California Marine Life Protection Act Initiative
Master Plan Science Advisory Team
Draft MLPA Evaluation Methods for MPA Proposals
November 9, 2007

MLPA Goals and Evaluation Elements

The MLPA Master Plan Science Advisory Team (SAT) analyzed the relative merits of the north central coast MPA arrays in meeting the SAT guidelines found in the MLPA Master Plan Framework and science-related MLPA goals (goals 1, 2, 3, 4 and 6). Table 1 provides an outline of the elements that relate to each of the goals for which the proposals are being evaluated.

Table 1. MLPA goals and the evaluation elements relating to each goal

MLPA Goal	SAT Evaluation of Scientific Elements
1. To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.	Habitats and protection levels
2. To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.	Size, spacing, protection levels, and protection to forage, breeding and rearing areas
3. To improve recreational, educational, and study opportunities provided by marine ecosystems that are subjected to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity.	Habitat replication
4. To protect marine natural heritage, including protection of representative and unique marine life habitats in California.	Habitats and protection levels
5. To ensure that California's MPAs have clearly defined objectives, effective management measures and adequate enforcement and are based on sound scientific guidelines.	No SAT evaluation specific to Goal 5
6. To ensure that the states' MPAs are designed and managed, to the extent possible, as a network.	Size and spacing guidelines

Protection Levels (Goals 1, 2, and 4)

Why categorize MPAs by protection levels? The Marine Life Protection Act (MLPA) identifies three types of Marine Protected Areas (MPA): State Marine Reserves (SMR), State Marine Conservation Areas (SMCA), and State Marine Parks (SMP). There is great variation in the type and magnitude of activities that may be permitted within these MPAs, in particular SMPs and SMCAs. This variety purposely provides designers of MPA packages with flexibility in proposing MPAs that either individually or collectively fulfill the various goals and objectives specified in the MLPA. However, this flexibility can result in complex and possibly confusing levels of protection afforded by any individual MPA or collection of MPAs. In particular, SMCAs allow for many possible combinations of recreational and commercial extractive activities.

Therefore, MPA proposals with similar numbers and sizes of SMCAs may in fact differ markedly in the type, degree, and distribution of protection throughout the study region. Thus, the purpose of categorizing MPAs by their relative level of protection is to simplify comparisons of the overall conservation value of MPAs within and among MPA array proposals.

Marine Protected Area Designations: State Marine Reserves (SMR) provide the greatest level of protection to species and to ecosystems by not allowing take of any kind (with the exception of scientific take for research, restoration, or monitoring). The high level of protection created by an SMR is based on the assumption that no other appreciable level of take or alteration of the ecosystem is allowed. In particular, SMRs provide the greatest likelihood of achieving MLPA goals 1, 2, and 4.

State Marine Parks (SMP) are designed to provide recreational opportunities and therefore can allow some or all types of recreational take of a wide variety of fish and invertebrate species by various means (e.g., hook and line, spear fishing). Because of the variety of species that potentially can be taken and the potential magnitude of recreational fishing pressure, SMPs that allow recreational fishing provide lower protection and conservation value relative to other, more restrictive MPAs (e.g., SMRs and some SMCAs). Although SMPs have lower value for achieving MLPA goals 1 and 2, they may assist in achieving other MLPA goals.

State Marine Conservation Areas (SMCA) potentially have the most variable levels of protection and conservation of the three MPA designations because they allow any combination of commercial and recreational fishing, as well as other extractive activities (e.g., kelp harvest).

How levels of protection are assigned: The level of protection afforded in an MPA that allows a specific activity was determined by examining the impacts that activity is likely to have on the ecosystems encompassed by the MPA. Those impacts fall into two main categories: (1) direct impacts of the activity and (2) indirect impacts of the activity on community structure and ecosystem dynamics. In the case of fishing, direct impacts include habitat disturbance and bycatch of non-target species caused by the fishing gear/method. Indirect impacts include any change in the ecosystem caused by removal of target and non-target species. In general, removal of species that play an integral role in the food web or perform a key ecosystem function (e.g. biogenic structure) will have impacts on species interactions throughout the ecosystem.

Several factors were taken into consideration when determining the indirect ecosystem impacts of harvest: 1) target-species interactions with resident species that are likely to be protected by MPAs, and 2) target-species mobility. Ultimately, the question asked was, “would there be a difference between ecosystems within an MPA that prohibits take of this species versus an area outside of the MPA where take is allowed?” For highly mobile species such as salmon, sardines, and anchovies, prohibiting take within an MPA would likely have little impact on local populations, therefore the ecosystem impacts of removing these species are considered to be low.

The levels of protection are presented on a 10-point scale, as follows. The numbers are intended as a ranking only and not as a quantitative assessment of the protection afforded. An

MPA that allowed multiple activities received the lowest level of protection assigned to those activities.
Very High (10) – no take of any kind allowed, this designation applies only to SMRs

High (8) – MPAs were assigned this level of protection if the SAT concluded that the allowed fishing activity had a very low bycatch of resident species, caused minimal habitat damage, and was likely to have little impact on ecosystems in the MPA. The mobility of the target species was an important factor in determining ecosystem impacts. Individuals of highly mobile species are expected to move frequently between MPAs and unprotected waters, so local populations of these species are unlikely to be enhanced by MPAs. Because the fishing activity is likely to have little impact on populations of target or any other species (low bycatch), the activity is expected to have little impact on the ecosystem. For example, fishing activities that received a high level of protection include salmon trolling near the surface in deep-water (>50m depth), and pelagic seine fishing for anchovies, sardines, and herring.

Mod-High (6) – Fishing activities assigned to this level of protection caused minimal habitat damage, but had either more bycatch or a greater likelihood of ecosystem impacts than those in the high (8) protection category. For example, MPAs that allowed non-troll salmon fishing or salmon trolling in waters shallower than 50m depth were assigned to this level of protection because of the likelihood of increased bycatch of resident benthic species such as rockfish. Similarly, MPAs that allowed crab fishing with traps/pots were assigned this level of protection because crabs are only moderately mobile and interact directly with the resident ecosystem. It is difficult to predict whether local populations of crabs will be affected by MPAs, but if they are, a reduction in the crab population in fished areas could have ecosystem-wide impacts.

Moderate (4) – Fishing activities assigned to this level of protection had higher bycatch of resident species or a greater likelihood of ecosystem impacts than those assigned to the mod-high (6) category. Examples of fishing activities that received a moderate (4) level of protection included hook and line fishing for halibut and other flatfish, diving for abalone, shore-based fishing with hook and line gear in larger MPAs.

Low (2) – Fishing activities assigned to this level of protection either directly targeted resident species, had significant bycatch of resident species, or targeted species whose removal is expected to have an impact on the resident ecosystem. Examples of fishing activities that received a low (2) level of protection included harvest of urchin, lingcod, cabezon, greenling, rockfish, and surfperches.

Low (0) – Only fishing activities that caused habitat destruction were assigned to this category. Harvest of kelp, mussels, and other habitat-forming organisms received a low (0) level of protection, as did trawl fishing.

Table 2. Level of protection and the activities associated with levels the levels of protection.

Level of Protection name	**Rank level of protection**	**MPA Designations**	**Activities associated with this protection level**
Very high	10	SMR	No take

High	8	SMCA	Salmon trolling in >50m depth sardine, anchovy, and herring (pelagic seine)
Mod-high	6	SMCA	Salmon trolling in <50m depth salmon fishing with non-troll H&L crab (traps) squid (seine)
Moderate	4	SMCA, SMP	Halibut (H&L) other flatfishes (H&L) abalone (diving) – white seabass shore-based finfishing in MPAs that extend offshore (due to limited access) hand harvest of clams
Low	2	SMCA, SMP	Urchin (diving) lingcod, cabezon, greenling, rockfish, and other reef fish surfperches
Low	0	SMCA, SMP	Kelp harvest mussel harvest trawl activities because of habitat destruction

Coastal MPAs are most effective at protecting species with limited range of movement and close associations to seafloor habitats. Less protection is afforded to more wide-ranging, transient species like salmon and other coastal pelagics (e.g., albacore, swordfish, pelagic sharks). This has led to proposals of SMCAs that prohibit take of bottom-dwelling species, while allowing the take of transient pelagic species. However, fishing for some pelagic species, like salmon near the bottom or in relatively shallow water, increases the likelihood of taking bottom species that are targeted for protection (e.g., California halibut, lingcod, rockfishes). Rates of bycatch are particularly high in shallow water where bottom fish move close to the surface and become susceptible to the fishing gear. In addition, for recreational salmon fishing, the practice of “mooching” has a potentially higher bycatch rate than that of trolling.

Participants at a national conference[1] on benthic-pelagic coupling considered the nature and magnitude of interactions among benthic (bottom-dwelling) and pelagic species, and the implications of these interactions for the design of marine protected areas. At this meeting, scientists, managers and recreational fishing representatives concluded that bycatch is higher in water depths <50m (164 ft) and lower in deeper water. This information, along with incidental catch statistics provided by CDFG, contributed to our categorization of MPAs into five possible levels of protection.

[1] Benthic-pelagic linkages in MPA design: a workshop to explore the application of science to vertical zoning approaches. November 2005. Sponsored by NOAA National Marine Protected Area Center, Science Institute, Monterey, CA.

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Salmon trolling:

Direct impacts – salmon trolling causes little or no direct habitat damage as gear never touches the seafloor. CDFG bycatch data are available for both recreational and commercial fisheries (Table 3). However, these data are not depth-specific and the recreational data do not distinguish trolling from mooching. In addition to these bycatch data, NOAA's National MPA Center's convened an expert workshop of fisheries biologists, marine ecologists, MPA managers and recreational fishermen at the MPA Science Institute in November 2005 in Monterey, California. This workgroup concluded that troll gear in deep water (>50m) is sufficiently far from the seafloor that there is little or no bycatch of resident benthic species. In shallower water (<50m), however, the work group concluded that bycatch of resident species (e.g., rockfish species and lingcod) increases.

Indirect impacts – Salmon generally feed on mobile forage species such as herring, sardines, anchovies, krill, squid, and smelt. As both salmon and their prey are highly mobile, MPAs are likely to have little impact on local populations of these species. Thus, the indirect ecosystem impacts of salmon take are predicted to be low.

Level of protection:

High (8) – if water depth in MPA is greater than 50m

Mod-high (6) – if water depth in MPA is less than 50m due to increased bycatch

Table 3. Bycatch estimates for salmon fisheries

Caught on recreational trips targeting salmon w/ H&L (2000-2007)	# of fish	% of Fish caught
salmon	**53,228**	**94.96%**
rockfish	1,584	2.83%
other (<1% of catch)	1,240	2.21%
Total	56,052	

Caught on commercial* trips targeting salmon w/ troll H&L gear (2000-2006)	lbs of fish	% of Fish wt caught
salmon	**15,557,819**	**99.82%**
other (<1% of catch)	27,297	0.14%
Total	15,585,117	

Caught on commercial* trips targeting salmon w/ non-troll H&L gear (2000-2006)	lbs of fish	% of Fish wt caught
salmon	**141,579**	**82.69%**
halibut	16,253	9.47%
pelagic spp.	6,234	3.64%
rockfish	3,514	2.05%
reef spp.	2,941	1.72%
other (<1% of catch)	696	0.43%
Total	171,218	

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* commercial bycatch data is includes landed fish only and does not include any discarded catch

Salmon mooching:

Direct impacts – Salmon mooching gear has contact with the bottom, but likely causes little habitat damage. Because this fishing gear targets the bottom, there is greater bycatch of benthic species including rockfish and lingcod which are likely to otherwise be protected by MPAs.

Indirect impacts – Salmon generally feed on mobile forage species such as herring, sardines, anchovies, krill, squid, and smelt. As both salmon and their prey are highly mobile, MPAs are likely to have little impact on local populations of these species. Thus, the indirect ecosystem impacts of salmon take are predicted to be low.

Level of protection:

Mod-high (6) – due to bycatch

Abalone hand collection:

Direct impacts –Because divers harvest selectively, there is little or no bycatch of non-target species. However, divers often accidentally remove sub-legal size individuals, which may kill the animal even though it is often immediately replaced. High numbers of divers at local access sites can lead to localized habitat impacts and behavioral responses of mobile species.

Indirect impacts – Abalone are important herbivores and prey in the nearshore rocky environment, therefore removal of this species is likely to have impacts on community structure within an MPA. Although abalone have deep water refugia beyond free-diving depths, depletion of local shallow adult spawning stocks within an MPA, combined with short larval dispersal distances, can reduce the local availability of young abalone as prey to small predators.

Level of protection:

Moderate (4) – due to indirect ecosystem effects

Urchin hand collection:

Direct impacts – Hand collection of urchins causes some habitat disturbance (anchoring, which can disturb both rock and kelp as habitat). Because divers harvest selectively, there is little or no bycatch of non-target species.

Indirect impacts – Urchins are important herbivores and prey in the nearshore rocky environment, therefore removal of this species is likely to have impacts on community structure within an MPA. It has also been shown that urchin populations can impact the level of kelp abundance (negatively), thereby altering the relative abundance of this species in a kelp forest. Rogers-Bennet and Pearse (2001) also showed that abalone recruit to sea urchins and that density of abalone recruits was greater in northern CA MPAs where urchins were protected from take.

Level of protection:

Low (2) – due to indirect ecosystem effects

Clam hand digging:

Direct impacts – Clam digging causes significant disturbance to soft-bottom intertidal habitats and may also alter the behavior of local shorebirds and marine mammals. There is

bycatch associated with this activity as excavation may kill non-target infaunal species, and improperly placed sublegal clams. The depth distribution extends beyond depths at which hand digging is feasible, thereby restricting the proportion of the population harvested.
Indirect impacts – clams are important filter-feeders in the nearshore soft-bottom ecosystem and prey for sharks, skates and rays, therefore removal of this species is likely to have impacts on community structure within an MPA.
Level of protection:
Moderate (4) – due to habitat disturbance and bycatch

Halibut hook and line:
Direct impacts – Halibut fishing with hook and line gear (including long-lines) involves bottom contact but causes little habitat disturbance. Bycatch includes demersal sharks, skates and rays, other flatfish, and a variety of reef fish including rockfish, lingcod, and cabezon that would otherwise be protected by MPAs (Table 4). In the recreational fishery, 29% of reported catch on halibut trips was composed of non-target species. In the commercial fishery, roughly 7% of species landed on halibut trips were non-target species. There is no information available on commercial catch discarded.
Indirect impacts – Halibut are an important predator in the coastal ecosystem. Any change in local abundance of halibut is anticipated to have impacts on communities within MPAs, however, the movement patterns of halibut are not fully understood. Several studies indicate that young (mostly sub-legal sized) halibut are only moderately mobile and most stay within 2-5 km of their tagging release site for months or years although some move hundreds of km within that same time period. There is also information to suggest that larger halibut may be more mobile than small. Given available information on halibut movement it is unclear whether local populations will change due to protection by the size of MPAs proposed in this process.
Level of protection:
Moderate (4) – due to bycatch and the importance of halibut as a top predator

Table 4. Bycatch estimates for halibut fisheries.

Caught on recreational trips targeting halibut w/ H&L (2000-2007)	# of fish	% of Fish caught
halibut	**7,888**	**70.63%**
demersal sharks, skates & rays	1,209	10.83%
pelagics wetfish	514	4.60%
freshwater or estuarine spp.	513	4.59%
rockfish	388	3.47%
surfperch	318	2.85%
reef spp.	185	1.66%
other (<1% of catch)	152	1.36%
Total	11,168	

Caught on commercial* trips targeting halibut w/ H&L gear (2000-2006)	lbs of fish	% of Fish wt caught
halibut	**527,982**	**92.59%**
reef spp.	15,037	2.64%
rockfish	11,147	1.95%
salmon	7,193	1.26%
other (<1% of catch)	8,875	1.56%
Total	570,233	

* commercial bycatch data is includes landed fish only and does not include any discarded catch

Halibut trawl:

Direct impacts – Bottom trawling for halibut causes significant habitat disturbance and bycatch of a variety of species including other flatfishes and rockfish (Table 5). It should be noted that there is currently no trawling allowed in state waters.

Indirect impacts – Halibut are an important predator in the coastal ecosystem. Any change in local abundance of halibut is anticipated to have impacts on communities within MPAs, however, the movement patterns of halibut are not fully understood. Several studies indicate that young (mostly sub-legal sized) halibut are only moderately mobile and most stay within 2-5 km of their tagging release site for months or years, although some individuals move hundreds of km within that same time period[2 3]. There is also information to suggest that larger halibut may be more mobile than small. Given available information on halibut movement it is unclear whether local populations will change as a result of the protection afforded by MPAs of the size proposed in this process.

Level of protection:

Low (0)

Table 5. Bycatch estimates for halibut trawl

Caught on commercial* trips targeting halibut w/ trawl gear (2000-2006)	lbs of fish	% of Fish wt caught
halibut	**2,286,577**	**43.66%**
flatfish	2,278,898	43.51%
rockfish	362,080	6.91%
roundfish	151,294	2.89%
demersal sharks, skates and rays	94,209	1.80%
reef spp.	51,662	0.99%
other (<1% of catch)	12,588	0.24%
Total	5,237,309	

[2] Domeier, M. L., C.S. Chun (1995). "A tagging study of the California halibut (Paralichthys californicus)." CalCOFI Rep. **36**: 204-207.

[3] Posner, M., R.J. Lavenberg (1999). "Movement of California halibut along the coast of California." California Fish and Game **85**(2): 45-55.

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* commercial bycatch data is includes landed fish only and does not include any discarded catch

Crab traps:

Direct impacts – Crab traps contact the bottom but cause only minor habitat disturbance. Bycatch includes rock crabs, octopus, sea stars, and female Dungeness crabs in low numbers (Table 6). Sea otters have been known to become entangled in traps.

Indirect impacts – Dungeness crabs are key predators in the benthic environment and their abundant larvae provide food for a variety of pelagic species. A significant reduction in Dungeness crab populations could have ecosystem-wide impacts, however, crabs show moderate mobility (10-15 km)[4] and it is unclear whether protection through MPAs of the sizes proposed would have an effect on local populations.

Level of protection:

Mod-high (6) - due to ecosystem impacts

Table 6. Bycatch estimates for the crab fishery.

Caught on commercial* trips targeting crab with traps/pots (2000-2006)	lbs of fish	% of Fish wt caught
Dungeness	28,324,432	99.87%
other crab	26,488	0.09%
octopus	6,819	0.02%
other (<0.1% of catch)	3,686	0.01%
Total	28,361,426	

* commercial bycatch data is includes landed fish only and does not include any discarded catch

White seabass:

Direct impacts – fishing for white seabass with hook and line gear causes little or no direct habitat damage as gear rarely touches the seafloor. White seabass have not been regularly targeted in the study region over the past 7 years, so it was impossible to assess region-specific bycatch for this species. An analysis of recreational bycatch information (Table 7) for white seabass state-wide indicates that a wide variety of reef species including rockfish, kelp bass, and lingcod are regularly caught on trips targeting white seabass. In fact, 77% of the catch on trips targeting white seabass was of non-target species, mostly kelpbass, which are not abundant in the study region. Moreover, it is not clear that these other species are true bycatch, but instead are targeted when seabass catch is poor.

[4] Smith, B. D., G.S. Jamieson (1991). "Movement, spatial distribution, and mortality of male and female dungeness crab Cancer magister near Tofino, British Columbia." Fishery Bulletin **89**(1): 137-148.

Indirect impacts – White seabass mainly feed on highly mobile coastal pelagics such as herring, anchovies, and squid, thus they are likely to have a low impact on the resident benthic ecosystem.

Level of protection:

Moderate (4) - due to bycatch

Table 7. Bycatch estimates for the white seabass fishery

Caught on recreational trips targeting white seabass w/ H&L (2000-2007, all California)	# of fish	% of Fish caught
reef spp.	1,716	41.48%
white seabass	**1,377**	**33.28%**
rockfish	238	5.75%
pelagic spp.	232	5.61%
shallow sand and kelp spp.	176	4.25%
demersal sharks, skates & rays	117	2.83%
halibut	110	2.66%
pelagics wetfish	108	2.61%
other (<1% of catch)	63	1.52%
Total	4,137	

Habitat (Goals 1, 2, 3, 4, and 6)

MPA networks should include 'key' marine habitats and each of these habitats should be represented in multiple MPAs across biogeographical regions, upwelling cells, and environmental and geographical gradients. 'Key' marine habitats should be replicated in multiple MPAs with 3-5 MPAs containing each habitat type in the biogeographic region.

Habitats identified in the *Master Plan for Marine Protected Areas* and that exist in the study region include: sand beach, rocky intertidal, estuary, shallow sand, deep sand, shallow rock, deep rock, kelp, and seagrass beds. The SAT also acknowledged three distinct biogeographical subregions within the north central coast study region. These are identified by oceanographic features, geomorphology and differing species compositions. The following three subregions were identified for evaluation purposes:

- Alder Creek to North Beach road at Point Reyes Headlands
- North Beach road at Point Reyes Headlands to Pigeon Point
- The state waters around the Farallon Islands.

Habitat availability is assessed for each subregion as well as the entire study region. This provides the relative amount of available habitat in the study region and in each subregion as area or linear measurements. Habitats with linear measurements include sandy or gravel beaches, rocky intertidal, coastal marsh, tidal flats, and surfgrass. In addition, MPAs in each proposal are assessed for eight habitats: hardbottom substrate 0-30, hardbottom substrate 30-100, softbottom substrate 0-30, softbottom substrate 30-100, kelp, estuary, sandy beach, and rocky shores. For each MPA proposal the percent of available habitat by subregion is determined in reference to the level of protection. In other words, the percent of habitat in a subregion that is covered by a specific level of protection is assessed.

Guidance in the *Master Plan for Marine Protected Areas* requires that habitat be replicated in 3-5 MPAs in the biogeographic region. However, spacing guidelines may require greater replication of habitats. Benefits of MPAs is largely dependent on the habitat contained in them. An MPA that does not contain habitat for a particular species (e.g., kelp forest), provides no benefit to that species.

An MPA was considered to include a specific habitat if the MPA encompassed a critical aerial extent of the habitat. This critical area was defined as an area sufficient to (1) encompass a high proportion of the species known to use the habitat (90%, see table 8) and, (2) sufficient abundance of such species to be resilient to movement and environmental perturbation. To determine the estimated area of habitat needed we examined biological survey data from a variety of habitat types present in the study region or from other areas in central California. Using a re-sampling procedure and a Michaelis-Menton model we estimated the amount of area needed to encompass 90% of the biodiversity of each habitat. The table below indicates that value for four habitat types.

Table 8. The amount of habitat in an MPA necessary to encompass 90% of local biodiversity.

Habitat type	**Representation needed to encompass 90% of biodiversity**	**Data source**
Rocky intertidal	0.53 linear mi	PISCO intertidal surveys
Rocky reefs (0-30 m)	1.01 linear mi	PISCO subtidal surveys
Rocky reefs (30-100 m)	0.12 square mi	Starr surveys
Soft bottom (30-100 m)	10.2 square mi	NMFS triennial trawl surveys 1977-2007

Survey data from the soft bottom (30-100m) habitat type indicates that a large area would need to be protected to ensure representative biodiversity. This may be a result of fishing pressure that reduces the abundance of species in this habitat, however it was impossible to assess the magnitude of the effect. A review of the depth distribution of soft-bottom fishes indicates that most fish that use the 30-100m depth range extend their distribution into shallower (0-30m) waters as well. Therefore, we combined the area of soft 0-30, and 30-100 meter habitat and used this combined area to assess the % of biodiversity encompassed by a given MPA.

There were several representative habitat types for which survey data was unavailable. We assessed the presence of these habitats in a given MPA as follows:

Soft bottom (0-30m) – the species that are unique to this habitat mainly inhabit the surf zone, therefore we used the linear extent of sandy beaches to assess the presence of this habitat.

The distribution and movement patterns of species in the surf zone is likely similar to that of species on shallow rocky reefs, therefore we assessed the % of biodiversity using the area/biodiversity relationship derived from 0-30m rocky reefs (1.0 linear mi = 90% biodiversity)

Sandy beaches – no data were available to make a scientific assessment of the relationship between beach length and biodiversity. We considered sandy beach habitat present if there was at least 1 mile of sandy beach in a given MPA.
Kelp – the aerial images used by CDFG to estimate kelp coverage do not reliably capture presence of the dominant kelp species in the study region, bull kelp (Nereocystis luetkeana). Therefore, kelp coverage estimates for the region are low and indicate large gaps between kelp patches. Kelp occurs over shallow rocky substrate (0-30m), so adequate protection of shallow rock habitat should ensure protection of kelp even where it does not appear on the maps. In the places where kelp does appear on CDFG maps, we calculated the linear extent of the kelp beds and assessed the % biodiversity using the area/biodiversity relationship derived from 0-30m rocky reefs (1.0 linear mi = 90% biodiversity) to determine whether kelp habitat was present in a given MPA.

Surfgrass – surfgrass occurs in shallow and intertidal rocky habitats along the coast of the study region. Few organisms live exclusively in surfgrass habitat but many intertidal and shallow rock species benefit from its presence. We assessed the percent biodiversity using the area/biodiversity relationship from the rocky intertidal (0.5 linear mi = 90% biodiversity)

Non-representative (mainly estuarine) habitats were not assessed for presence absence as their distribution does not lend itself to spacing assessments.

For the upwelling center habitat category, we counted all MPAs that included shallow and moderate depth habitats in the vicinity of the major upwelling centers of the north central coast – Point Arena and Point Reyes.

Size and Spacing (Goals 2 and 6)

Guidance on spacing found in the *Master Plan for Marine Protected Areas* states:

1. “For an objective of facilitating dispersal of important bottom-dwelling fish and invertebrate groups among MPAs, based on currently known scales of larval dispersal, MPAs should be placed within 50-100 km (31- 62 mi or 27- 54 nm) of each other.”

This guideline arises from a number of studies that examine the persistence of marine populations with a network of marine reserves (Botsford et al. 2001, Gaines et al. 2003, Gaylord et al. 2005) and its connection to larval dispersal. The spacing distances arise from a number of recent syntheses of data on larval dispersal in marine fish, invertebrates and seaweeds (Shanks et al. 2003, Kinlan and Gaines 2003, Kinlan et al. 2005) and advances in modeling of larval transport (e.g., Siegel et al. 2003, Cowen et al. 2006). As with adult movement, scales of larval movement vary enormously among species (meters to 100s of km). In contrast to adult movement, however, it is the short distance dispersers that pose the biggest challenge for connections between MPAs.

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Since the spacing guidelines are targeted at ensuring connectivity among MPAs for different species, MPAs must be characterized by the habitats they contain. Thus, the spacing analysis must be based on the minimum amount of habitat contained in an MPA as described above. For each habitat the spacing between all MPAs that included that habitat was determined linearly from a central node in the MPA. These spacings were compared to the maximum spacing guidelines found in the *Master Plan for Marine Protected Areas.*

The SAT guidance in regard to offshore islands, specifically the Farallon Islands, is that current MPA size guidelines should apply, however the spacing guidelines will not. In terms of spacing, the Farallons will not be considered in the spacing analysis for MPAs along the mainland.

Guidance on size found in the *Master Plan for Marine Protected Areas* states:

1. "For an objective of protecting adult populations, based on adult neighborhood sizes and movement patterns. MPAs should have an alongshore span of 5-10 km (3-6 mi or 2.5-5.4 nm) of coastline, and preferably 10-20 km (6-12.5 mi or 5.4- 11nm). Larger MPAs would be required to fully protect marine birds, mammals and migratory fish."

2. "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, MPAs should extend from the intertidal zone to deep waters offshore".

The first size guideline arises primarily from data on the movement of adult and juvenile fish and invertebrates. Since MPAs will be most effective if they are substantially larger than the distance that individuals move, larger MPAs provide benefit to a wider diversity of species. A summary of existing scientific studies of adult movement (See Appendix 1) shows that adult movement varies greatly among California's marine species (Table 9). Therefore the choice of any MPA size determines the subset of species that could potentially benefit. For species with average movement distances of 100s to 1000s of miles, MPAs are unlikely to be a source of significant protection (except when they protect critical locations, e.g., spawning or nesting grounds). As a result, the *Master Plan for Marine Protected Areas* guidelines focus on species in the first three movement categories in Table 9. The minimum size guideline of 5 to 10 km targets species in the first two categories. The preferable 10 to 20 km size range attempts to provide substantially more benefit to the important group of species in category 3 (10 - 100 km movement). This group includes a number of important rockfishes from the California coast. Therefore, MPAs that meet the preferable size guideline should protect more biological diversity than MPAs that just meet the less stringent minimum guideline.

Table 9. Scales of adult movement for California coastal marine species *(This table is draft and needs review by the authors)*

Move 0-1 km	**Move 1-10 km**	**Move 10-100 km**
0-0.5 km striped surfperch pile surfperch Pacific staghorn sculpin	**1-5 km** gopher rockfish blue rockfish bocaccio	**10-20 km** Dungeness crab lingcod yellowtail rockfish

painted greenling kelp greenling kelp bass kelp rockfish black-and-yellow rockfish widow rockfish vermillion rockfish yelloweye rockfish olive rockfish monkeyface prickleback* cabezon black surfperch red irish lord brown rockfish copper rockfish quillback rockfish starry rockfish* grass rockfish* rosy rockfish* treefish*	California halibut** walleye surfperch* greenspotted rockfish*	black rockfish **20-125 km** canary rockfish

* studies of this species had fewer than 10 individuals
** see the response to question 4 in this document for more information

The second size guideline arises from an attempt to connect habitats across depth ranges. Many marine species spend different parts of their life cycle in different habitats that often span a range of depths. By connecting these different habitats in a single MPA, species that move among contiguous habitats will likely benefit.

Hence, *Size Guideline #2: "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, MPAs should extend from the intertidal zone to deep waters offshore."*

This guideline reflects the recommendation of the SAT that MPAs extend from the shore to the boundary of state waters (3 miles). Extending MPA boundaries to the edge of state waters has the added benefit of allowing for connections with future MPA designations in federal waters. The combination of these two size guidelines forms the basis for SAT evaluation of MPA areas that use both the alongshore and offshore dimensions.

Methods of SAT analysis of MPAs relative to these size guidelines:

- We measured the alongshore length and area of each proposed MPA
- When MPAs shared boundaries, we combined contiguous MPAs into a single MPA cluster
- We considered the level of protection in each component of an MPA cluster
- We tabulated the sizes of all MPAs and MPA clusters with respect to the MPF minimum and preferable guidelines.

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- We considered which habitats were represented in MPA clusters that meet MPF minimum and preferable guidelines.

Protection of foraging, breeding, rearing areas (Goal 2)

For many species of fish and invertebrates, protection of a full range of representative and unique habitats will provide protection of their nursery areas. This analysis specifically focuses on birds including seabirds, shorebirds and waterfowl, and mammals. Population in this evaluation refers to the number of animals that use a site for breeding or resting. Sharks will not be included in this analysis except in general terms as they relate to pinniped rookeries. Each proposed MPA or Special Closure will be assessed based on in situ information about how that area will contribute to protection of birds, mammals and sharks in the study region. For example, there are no large seabird colonies in Sonoma County compared to the Farallon Islands; however, there are concentrations of birds that may be significant for the northern part of the study region. Additionally, analysis will look at areas as they apply to each of the 3 bioregions identified by the SAT (north of Point Reyes, south of Point Reyes and the Farallon Islands).

Evaluation will focus on:

1. **Protection of seabird breeding colonies and pinniped rookeries based on population size, location and species composition**.
The analysis examine whether or not MPA and Special Closure proposals cover areas containing significant colonies or colony complexes (i.e., groups of nearby colonies along a stretch of coast) of species likely to benefit from MPAs or closures. Evaluations will be based on the numbers of animals, or in some cases the proportion of the study region population, covered for species likely to benefit with a focus on species most likely to benefit. For specific colony protection, the evaluation will examine whether the proposal provided for specific protections, such as no-entry zones or other spatial regulations that would reduce human disturbance (e.g., no fishing allowed may reduce the numbers of boats), and whether or not the buffer zones protect significant enough animals to be worthwhile or if other measures might be more appropriate.

Data used for these assessments mainly would be from the bird colony count data and GIS layers provided by the NOAA Biogeographic Assessment, from pinniped data compiled from Mark Lowry and Sarah Allen and already contained in the CDFG database (we are also working with NOAA staff to get updated information), and other sources when necessary. Within the boundaries of each proposed MPA or Special Closure, we will need a list of the bird and mammal colonies contained within it, the numbers of breeding animals for each species, and the proportion of the sub-regional populations (i.e., north or south of Pt. Reyes, Farallon Islands) contained within it. For proposed no-entry zones, we will need a map showing the proposed no-entry area and details on proposed regulations (e.g., seasonal or year-round closures, distance from shore).

At the Farallon Islands, bird and mammal colonies are not evenly distributed. There is no GIS layer of such distribution, but maps are available in various publications and reports. The value of potential no-entry zones would be evaluated based on these maps of distribution.

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For sea otters, we will utilize data from annual statewide surveys to overlay otter densities and proposed MPAs. Since the otter population has been expanding northward, we may also examine potential future habitat. This would likely be done by examining amount of potential habitat, such as kelp beds, rocky substrate, etc.

2. Bird and mammal resting (roost/haulout/raft) locations based on population size, location and species composition.

Assessment of resting areas or haulout sites would be done in the same fashion as for colonies/rookeries. The best data to use for seabird roosts would be on Brown Pelicans, an endangered species. Pelican roost data would also be used as a surrogate for other species unless other specific data were available. For pinnipeds, data on pinniped haul-outs already in the CDFG-MLPA database would be utilized.

3. Bird and mammal foraging concentrations based on population size, location and species composition.

For breeding species, we will focus on four species most likely to benefit based on limited foraging ranges. For birds, pelagic cormorant, Brandt's cormorant, and pigeon guillemot. For pinnipeds, the harbor seal. These species mainly forage in nearshore waters within a few miles of colonies. However, other species likely to benefit (e.g., common murre) may also be added to evaluations on a case-by-case basis.

Evaluations of benefits to birds and mammals will be based on whether or not proposed regulations may benefit forage species, how much foraging area will be protected near colonies, and how many animals of the species likely to benefit stand to benefit. For this, we will need 3-mile buffers (or possibly larger on a case by case basis) drawn around colonies to examine how much of principle foraging areas will be encompassed by proposed MPAs. From this, we will need calculations of % of foraging habitat the proposed MPAs cover from each colony. We also may request to have at-sea density for certain species (e.g., Brandt's cormorant, common murre, harbor seal) plotted over proposed MPAs as an additional evaluation tool on a case-by-case basis.

For non-breeding birds (e.g., waterfowl, shorebirds), we will evaluate whether proposed MPAs encompass important concentration areas and what proportion of estimated populations are encompassed whether or not proposed regulations may benefit forage species,

- For waterfowl wintering in the coastal estuaries, we will use data provided by the US Fish and Wildlife Service from the annual winter survey (recently provided to MLPA). Long-term averages will be used for each estuary and each species likely to benefit (e.g., brant, scaup, scoter, bufflehead, goldeneye). There is no GIS data with this, just estuary name and numbers of birds, so we will have to gauge what we can based on what's available and possibly pers. comms. from those who do the surveys.
- For outer coast non-breeding waterfowl, we will focus on species most likely to benefit: western/Clark's grebes; and surf scoter. For these, we will utilize bird density data from the NOAA Biogeographic Assessment. We will need the bird density blocks overlayed with the proposed MPAs. Exactly how density data is presented will depend on the level of detail available. For example, in the NOAA Biogeographic Assessment, density maps are provided for three separate oceanic seasons (Upwelling, Oceanic, and Davidson Current). We would

prefer to have data presented in this fashion, as well as an overall map combining data from all three seasons. That will depend on what the CDFG GIS specialists can provide.
- For migrant and wintering shorebirds, we are trying to get data provided from recent surveys. These data, if available, would be utilized in much the same way as the estuarine waterfowl.

Fishery impacts

In order to conduct the analysis of relative effects of the MPA packages on commercial fisheries that are conducted in the waters in the North Central Coast Study Region (NCCSR), we use data layers characterizing the spatial extent and relative stated importance of fishing grounds of 8 commercial fisheries (i.e. halibut, coastal pelagics, market squid, nearshore rockfish, deep nearshore rockfish, urchin, Dungeness crab and salmon) in the North Central Coast Study Region. This information was collected during interviews in the summer of 2007, using a stratified, representative sample of 174 fishermen whose individual responses regarding the relative importance of ocean areas for each fishery were standardized using a 100-point scale and normalized to the reported fishing grounds for each fishery.

Using this data, we 1) conduct an analysis and evaluation of the potential impacts on commercial fishing grounds and 2) analyze the socioeconomic impacts on commercial fisheries in order to assess the relative effects of the ten MPA network proposals (Packages Turquoise A, Turquoise B, Emerald A, Emerald B, Jade A, Jade B, Alternative A, Alternative B, Alternative C, Alternative D). For both, results will be reported at the study region/port group levels. For this analysis, port groups have been defined as: Bodega Bay, Point Arena, Bolinas, San Francisco and Half Moon Bay.

The ten MPA network proposals under review vary according to their spatial extent and the commercial fisheries they affect. Specifically, they vary by the number and types of fisheries permitted within the boundaries of particular MPAs within a network. Furthermore, study area (SA) fisheries themselves vary in spatial extent and frequently overlap. Most of them are conducted in fishing grounds that extend beyond the state waters of the NCCSR, and we report the effects both in terms of total fishing grounds (G) and those that fall within the study area. Since any one MPA may have different effects on different fisheries, and different fisheries may be affected differently by all MPAs, it is therefore necessary to consider single MPAs and single fishery uses independently. Note that because current fishery closures affect all proposals equally, they have no differential effect.

It should be noted that this analysis assumes that each of the MPA network alternatives completely eliminate fishing opportunities in areas closed to specific fisheries and that fishermen are unable to adjust or mitigate in any way. In other words, the analysis assumes that all commercial fishing in an area affected by an MPA would be lost completely, when in reality it is more likely that effort would shift to areas outside the MPA. The effect of such an assumption is most likely an overestimation of the impacts, or a “worst case scenario.”

We conduct an overlay of each MPA with each fishery considered in this study. MPAs are grouped according to level of protection, using the same levels of protection as elsewhere in

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the Science Advisory Team (SAT) evaluations. In other words, for each MPA and protection level within each package, we assess the commercial fisheries that would be affected.

We compile results in a series of spreadsheets, summarizing the effects of the various MPA packages on commercial fisheries, both in terms of the area affected and the relative value lost. We use the same method of analysis as developed in the Central Coast process (see Scholz et al., 2006), creating a weighted surface that represents the stated importance of different areas for each fishery. More specifically, we multiply these stated importance values by the proportion of in-study region landings (by port and by fishery). These estimates then feed into the socioeconomic impact calculations described below.

Additionally, we consider the percentage of area and value affected with the fishing grounds which are constrained by existing fishery management areas closures and/or fishery exclusion zones. We evaluate and determine if there are individuals that would be disproportionately affected (i.e., 100% or a larger portion of their grounds are inside a proposed MPA that would restrict fishing).

We also calculate the estimated maximum potential economic impact of each proposed MPA package (for description of methods, please see attached white paper). To accomplish this, we estimate the maximum potential economic impact for each of the proposed MPA packages using methods similar to those utilized in the Central Coast process by Wilen and Abbott (2006). This analysis for the North Central Coast, however, differs in a very important respect, that is, by having original survey data on fishermen operating costs collected through the interview process.

References

Scholz, Astrid, Charles Steinback and M. Mertens. 2006. Commercial fishing grounds and their relative importance off the Central Coast of California. Report submitted to the California Marine Life Protection Act Initiative. May 4, 2006.

Wilen, James and Joshua Abbott, "Estimates of the Maximum Potential Economic Impacts of Marine Protected Area Networks in the Central California Coast," final report submitted to the California MLPA Initiative in partial fulfillment of Contract #2006-0014M (July 17, 2006)

Recreational, educational, and study opportunities (Goal 3)

In Phase I of implementation for the central coast study region, MLPA Initiative staff and the Master Plan Science Advisory Team (SAT) evaluation subteam used some simple metrics to evaluate how well the proposed MPA packages address Goal 3 of the MLPA.

Goal 3 of the Marine Life Protection Act (MLPA) is:

> *"To improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity*."

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In evaluation of the draft proposals and arrays developed for implementation of Phase II, the north central coast, the MLPA Initiative staff proposes the inclusion of similar parameters used in Phase I, with some modification of the methodology. Many of the parameters are measurements of access, which is considered important for increasing recreation, education, and study activities. Metrics used to evaluate each draft array and proposal for the north central coast study region would include:

- *Distance of proposed MPAs to boat ramp/launch/port*. The number of MPAs within 0-5, 5-15, and 15-50 miles of a boat launch, port, or harbor. The 0-5mi distance reflects potential use of MPAs by users with small craft.

- *Distance of proposed MPAs from the region's major ports*. The number of MPAs within 0-5, 5-15, and 15-50 miles of the major port (i.e. San Francisco, Bodega, or Half Moon Bay). The 0-5mi distance reflects potential use of MPAs by users with small craft.

- *Distance of proposed MPAs from major marine research institutions.* The number of MPAs within 0-15 and 15-50 miles of a major marine research institution. (i.e. Bodega Bay Marine Lab (University of California, Davis) and Romberg Tiburon Center for Environmental Studies (San Francisco State University)).

- *Number of established marine research monitoring sites*. The number of sites monitored by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), Cooperative Research and Assessment of Near-shore Ecosystems (CRANE), and Multi-Agency Rocky Intertidal Network (MARINe) within MPAs.

- *Number of access points within and near MPAs.* The number of access points within SMRs and high protection SMCAs and the number of access points within 2 miles of those MPAs. Also, the number of access within moderate and low protection MPAs. and within 2 miles of those MPAs. (Only shoreline MPAs would be considered in the evaluation of access.)

Unlike the Goal 3 evaluation for the central coast study region, the Goal 3 evaluation for the north central coast will not include the distance between MPAs and major population centers. The MLPA Initiative staff considers that the dominance of San Francisco as the only major population center in the north central coast study region, would be likely to skew the evaluation.

The above metrics will be evaluated with the help of Geographic Information Systems and communicated in a memo from the MLPA Initiative to the Department of Fish and Game. The memo will explain the Goal 3 evaluation methodology, evaluate and summarize the performance of internal and external MPA proposals/draft arrays against Goal 3, and include a graphic presentation of the evaluation.

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Posner, M., R.J. Lavenberg (1999). "Movement of California halibut along the coast of California." California Fish and Game **85**(2): 45-55.

Smith, B. D., G.S. Jamieson (1991). "Movement, spatial distribution, and mortality of male and female dungeness crab Cancer magister near Tofino, British Columbia." Fishery Bulletin **89**(1): 137-148.

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