas benefit from protection beyond that offered by standard waste discharge restrictions. The SAT recommends avoiding locations of poor or threatened water quality, including:

- areas that are significantly impacted by a variety of pollutants from storm drain and agricultural runoff as well as areas impacted by dredge disposal activities
- municipal sewage or industrial outfalls

The SAT determined that MPAs may be placed in or near areas of impaired water quality if there are other reasons to place MPAs in such areas.

Since water quality evaluations are not mandated by the MLPA, these guidelines based on consideration of water quality are secondary to other MPA network design guidelines. Other guidelines (including bioregions, habitat representation and replication, and MPA size and spacing) should be used to drive design of alternative MPA proposals. Water quality considerations may be incorporated if other guidelines have been met.

Recreational and Commercial Fishery Impacts

While fishery impacts are not the focus of the MLPA, they may be considered in designing alternative MPA proposals. The evaluation of maximum potential recreational and commercial fishery impacts utilizes region-specific data collected by MLPA contractor Ecotrust on areas of importance.

To evaluate the potential recreational and commercial fishery impacts, MLPA Initiative staff and contractors:

- conduct local knowledge interviews with recreational and commercial fishermen, using an interactive, custom computer interface, to collect geo-referenced information about the extent and relative importance of study region commercial and recreational fisheries.
- organize impact analyses by port, fishery, and/or user group.
- evaluate and summarize the maximum potential impacts on commercial, commercial passenger fishing vessel (CPFV), and recreational fishing grounds both in terms of total area and value affected, with results summarized for both study region fishing grounds and total fishing grounds[3].
- conduct an impact analysis for commercial and CPFV fisheries.
- consider or identify “outliers” (i.e., fisheries and individual fishermen likely to experience disproportional impacts).
- assess the effect of existing fishery management area closures and other constraints on fishing grounds.

[3] Impact analyses represent a “worst case scenario” in which fisherman cannot fish in a different location.