California Marine Life Protection Act Initiative

Methods Used to Evaluate Draft MPA Proposals in the North Central Coast Study Region (DRAFT)

May 23, 2008 revised draft

IN TRACK CHANGES FORMAT

Highlighted text indicates those areas where SAT members should focus their review time in preparation for the May 30, 2008 meeting

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EXECUTIVE SUMMARY

This document provides details of the methods used to evaluate draft marine protected area (MPA) proposals for the California Marine Life Protection Act (MLPA) North Central Coast Study Region. The proposals are being developed through the California MLPA Initiative, a public/private partnership designed to assist the State of California in implementing the MLPA [California Fish and Game Code, Section 2853]. Development and evaluation of draft 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~~California's Marine Life Protection Act (MLPA) [~~. Evaluations of proposals are conducted relative to MLPA goals, scientific guidelines, and California Department of Fish and Game (CDFG) feasibility criteria. Potential impacts to commercial and recreational consumptive users are also evaluated.

The MLPA Master Plan Science Advisory Team (SAT) and MLPA Initiative staff evaluate draft MPA proposals ~~for the north central coast study region~~ relative to the science guidelines found in the *California MLPA Master Plan for Marine Protected Areas* (Master Plan) and MLPA goals (goals 1, 2, 3, 4 and 6). The SAT developed the methods to evaluate the potential of the draft proposals to fulfill scientific and ecologically-oriented goals of the MLPA (i.e., goals 1, 2, 4 and 6). MLPA Initiative staff developed the methods used to evaluate the MLPA goal pertaining to improved recreational, educational, and study opportunities (i.e., Goal 3). The criteria established by CDFG for its feasibility evaluation are contained in a separate document. All evaluations and analysis are forwarded to the MLPA Blue Ribbon Task Force (BRTF) for its consideration in providing policy guidance to the NCCRSG and California Fish and Game Commission.

This executive summary provides an overview of the elements of the SAT's and Initiative staff's evaluation relative to MLPA goals (Table 1). The full document, *Methods Used to Evaluate Draft MPA Proposals in the North Central Coast Study Region,* provides rationale and greater detail for how the guidelines were developed and made operational in the evaluation process.

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.	Habitat representation 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 and spacing guidelines; 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; accessibility;

4. To protect marine natural heritage, including protection of representative and unique marine life habitats in California.	Habitat representation, replication, 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 state's MPAs are designed and managed, to the extent possible, as a network.	Size and spacing guidelines

Protection Levels (Goals 1, 2, 4 and 6)

The Marine Life Protection Act ~~(MLPA)~~ identifies three types of marine protected areas (MPAs): state marine reserve (SMR), state marine conservation area (SMCA), and state marine park (SMP). There is great variation in the type and magnitude of activities that may be permitted within these MPAs (particularly within SMPs and SMCAs), which influences the degree of protection conferred by these designations. Categorizing MPAs by their relative level of protection simplifies comparisons of the overall conservation value of MPAs within and among MPA proposals and ensures that proposals fulfill the goals of the MLPA.

The MPA types, and activities associated with each protection level, are presented in Table 2. The SAT assigns to each MPA one of six protection levels, from low to high, depending on the allowed activities proposed.

In assigning MPA protection levels the SAT considers:

- The ~~specificity that proposals provide about~~proposed allowed uses within each MPA (e.g. specific fishing methods)
- The depth in which allowed uses could occur (For example, salmon trolling in different depth zones could confer different levels of protection)

MPAs that the SAT determines to have a protection level of moderate-high, high, or very high, are then considered as part of the size and spacing analysis (see below).

Table 2. Level of protection and the activities associated with levels of protection in the MLPA North Central Coast Study Region

	Level of Protection	MPA Types	Activities associated with this protection level
	Very high	SMR	No take
	High	SMCA	In water depth > 50m: pelagic finfish[1] by hook and line (salmon by troll only); coastal pelagic finfish[2] by seine ~~pelagic finfish[3] by hook and line in water with bottom depth greater than 50m (salmon by troll only); coastal pelagic finfish[4] by seine in water with bottom depth greater than 50m~~ ~~pelagic finfish including salmon (troll hook and line (H&L) in water with bottom depth greater than 50m), sardine, anchovy, and herring and mackerel (pelagic seine)~~
	Moderate-high	SMCA	In water depth < 50m: pelagic finfish[3] by hook and line (salmon by troll only); coastal pelagic finfish[4] by seine; Dungeness crab (traps/pots), squid (pelagic seine)~~pelagic finfish[11] by hook and line in water with bottom depth less than 50m (salmon by troll only); coastal pelagic finfish[22] by seine with bottom depth less than 50m; Dungeness crab (traps/pots), squid (pelagic seine)~~~~pelagic finfish including salmon (troll H&L in water with bottom depth less than 50m)*, Dungeness crab (traps/pots), squid (pelagic seine)~~
	Moderate	SMCA SMP	salmon (non-troll H&L); abalone (diving); halibut, white seabass, shore-based finfish, croaker, and flatfishes (H&L); smelt (H&L and hand/dip nets); clams (hand harvest); giant kelp (hand harvest)~~salmon (non-troll H&L); abalone (diving); halibut, white seabass, shore-based finfish, croaker, and flatfishes (H&L); smelt (H&L and hand/dip nets); clams (hand harvest); giant kelp (hand harvest~~~~salmon (non-troll H&L), abalone (diving), halibut, white seabass, shore-based finfish and flatfishes (H&L), clams (hand harvest), giant kelp (hand harvest)~~)

[1] Pelagic finfish: 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.

[2] Coastal pelagic finfish: northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasi*), jack mackerel (*Trachurus symmetricus*), Pacific mackerel (*Scomber japonicus*), and Pacific sardine (*Sardinops sagax*).

[3] Pelagic finfish: 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.

[4] Coastal pelagic finfish: northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasi*), jack mackerel (*Trachurus symmetricus*), Pacific mackerel (*Scomber japonicus*), and Pacific sardine (*Sardinops sagax*).

	Moderate-low	SMCA SMP	Urchin (diving); lingcod, cabezon, greenling, rockfish, and other reef fish (H&L); surfperches (H&L)~~uUrchin (diving), lingcod, cabezon, greenling, rockfish, and other reef fish (H&L), surfperches (H&L)~~
	Low	SMCA SMP	bull kelp and mussels (any method); all trawling; giant kelp (mechanical harvest); mariculture (~~any~~existing methods)~~bull kelp and mussels (any method), all trawling, giant kelp (mechanical harvest), mariculture~~

~~* The SAT feels that the allowance of salmon trolling at depths shallower than 50 meters in an MPA would result in a level of protection that ranges from high to moderate-high. For the purposes of evaluating MPA proposals a new category will be created that reflects this range where salmon trolling is the only allowed use.~~

Habitat Representation Analyses (Goals 1 and 4)

California marine habitats are categorized by the MLPA and have been further subdivided by the SAT based on depth categories of 0-30 m, 30-100 m, 100-200 m, and greater than 200 m.

In evaluating habitat representation the SAT considers:

- A habitat to be "present" within an MPA if that MPA contains enough habitat to capture 90% of the local biodiversity (this differs by habitat, see Table 3).
- The degree of habitat representation proposed within each of the 3 defined SAT subregions within the MLPA North Central Coast Study Region (North of approximately Point Reyes, South of approximately Point Reyes, and the waters around the Farallon Islands~~s~~).
- In the north central coast study region, habitats deeper than 100m are generally not available and therefore do not need to be represented.

Table 3. The amount of habitat in an MPA necessary to encompass 90% of local biodiversity

Habitat	Representation needed to encompass 90% of biodiversity	Data Source
Rocky Intertidal	**~0.5 linear miles**	**PISCO Biodiversity**
Shallow Rocky Reefs/Kelp Forests (0-30 M)	**~1 linear miles**	**PISCO Subtidal**
Deep Rocky Reefs (30-100 M)	**~0.1 square miles**	**Starr surveys**
Sandy Habitat (30-100 M)	**~10 square miles**	**NMFS triennial trawl surveys 1977-2007**
Sandy Habitat (0-30 M)	**~1 linear miles**	**Based on shallow rocky reefs**
Sandy Beaches	**~ 1 linear mile**	
Estuary	**~0.12 square miles**	**SONGS mitigation team surveys**

Habitat Replication (Goals 1, 3 and 4)

Habitat replication within a biogeographic region is required by the MLPA Master Plan. The SAT has further recommended replication within study regions for ecological and other purposes. To evaluate replication the SAT considers whether there is a minimum amount of habitat present within an MPA, as described above, and whether the MPA meets the minimum size threshold, as described below. Habitat ~~representation~~ replication is used as an analytical tool in two different sets of analyses and the evaluation of habitat replication is done in two ways:

- In the habitat representation analyses (Section 4.0, Goals 1 and 4), habitat replication is expressed *within the biogeographical region (Point Conception to Oregon)* relative to the MLPA Master Plan guidelines of 3-5 replicates per biogeographic region. For the analysis, habitats replicated in the north central coast proposals are summarized with those implemented in the central coast study region. Proposals that follow the size and spacing guidelines (see below) automatically result in some habitat replication within the study region.
- In the analysis of recreational, educational, and study opportunities (Section 7.0, Goal 3), habitat replication *within the study region* is summarized. The analysis also provides information on the potential for MPAs to contribute to regional monitoring efforts.

Size and Spacing Analyses (Goals 2 and 6)

Size and spacing guidelines were developed to provide for the persistence of important bottom-dwelling fish and invertebrate groups within MPAs and their dispersal among MPAs and to promote connectivity in the network (Goals 2 and 6).

In evaluating the size of MPAs, the SAT considers:

- Whether MPAs cover an alongshore span of at least 3-6 miles (preferably 6-12 miles) to protect the neighborhood size of adult species, as recommended in science guidelines of the Master Plan
- Whether MPAs extend offshore to deep waters, as recommended in the Master Plan science guidelines. The SAT has determined that MPAs that extend to the state water boundary, three miles offshore, best meet this guidance ~~-~~for the purpose of implementing the MLPA.

The SAT makes operational the Master Plan guidance above by using a minimum size threshold of 9 square miles (3 miles alongshore and 3 miles offshore) to evaluate MPAs with regard to goals 2 and 6 of the MLPA. (No MPA that is smaller than 9 square miles could meet both the alongshore and onshore-offshore size guidelines mentioned above.)

In evaluating the spacing of MPAs, the SAT ~~considers~~:

- Considers wWhether an MPA has sufficient habitat present (see Table 3 above), is of sufficient size (minimum cluster size of 9 square miles), and has at least moderate-high protection level to count toward the spacing analysis.
- Combines aAdjacent MPAs together as a "cluster." as long as they are each at least of moderate-high protection and are intended by stakeholders to contribute toward population and network goals (goals 2 and 6).
- Determines wsWhether similar habitats within MPAs are spaced within 31-62 miles of one another, as recommended in the Master Plan science guidelines. The SAT has made operational this guidance by considering the distance between MPAs that contain each of the key habitats. The spacing analysis is done separately for each habitat. Each habitat is analyzed separately for the spacing analysis.

The spacing analysis is conducted separately for each habitat and with a focus on MPAs at three different levels of protection: at least "moderate-high" protection; at least "high" protection; and, finally, only MPAs with "very high" levels of protection. For example, in the "high" level of protection spacing analysis, only MPAs with a "high" or "very high" level of protection are considered).

Protection of Foraging, Breeding and Rearing Areas (Goal 2)

MPAs can protect birds and mammals by protecting their forage base and by reducing human disturbance to roosting sites, haul-outs, breeding colonies, and rookeries. To evaluate the protection afforded by proposed MPAs to birds and mammals the SAT:

- Identifies proposed MPAs or special closures that might contribute to protection of birds and mammals.
- Identifies focal species likely to benefit from MPAs and for which data are available.
- Analyzes the proportion (of total numbers of individuals) of breeding bird/mammals at colonies and rookeries potentially benefiting by proposed MPAs.
- Analyzes the proportion of nearby foraging areas protected by MPAs, defined by evaluating protection of buffered areas around colonies.

Recreational, Education and Study Opportunities (Goal 3)

MLPA Initiative staff evaluates~~d~~ the potential recreational, educational, and study opportunities provided by each MPA proposal in terms of the MPAs' overall accessibility, proximity to educational institutions, inclusion of existing monitoring sites, and consideration of replication in design.

In evaluating the draft proposals Initiative staff considers:

- Access points within and near MPAs, including proximity to boat launches and ports. Proximity to MPAs that allow many uses versus MPAs that allow few uses may have different effects on different users.
- Inclusion of existing monitoring sites and close proximity to research institutions, which may increase study opportunities.
- Replication of habitats within MPAs, which may contribute to increasing research opportunities.

Recreational and Commercial Fishery Impacts

While fishery impacts are not the focus of the MLPA, they may be considered in designing MPA networks. The evaluation of maximum potential recreational and commercial fishery impacts utilizes region-specific data collected by MLPA contractor Ecotrust on areas of importance. Potential impacts to the abalone fishery are based on landings data from CDFG.

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

- Organize impact analyses by port and/or fishery and summarize the maximum potential impacts by total area or value affected within the study region or in total fishing grounds[5].
- Evaluate the potential impact of proposed MPAs to abalone index sites and abalone landings

[5] Impact analyses represent a "worst case" scenario where fisherman cannot fish in a different location.

Water and Sediment Quality

While water and sediment quality are not subject to management under the MLPA, these factors may be important in designing MPA networks. Where water quality or sediment quality is significantly compromised, marine life may be affected. Effects can be on bioaccumulation, as well as population rate parameters (growth, reproduction, and mortality), influencing population levels and also the ecological community composition through a variety of interactions (e.g., decreased diversity, loss of sensitive species and abundance of tolerant species). Thus, it is recognized that habitat is altered where water quality or sediment quality is degraded.

In the design of MPA networks for the MLPA North Central Coast Study Region, there has been no organized attempt to assess water quality or sediment quality concerns and these factors have not been included in the evaluations of MPA proposals. However, the status of water quality in the NCCSR was presented, for information purposes, to the NCCRSG and BRTF. In general, the various proposals did not site MPAs at the mouth of San Francisco Bay, which is known to emit a variety of pollutants from watershed and other pollution sources within the bay. Many of the proposed MPAs were also located at existing Areas of Special Biological Significance.

1.0 OVERVIEW

This document provides details of the methods used to evaluate draft marine protected area (MPA) proposals for the California Marine Life Protection Act (MLPA) North Central Coast Study Region. The proposals are being developed through the California MLPA Initiative, a public/private partnership designed to assist the State of California in implementing the MLPA [California Fish and Game Code, Section 2853]. Development and evaluation of draft 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 ~~California’s Marine Life Protection Act (MLPA)~~the MLPA. Evaluations of proposals are conducted relative to MLPA goals, scientific guidelines, and California Department of Fish and Game (CDFG) feasibility criteria. Potential impacts to commercial and recreational consumptive users are also evaluated. The evaluations are conducted by the MLPA Master Plan Science Advisory Team, MLPA Initiative staff, and contractors to the MLPA Initiative~~, a public/private partnership designed to assist the State of California in implementing MLPA~~.

2.0 MLPA GOALS AND EVALUATION ELEMENTS

The MLPA Master Plan Science Advisory Team (SAT) and MLPA Initiative staff evaluate draft MPA proposals for the north central coast study region relative to the science guidelines found in the *California MLPA Master Plan for Marine Protected Areas* (Master Plan) and MLPA goals (goals 1, 2, 3, 4 and 6). The SAT developed ~~the~~ methods to evaluate the potential of the draft proposals to fulfill scientific and ecologically-oriented goals of the MLPA (i.e. goals 1, 2, 4~~3~~ and 6). MLPA Initiative staff developed ~~the~~ methods used to evaluate the MLPA goal pertaining to improved recreational, educational, and study opportunities (i.e., Goal 3). The criteria established by the ~~California Department of Fish and Game (~~CDFG~~)~~ for its ~~feasibility~~ evaluation of the feasibility of MPA proposals are contained in a separate document. All evaluations and analysis are forwarded to the MLPA Blue Ribbon Task Force (BRTF) for its consideration in providing policy guidance to the North Central Coast Regional Stakeholder Group (NCCRSG) and California Fish and Game Commission. Table 1 provides an overview of the elements of the evaluation relative to MLPA goals.

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.	Habitat representation 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 and spacing guidelines; 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; accessibility;
4. To protect marine natural heritage, including protection of representative and unique marine life habitats in California.	Habitat representation, replication, 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

3.0 PROTECTION LEVELS (GOALS 1, 2, 4 AND 6)

Summary of Guidelines: Level of Protection

In assigning MPA protection levels the SAT considers:

- The ~~specificity that proposals provide about~~proposed allowed uses within each MPA (e.g. specific fishing methods)
- The depth in which allowed uses could occur (For example, salmon trolling in different depth zones could confer different levels of protection)

Why Categorize MPAs by Protection Levels?

The ~~Marine Life Protection Act (~~MLPA~~)~~ identifies three types of marine protected areas~~ (MPA)~~: state marine reserve (SMR), state marine conservation area (SMCA), and state marine park (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 proposals with flexibility in ~~designing~~ crafting MPAs that either individually or collectively fulfill the various goals and objectives specified in the MLPA. However, this flexibility can result in a wide range of anticipated protection levels~~s~~ 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 proposed MPA arrays.

Marine Protected Area (MPA) Designations

State marine reserves (SMR) provide the greatest level of protection to species and to ecosystems by prohibiting take of any kind (with the exception of permitted 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 may allow any combination of commercial and recreational fishing, as well as other extractive activities (e.g., kelp harvest).

Assigning Levels of Protection

The SAT determines what level of protection is afforded in an MPA that allows a specific activity by examining the impacts that the 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 may include habitat disturbance and removal of target and non-target species caused by the fishing gear or method. Indirect impacts may 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) are considered to have impacts on species interactions throughout the ecosystem.

The SAT takes~~ook~~ several factors into consideration when determining the indirect ecosystem impacts of each type 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 that assists~~ed~~ in the determination of impacts i~~wa~~s: "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 abundance, therefore the ecosystem impacts caused by removing these species are considered to be low.

To consider the catch associated with specific gear types and target species, the SAT examined four sources of data in the analysis: 1) California Recreational Fisheries Survey (CRFS), 2) CDFG commercial landing receipt data, 3) CDFG log book data from recreational Commercial Passenger Fishing Vessels (CPFVs), and, where adequate scientific information was lacking, 4) input from stakeholders familiar with relevant species or fisheries.

The CRFS data, commercial landing receipt data, and CPFV log book data are all limited in their ability to accurately reflect 'bycatch' because information is reported at the trip level. Bycatch, in this document, means fish or other marine life that are taken (both landed and discarded) in a fishery but which are not the target of the fishery. ~~Fishers~~ Anglers may switch target species during a trip and retain a mixed species catch but this shift in effort to a different target species is not always reflected accurately by the sampling. For example, a~~ fisher~~n angler may report a trip as a salmon trip but, at some point, switch fishing effort to target halibut. Both salmon and halibut may have been retained, but at the trip level there is insufficient resolution in the data to determine if those halibut were caught incidentally while fishing for salmon, or were caught cleanly in a separate fishing event on the same trip. Nevertheless, the ecological impacts from that fishing trip include the removal of salmon and any other species that were either retained or discarded. Due to the inability of these data to accurately reflect 'bycatch,' the term 'associated catch' is used in reference to data where it can not be determined if the reported catch was incidental to fishing for the target species. Associated catch is defined in this document as the removal or mortality of species other than the declared target species and includes any organisms that are: 1) captured incidentally in a fishery whether they are discarded (either dead or alive), kept for personal use, or sold; or 2) captured as a secondary target species where it could not be determined if effort shifted to a secondary target species.

The CRFS data used in this analysis may provide a better estimate of associated catch than commercial landing receipt data because it includes both landed and discarded catch. However, the CRFS data used in this analysis only reflect sampled trips, and are not expanded for total effort. These data include both examined catch and catch that was not examined by a sampler but reported by anglers as discarded either dead or alive. Because not all discarded fish were weighed, CRFS data are reported as numbers of fish. Additional CRFS onboard observer data for the study region are provided in Appendix A. The CRFS onboard observer data highlight catch that was caught incidentally to a target species.

Commercial landing receipt data only provide data for species that were landed and brought to market. Discarded catch is not reported on landing receipts and was not available for this analysis. Thus, the commercial landing receipt data are likely to provide a reasonable estimate of associated catch only for marketable species that are legal to retain in conjunction with the primary target species. Again, commercial fishermen~~s~~ may switch target species during a trip and report those on a single landing receipt. For each trip in which a given species made up the largest proportion of the catch, those species and all other species reported on the same landing receipts using similar gear are represented as a percent of the landed catch. Ecological impacts may result from removal of all of the species considered here as 'associated catch'.

Log book data from CPFV recreational fishing trips in the study region are provided in Appendix A. These data report the number of landed and discarded target species as well as incidental catch and, in many cases, the depth where the majority of the catch was taken. However, in some cases it may be possible that a single target species was recorded for a trip where effort shifted to a secondary target species that was not recorded as a target. The data from those trips would be considered 'associated catch' rather than 'bycatch'.

Throughout this analysis, the associated catch for a fishery was only one consideration of the ecological consequences of that activity. As described above, in determining the level of protection to assign to an activity, the SAT considered both direct and indirect impacts, such as habitat disturbance or removal of individuals from the ecosystem, and the consequences those individuals may have on the ecosystem or community dynamics.

Levels of Protection

The levels of protection as they apply to the north central coast study region are presented below. For an MPA that allows multiple activities, the lowest level of protection for any allowed activity is assigned to that MPA. The SAT acknowledges that multiple uses within an MPA may have cumulative impacts on the ecosystem that exceed those of the individual activities. Such cumulative impacts are difficult to predict and the SAT has not addressed this concern in assigning levels of protection.

Very High – no take of any kind allowed. This designation applies only to SMRs.

High – MPAs were assigned this level of protection if the SAT concluded that the allowed fishing activity has a very low associated-catch of resident species, causes minimal habitat damage, and is 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 abundance of these species is 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 associated catch), 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~~hook and line fishing for pelagic finfish[6] (including salmon) near the surface in deep-water (>50m depth), and pelagic seine fishing for coastal pelagic finfish[7]~~anchovies, sardines, and herring~~ in deep water (>50m depth).

Moderate-high – Fishing activities assigned to this level of protection cause minimal habitat damage, but have either more associated catch or a greater likelihood of ecosystem impacts than those in the high protection category. For example, MPAs that allow ~~salmon trolling~~hook and line fishing for pelagic finfish (including salmon) in waters shallower than 50m depth were assigned to this level of protection because: 1) The likelihood of increased associated catch of resident benthic species such as rockfish is higher; and 2) there is a potential impact to the MPA ecosystem if a pelagic predator is removed at this depth[8]~~[2]~~. Similarly, MPAs that allow 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 – Fishing activities assigned to this level of protection have higher associated catches of resident species or a greater likelihood of ecosystem impacts than those assigned to the mod-high category. Examples of fishing activities that received a moderate level of protection include hook and line fishing for halibut and other flatfish, diving for abalone, shore-based fishing with hook and line gear in larger MPAs, and hand harvest of giant kelp.[8]

Moderate-low – Fishing activities assigned to this level of protection either directly target resident species, have significant associated catch of resident species, or target species

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[6] Pelagic finfish: 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.

[7] Coastal pelagic finfish: northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasi*), jack mackerel (*Trachurus symmetricus*), Pacific mackerel (*Scomber japonicus*), and Pacific sardine (*Sardinops sagax*).

[8] 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.

whose removal is expected to have an impact on the resident ecosystem. Examples of fishing activities that received a low-mod level of protection include harvest of urchin, lingcod, cabezon, greenling, rockfish, and surfperches.

Low – Only fishing activities that cause alter habitat destruction were assigned to this category. Harvest of bull kelp, mussels, and other habitat-forming organisms received a low level of protection, as did trawl fishing, and mechanical harvest of giant kelp and .mariculture.

Table 2. Level of protection and the activities associated with levels of protection in the MLPA North Central Coast Study Region

	Level of Protection	MPA Types	Activities Associated with this Protection Level
	Very high	SMR	No take
	High	SMCA	In water depth > 50m: pelagic finfish[9] by hook and line (salmon by troll only); coastal pelagic finfish[10] by seine salmon (troll hook and line (H&L) in water with bottom depth greater than 50m), coastal pelagic finfish (sardine, anchovy, and herring) Pelagic finfish[4511] by hook and line, salmon by troll only in water with bottom depth greater than 50m (salmon by troll only),; coastal pelagic finfish[s56] by seine in water with bottom depth greater than 50m in water with bottom depth greater than 50 m(pelagic seine)
	Moderate-high	SMCA	In water depth < 50m: pelagic finfish[9] by hook and line (salmon by troll only); coastal pelagic finfish[10] by seine; Dungeness crab (traps/pots), squid (pelagic seine)salmon (troll H&L in water with bottom depth less than 50m), Dungeness crab (traps/pots), squid (pelagic seine)Pelagic finfish[443] by hook and line, salmon by troll only in water with bottom depth less than 50m (salmon by troll only);, coastal pelagic finfish[s55] by seine with bottom depth less than 50m;, Dungeness crab (traps/pots), squid (pelagic seine)

[9] Pelagic finfish: 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.

[10] Coastal pelagic finfish: northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasi*), jack mackerel (*Trachurus symmetricus*), Pacific mackerel (*Scomber japonicus*), and Pacific sardine (*Sardinops sagax*).

[11] Pelagic finfish: 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.

	Moderate	SMCA SMP	salmon (non-troll H&L); abalone (diving); halibut, white seabass, shore-based finfish, croaker, and flatfishes (H&L); smelt (H&L and hand/dip nets); clams (hand harvest); giant kelp (hand harvest)salmon (non-troll H&L),); abalone (diving),); halibut, white seabass, shore-based finfish, croaker, and flatfishes (H&L);, smelt (H&L and hand/dip nets),; clams (hand harvest),); giant kelp (hand harvest)
	Moderate-low	SMCA SMP	Urchin (diving),); lingcod, cabezon, greenling, rockfish, and other reef fish (H&L),); surfperches (H&L)
	Low	SMCA SMP	bull kelp and mussels (any method),); all trawling, ; giant kelp (mechanical harvest),; mariculture (anyexisting methods)

* The SAT feels that the allowance of salmon trolling at depths shallower than 50 meters in an MPA would result in a level of protection that ranges from high to moderate-high. For the purposes of evaluating MPA proposals a new category will be created that reflects this range where salmon trolling is the only allowed use.

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 sea floor or over rocky substrate in relatively shallow water, may increase the likelihood of inadvertently catching bottom species that are intended for protection within the MPA (e.g., lingcod, cabezon, rockfishes). Although depth- and habitat-related associated bycatch catch information for specific fisheries are not readily available, it is likely that associated bycatch catch is highest 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" (slowly drifting while fishing with weights to target deeper salmonsalmon at greater depths) may have a higher potential for associated bycatch catch than that of trolling.

Participants at a national conference[12] 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 depths where seafloor is <50m (27 fathoms,164 ft) and is lower in depths where seafloor is >50m. This information, along with associated-catch information provided by CDFG, contributed to SAT categorization of MPAs into levels of protection.

Various extractive activities and associated levels of protection are described below. Further supporting data can be found in Appendix A.

[12] 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.

Salmon trolling for pPelagic finfish[13] (including salmonhook and line and salmon by troll only):

Direct impacts – salmon areand other pelagic finfish are highly mobile pelagic species that are unlikely to benefit directly from MPAs constrained within state waters, unless those MPAs protect spawning aggregations or fishsalmon congregating near river mouths. Salmon trollingFishing for these species near the surface (including hook and line fishing for bait fish) causes little or no direct habitat damage as gear rarely touches the seafloor.

Salmon are the most commercially and recreationally significant pelagic finfish in the study region, so the SAT focused the analysis of impacts on the salmon fishery. Data on associated catch are available from CDFG for both recreational and commercial fisheries (Appendix A(1)). However, these data are not depth-specific and the recreational data do not distinguish trolling from mooching. In addition to these data, NOAA's National MPA Center 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 shallow troll gear in deep water (seafloor >50m) is sufficiently far from the seafloor that there is little or no bycatch of resident benthic species. In shallower water (seafloor <50m), however, the work group concluded that bycatch of resident species (e.g., rockfish species and lingcod) increases. The SAT is examineding the additional CPFV log book data with respect to the 50m depth guideline and has received additional input from RSG members indicating that incidental take of resident species is related to several variables, including water depth, habitat (rock versus sand), trolling speed, trolling depth and bait. Thus, the 50 m isobath may be adjusted with consideration of bottom habitat (i.e. proximity to rocky habitat).

Indirect impacts – Salmon and other pelagic finfish generally feed on mobile forage species such as anchovies, krill, crab larvae, herring, sardines, squid, and smeltplanktonic organisms.[14,15] As both pelagic finfishsalmon and their prey are highly mobile, MPAs are likely to have little impact on the local abundance of these species. Thus, the indirect ecosystem impacts of salmon pelagic finfish take are predicted to be low.

Level of protection:

High – if water depth in MPA is greater than 50m; and

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[13] Pelagic finfish: 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.

[14] Hunt, S.L., T.J. Mulligan, and K. Komori. 1999. Oceanic feeding habits of Chinook salmon, Onocorhynchus tshawytscha, off northern California. Fish. Bull. of Fish & Wild. Ser. 97: 717-721.

[15] Merkel, T.J. 1957. Food habits of the king salmon, Onocorhynchus tshawytscha (Walbaum), in the vicinity of San Francisco, California. Cal. Fish and Game 43: 249-270.

Mod-high – if water depth in MPA is less than 50m due to potential increase in associated catch of resident species

The 50m depth contour undulates along the coastline, thus it is difficult to create MPA boundaries that follow the 50m depth contour while also adhering to other guidelines such as ~~the Department's~~CDFG feasibility guidance to use straight lines of latitude and longitude. To apply the assignment of a level of protection based around the 50m depth contour the following criteria will be used:

1) The entire MPA "cluster" (see section 5.0 for description) will be considered together (both the inshore and offshore combination of SMR and SMCA or SMP~~ and SMR~~).
2) For a high level of protection no more than 15% of the total area in the cluster that is ~~that is less~~shallower than 50m or ~~no more than~~ 15% of ~~the total area for~~ either rock or soft-bottom habitats shallower than 50m may allow trolling for pelagic finfish (including salmon).
    a. This method applies only to the shallow (<50m) habitats that are of sufficient size to count towards the size and spacing guidelines (9 square miles, see section 5.0 for more details).
3) MPA clusters that allow trolling across more than 15% of the total <50m area or the shallow (<50m) rock or soft-bottom habitats will receive a moderate-high level of protection.

Salmon mooching (non-troll H&L):

Direct impacts – Salmon (*Oncorhynchus* spp) are highly mobile pelagic species that are unlikely to benefit directly from MPAs constrained within state waters. Salmon mooching gear can have contact with the bottom, but likely causes little habitat damage. Based on the slower speed that gear or bait travels through the water, there may be greater bycatch of benthic species including rockfish and lingcod which are likely to otherwise be protected by MPAs. Commercial catch data show that more than 20% of the fish landed on non-troll salmon trips are halibut. This likely reflects a switch in target species, not true bycatch. However, it is impossible to determine the true magnitude and composition of the incidental catch. Nevertheless, this indicates that on trips where salmon are commercially caught using non-trolling hook and line gear more than 20% of the catch associated with those trips and landed were not salmon.

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 the local abundance of these species. Thus, the indirect ecosystem impacts of salmon take are predicted to be low.

Level of protection:

Moderate – due to associated catch

Coastal pelagic~~s~~ finfish[16] (~~sardine, anchovy, herring, and mackerel~~pelagic seine gear):

[16] Coastal pelagic finfish: northern anchovy (*Engraulis mordax*), Pacific herring (*Clupea pallasi*), jack mackerel (*Trachurus symmetricus*), Pacific mackerel (*Scomber japonicus*), and Pacific sardine (*Sardinops sagax*).

Direct impacts – Sardine (*Sardinops sagax*), anchovy (*Engraulis mordax*), herring (*Clupea pallasi*), mackerel (*Scomber japonicus*), and jack mackerel (*Trachurus symmetricus*) are highly mobile pelagic species that are unlikely to benefit directly from MPAs constrained within state waters. Fishing for coastal pelagic ~~species (wetfish)~~finfish with pelagic seine or hook and line gear near the surface in deep water causes little or no direct habitat damage as gear never touches the seafloor. Landings of non-target species are low and comprised almost entirely of other highly-mobile schooling fish (Appendix A(6)), therefore the direct impacts of the fishing activity on the resident ecosystem are expected to be low in deep water. In shallow water, there is a greater potential for gear to contact the bottom and greater potential for capture of benthic-associated species such as schooling juvenile croaker. In shallow water, the direct impacts of seining for coastal pelagic finfish on the resident ecosystem are expected to be moderate.

Indirect impacts – Sardines, anchovies, herring, and mackerel feed on a variety of planktonic organisms. As these schooling species and their prey are highly mobile, MPAs are likely to have little impact on the local abundance of these species. Thus, the indirect ecosystem impacts of take of schooling coastal pelagics are predicted to be low.

Level of protection:
High – if water depth in MPA is greater than 50m; and
Mod-high – if water depth in MPA is less than 50m due to potential increase in associated catch of resident species
~~High~~

Squid (pelagic seine gear):
Direct impacts – Market squid (*Loligo opalescens*) are a highly mobile pelagic species that is unlikely to benefit directly from MPAs constrained within state waters unless those MPAs protect spawning aggregations. Fishing for squid with pelagic seine gear targets the species during the vulnerable spawning period, however, squid grow quickly and spawn only once making the population less vulnerable to spawning-targeted fishing than other species. Pelagic seine gear causes little or no direct habitat damage as gear ~~never~~rarely touches the seafloor. Landings of non-target species are low and comprised almost entirely of other highly-mobile schooling fish (Appendix A(7)), thus the direct impacts of the fishing activity on the resident ecosystem are expected to be low.

Indirect impacts – Although squid are a highly mobile pelagic species ~~(like other wetfish)~~ they form spawning aggregations and deposit large numbers of eggs near the bottom. Because of the importance of spawning squid and their eggs as prey in the nearshore ecosystem, the abundance of squid may have indirect ecosystem impacts on resident species.

Level of protection:
Mod-high

Surf smelt (hand nets from shore/hook and line):

Direct impacts – Surf smelt (*Hypomesus pretiosus*) are a highly mobile pelagic species that is unlikely to benefit directly [spawing aggs] from MPAs constrained within state waters only if those MPAs protect spawning aggregations. Fishing for smelt near shore with hook and line gear or hand nets targets this species during the vulnerable spawningFishing for smelt with hand nets from shore causes little or no direct habitat damage. period and has the potential for catch of a variety of benthic associated or resident species including croaker, and surfperch.Landings of non-target species are low as surf smelt are targeted in high-density spawning aggregations, t Because surf smelt and other species taken in association with the surf smelt fishery may otherwise be protected by MPAs, the direct impacts of the surf smelt fishery are expected to be moderatehus the direct impacts of the fishing activity on the resident ecosystem are expected to be low.

Indirect impacts – Although smelt are a highly mobile pelagic species they form spawning aggregations and deposit large numbers of eggs on sandy shores. Because of the importance of spawning surf smelt and their eggs as prey in the nearshore ecosystem, the abundance of surf smelt may have indirect ecosystem impacts on resident species.

Level of protection:
Moderate

Croaker (unspecified hook and line gear):

Direct impacts – White croaker (*Genyonemus lineatus*) are a moderately mobile species that may benefit directly from MPAs within state waters. Fishing for croaker with hook and line gear causes little or no direct habitat damage as gear rarely touches the seafloor. The recreational fishing database (CRFS) shows that a variety of non-target species may be landed in association with croaker fishing including sculpin, a variety of surfperch, and flatfish. Because croaker and other some species taken in association with the striped basscroaker fishery may otherwise be protected by MPAs, the direct impacts of the striped basscroaker fishery are expected to be moderate.

Indirect impacts – White croaker are important predator and prey in the shallow sandy benthic environment. Croaker feed on a variety of benthic invertebrates including crabs, shrimps, and worms, thus their abundance is likely to have indirect impacts on the benthic ecosystem. The mobility of croaker is not well known, however studies in southern California show that toxin concentrations in croaker are high close to the sources of those toxins, but concentrations in fish just 2-5 km distant are significantly lower[17]. These studies indicate that croaker may live relatively sedentary lives.

Level of protection:
Moderate

Abalone hand collection:

[17] Philips, C., M. Venkatesan, and T. Lin 2001. Linear alkybenzenes in muscle tissues of white croaker near a large ocean outfall in southern California, USA. Environmental Toxicology and Chemistry, 20(2):231-238.

Direct impacts – Abalone (*Haliotis* spp.)are relatively sedentary ~~species~~ organisms that are likely to benefit directly from MPAs within state waters, therefore removing abalone from an MPA could reduce the protection afforded them. Because divers harvest selectively, there is little or no catch of non-target species, with the exception of other invertebrates attached to the abalone themselves. However, divers sometimes accidentally remove sub-legal size individuals, which may kill the animal even though it is often immediately replaced. High numbers of scuba divers at local access sites has been shown to lead to localized habitat impacts[18] and the same may be true for free-divers. Divers may also cause behavioral responses in mobile species[19].

Indirect impacts – Abalone are important herbivores that feed 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 generally beyond free-diving depths, localized depletion of shallow adult spawning stocks within an MPA, combined with short larval dispersal distances, could reduce the local availability of young abalone as prey to small predators. In the case of the (currently closed) commercial abalone fishery, use of diving or "hookah" gear may reduce the deep water abalone refugia thereby increasing the potential for local depletion of adult spawning stocks.

Level of protection:
Moderate – due to indirect ecosystem effects

Urchin hand collection:

Direct impacts – Urchins (*Strongylocentrotus* spp.) are relatively sedentary species that are likely to benefit directly from MPAs within state waters, therefore removing urchins from an MPA could reduce the protection afforded them. 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 catch 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. Throughout their range, urchin populations can impact (decrease) kelp abundance, thereby altering the relative abundance of macroalgae in a kelp forest. Young abalone seek shelter beneath the spines of sea urchins and the density of abalone recruits can be greater in northern California MPAs where urchins are protected from take[20]. Although it is possible that urchin harvest could have the effect of increasing kelp forest habitat and the species associated with this habitat, it is also possible that altering the abundance of this important benthic species could have other unforeseen

[18] Schaeffer, T.N., M.S. Foster, M.E. Landrau, and R.K. Walder. 1999. Diver disturbance in kelp forests. Cal. Fish and Game 85: 170-176.

[19] Parsons, D.M. and D.B. Eggleston. 2006. Human and natural predators combine to alter behavior and reduce survival of Caribbean spiny lobster. J. Exp. Mar. Biol. Ecol. 334: 196-205.

[20] Rogers-Bennett, L. and J.S. Pearse. 2001. Indirect Benefits of Marine Protected Areas for Juvenile Abalone. Conservation Biolology. 15(3):642-7.

consequences for nearshore ecosystems. Regardless of whether ecosystem impacts caused by urchin harvest are perceived as good or bad, it is likely that changes in urchin abundance will have ecosystem-wide consequences.

Level of protection:
Moderate-low – due to indirect ecosystem effects

Clam hand digging:

Direct impacts – Clams are relatively sedentary species that are likely to benefit directly from MPAs within state waters, therefore removing clams from an MPA could reduce the protection afforded them. Clam digging causes significant disturbance to soft-bottom intertidal habitats and may also alter the behavior of local shorebirds and marine mammals. There are impacts 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 – due to habitat disturbance and impacts to non-target species

Halibut hook and line:

Direct impacts – California halibut (*Paralichthys californicus*) are a moderately mobile species that may benefit directly from MPAs within state waters. Halibut fishing with hook and line gear (including long-lines) involves bottom contact but causes little habitat disturbance. Associated catch 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 (Appendix A(3)). In the recreational fishery, 29% of reported catch on halibut trips was composed of non-target species, but it is possible that this high associated catch rate reflects switching of target species within a trip. In the commercial fishery, roughly 5% of species landed on halibut trips were non-target species. There is no information available on discarded commercial catch.

Indirect impacts – California halibut are an important predator in the coastal ecosystem, feeding on a variety of schooling fish and benthic organisms.[21] A change in local abundance of halibut may 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) California 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

[21] Cailliet, G.M., et al. 2000. Biological characteristics of nearshore fishes of California: a review of existing knowledge and proposed additional studies. Final Report to Pacific States Marine Fisheries Commission.

km within that same time period.[22,23] There is also information to suggest that larger halibut may be more mobile than small and anecdotal reports from fishermen indicate that California halibut in the study region engage in seasonal migration. Given available information on halibut movement it is unclear whether local populations and their effect on ecosystems within an MPA will change due to protection by the size of MPAs proposed in this process.

Level of protection:
Moderate – due to associated catch and the importance of halibut as a top predator

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

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

Halibut trawl:

Direct impacts – California halibut (*Paralichthys californicus*) are a moderately mobile species that may benefit directly from MPAs within state waters. Bottom trawling for halibut causes significant habitat disturbance and is associated with catch of a variety of species including other flatfishes and rockfish (Appendix A(3)). The SAT notes that there is currently no trawling allowed in state waters.

Indirect impacts – As stated above, California halibut are an important predator in the coastal ecosystem, feeding on a variety of schooling fish and benthic ~~organisms[9]~~organisms[10]. A change in local abundance of halibut may 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) California 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.[22,23] There is also information to suggest that larger halibut may be more mobile than small and anecdotal reports from fishermen indicate that California halibut in the study region engage in seasonal migration. Given available information on halibut movement it is unclear whether local populations and their effect on ecosystems within an MPA will change due to protection by the size of MPAs proposed in this process.

Level of protection:
Low

Crab traps:

Direct impacts – Dungeness crab (*Cancer magister*) are a moderately mobile species that may benefit directly from MPAs within state waters. Crab traps contact the bottom but cause only minor habitat disturbance. Catch associated with Dungeness crab trapping includes rock crabs, octopus, sea stars, and female Dungeness crabs in low numbers (Appendix A(4)). Although infrequent, sea otters have been known to become entangled in traps of various kinds including crab traps[24,25]; a leatherback sea turtle was entangled and drowned at Point Reyes in 1996; and a humpback whale was entangled in multiple trap lines outside of San Francisco Bay in 2005 [26]. An example of t~~T~~he effect of a spatial closure on the abundance [catch per unit effort (CPUE)] and size distribution of Dungeness crabs ~~was determined~~can be found in studies at the mouth of the Glacier Bay National Park fishing closure[27]. Both the abundance (CPUE) and size of legal-sized male crabs in this area increased relative to that within the Park prior to closure and outside the Park after the closure. Sample sites were located 15-20 km outside of, and 10-20 km inside of, the closure boundary (at the mouth of Glacier Bay).

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)[28] and it is unclear whether protection through MPAs of the sizes proposed would have an effect on local populations.

Level of protection:
Mod-high - due to ecosystem impacts

White seabass:

Direct impacts – White seabass (*Atractoscion nobilis*) are highly mobile pelagic species that are unlikely to benefit directly from MPAs constrained within state waters. 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 declared as a fishing target in the study region over the past 7 years, so it was impossible to assess associated catch specific to this study region. An analysis of recreational catch information (Appendix A(5))

[24] Newby, T. C. 1975. "A sea otter (*Enhydra lutris*) food dive record". Murrelet 56:19.
[25] Richardson, S. and Allen, H. 2000. "Draft Washington state recovery plan for the sea otter." Washington Department of Fish and Wildlife, Olympia, Washington. 67pp.

[26] Pers. Comm, Sarah Allen, Science Advisor, Point Reyes Natl. Seashore
[27] Taggart, S. J., T. C. Shirley, C.E. O'Clair and J. Mondragon. 2004. Dramatic increases in the relative abundance of large male Dungeness crabs, Cancer magister, following closure of commercial fishing in Glacier Bay, Alaska. Amer. Fish. Soc. Symp. 42:243-253.
[28] 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.

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 kelp bass (in southern California), which are not abundant in the study region. Moreover, it is not clear that these other species are incidental catch, but instead may be targeted when seabass catch is poor. Thus, information on overall associated catch, especially in northern California, is poor.

Indirect impacts – tagging studies of white seabass in the Santa Barbara Channel Islands indicate the species is highly mobile.[29] 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 - due to catch associated with fishing for white seabass

~~**Coastal pelagics (sSardine, aAnchovy, and hHerring, and mMackerel (pelagic seine gear):**~~

~~*Direct impacts* – Sardine (*Sardinops sagax*), anchovy (*Engraulis mordax*), and herring (*Clupea pallasi*), mackerel (*Scomber japonicus*), and jack mackerel (*Trachurus symmetricus*) are highly mobile pelagic species that are unlikely to benefit directly from MPAs constrained within state waters. Fishing for coastal pelagic species (wetfish) with pelagic seine or hook and line gear near the surface in deep water causes little or no direct habitat damage as gear never touches the seafloor. Landings of non-target species are low and comprised almost entirely of other highly-mobile schooling fish (Appendix A(6)), therefore the direct impacts of the fishing activity on the resident ecosystem are expected to be low.~~

~~*Indirect impacts* – Sardines, anchovies, and herring, and mackerel feed on a variety of planktonic organisms. As these schooling species and their prey are highly mobile, MPAs are likely to have little impact on the local abundance of these species. Thus, the indirect ecosystem impacts of take of schooling coastal pelagics are predicted to be low.~~

~~*Level of protection*:~~
~~High~~

~~**Squid (pelagic seine gear):**~~

~~*Direct impacts* – Squid Market squid (*Loligo opalescens*) are a highly mobile pelagic species that is unlikely to benefit directly from MPAs constrained within state waters. Fishing for squid with pelagic seine gear causes little or no direct habitat damage as gear never touches the seafloor. Landings of non-target species are low and comprised almost entirely of other highly-mobile schooling fish (Appendix A(7)), thus the direct impacts of the fishing activity on the resident ecosystem are expected to be low.~~

[29] Dr. James Lindholm, pers. comm. and unpublished data

~~*Indirect impacts* – Although squid are a highly mobile pelagic species (like other wetfish) they form spawning aggregations and deposit large numbers of eggs near the bottom. Because of the importance of spawning squid and their eggs as prey in the nearshore ecosystem, the abundance of squid may have indirect ecosystem impacts on resident species.~~

~~*Level of protection*:~~
~~Mod-high~~

~~**Surf smelt (hand nets from shore):**~~

~~*Direct impacts* – Surf smelt (*Hypomesus pretiosus*) are a highly mobile pelagic species that is unlikely to benefit directly from MPAs constrained within state waters. Fishing for smelt with hand nets from shore causes little or no direct habitat damage. Landings of non-target species are low as surf smelt are targeted in high-density spawning aggregations (Appendix A(XX)), thus the direct impacts of the fishing activity on the resident ecosystem are expected to be low.~~

~~*Indirect impacts* – Although smelt are a highly mobile pelagic species they form spawning aggregations and deposit large numbers of eggs on sandy shores. Because of the importance of spawning surf smelt and their eggs as prey in the nearshore ecosystem, the abundance of surf smelt may have indirect ecosystem impacts on resident species.~~

~~*Level of protection*:~~
~~Mod-high~~

Striped Bass (unspecified hook and line gear):

Direct impacts – Striped bass (*Morone saxatilis*) are a non-native and highly mobile pelagic species that is unlikely to benefit directly from MPAs constrained within state waters. Fishing for striped bass with hook and line gear causes little or no direct habitat damage as gear rarely touches the seafloor. The recreational fishing database (CRFS) shows that a variety of non-target species may be landed in association with striped bass fishing. Significantly, more than 7% of the catch is comprised of demersal sharks, skates and rays, a group of important benthic predators with generally low reproductive rates. However, the CRFS dataset includes data from San Francisco bay and it is likely that much of the shark, skate, and ray catch occurs in the bay, not in the study region. Because some species taken in association with the striped bass fishery may otherwise be protected by MPAs, the direct impacts of the striped bass fishery are expected to be moderate. More information can be found in Appendix A(8).

Indirect impacts –Because of the high mobility of striped bass, MPAs are likely to have little impact on their local abundance, and the indirect ecosystem impacts of striped bass take are predicted to be low. Incidental removal of other species (including skarks, skates, and rays), however, may have broader impacts on the benthic ecosystem.

Level of protection:
~~Under consideration, suggested:~~ Moderate

~~**Croaker (unspecified hook and line gear):**~~

~~*Direct impacts* – White croaker (*Genyonemus lineatus*) are a moderately mobile species that may benefit directly from MPAs within state waters. Fishing for croaker with hook and line gear causes little or no direct habitat damage as gear rarely touches the seafloor. The recreational fishing database (CRFS) shows that a variety of non-target species may be landed in association with croaker fishing including sculpin, a variety of surfperch, and flatfish (Appendix A(XX)). Because some species taken in association with the striped bass fishery may otherwise be protected by MPAs, the direct impacts of the striped bass fishery are expected to be moderate.~~

~~*Indirect impacts* – White croaker are important predator and prey in the shallow sandy benthic environment. Croaker feed on a variety of benthic invertebrates including crabs, shrimps, and worms, thus their abundance is likely to have indirect impacts on the benthic ecosystem. The mobility of croaker is not well known, however studies in southern California show that toxin concentrations in croaker are high close to the sources of those toxins, but concentrations in fish just 2-5 km distant are significantly lower[30]. These studies indicate that croaker may live relatively sedentary lives.~~

~~*Level of protection*:~~
~~Moderate~~

Shorefishing:

The ecological consequence of removing fish from shallow (< 10 m depth) waters using shore fishing techniques depends on habitat type (sandy versus rocky bottom), the species associated with these habitats, their ecological roles, their relative range of movement alongshore and across depth ranges, and how many of each of those species are removed by shore fishing.

The most commonly taken fish species taken by recreational anglers from the sandy shore include approximately 6 species of surfperches, 3 species of croakers, 2 species of sculpin, 7-9 species of flatfishes, 8 species of sharks, 7-9 species of skates and rays, stripped bass, and sturgeon (Appendix A(9)). All of these species move from shallower to deeper depths and back with the possible exception of barred, calico, and redtail surfperches, whose range may be more limited to the sandy surf zone.[31] For some species mentioned above, effects of extraction from sandy beach surf zones may be limited to that habitat, whereas effects on many others are likely to extend into adjacent deeper (less than 30 m depth) sand habitat offshore.[31]

[30] Philips, C., M. Venkatesan, and T. Lin 2001. Linear alkybenzenes in muscle tissues of white croaker near a large ocean outfall in southern California, USA. Environmental Toxicology and Chemistry, 20(2):231-238.
[31] Pers. comm. Milton Love, Associate Research Biologist, UC Santa Barbara

The most commonly taken fish species taken by recreational anglers from the rocky shore include approximately 9 species of perches, 17 species of rockfishes, 6 species of sculpins, 4 species of greenling, 5 species of gunnels and pricklebacks, and the monkeyface and wolf eels (Appendix A(9)). The horizontal range of movement of most of these rocky reef-associated species is limited and summarized in the MPA size guidelines section. The depth range of movement for most of these species ranges from shallows (5-10 m depth) to 30 m depth. Thus, extraction of reef-associated species from shallow waters likely influences species abundance on contiguous deeper rocky reefs to depths of 20-30 m.

Based on the potential level of fishing effort by an unrestricted recreational fishery and the diversity of species potentially extracted from a proposed MPA by shore fishing, the SAT recommends a level of protection of ~~(suggested moderate or moderate-low)~~moderate.

Level of protection:

Moderate – due to diversity of species extracted and their ecosystem interactions

Mariculture activities:

Mariculturists in Tomales Bay and Drake's Estero culture several bivalve species using four main methods. Impacts vary according to method, but a general list of potential impacts are:

- Bivalves and associated farming equipment can reduce eelgrass cover, change species distributions in eelgrass beds, ~~create anoxic conditions,~~ and alter sediment deposition patterns.
- Farming equipment can preempt space in the intertidal, altering shorebird foraging and distributions~~; marine mammal behavior could also be altered~~.
- Maintenance operations can trample sediments, damage eelgrass beds, and disturb shorebirds and perhaps marine mammals.
- Wooden culturing racks are commonly treated with a highly toxic preservative that can leach into the environment and accumulate in organisms and sediments, ~~though the industry recognizes this problem and~~ but the use of wooden racks reportedly is being eliminated in the north central coast study region (NCCSR).
- Bivalves and associated farming equipment provide large amounts of hard substrate habitat that may not be naturally present, altering ~~species~~ communities.
- Almost all cultured species are non-indigenous species, and ~~pas~~historic~~t~~ shipments of live animals from their native range have accidentally introduced other species to mariculture areas, some of which have had substantial impacts. Mariculture stock is no longer being imported from foreign sources, and disease is carefully monitored to reduce transmission. However, the potential exists for cultured species to provide a foundation for the continued establishment of non-native species that may be introduced via other vectors.
- Bivalves serve a critical ecosystem function by filtering bacteria and phytoplankton which accumulate nutrients and heavy metals from the water. Whether these changes are perceived to be positive or negative is a complex value judgment.

Additional information on mariculture in the MLPA North Central Coast Study Region is provided in Appendix A(10).

Level of protection:
Low – due to habitat impacts (for existing mariculture methods, new methods may require review and discussion)
~~*Level of protection: Low*~~

4.0 HABITAT REPRESENTATION ANALYSES (GOALS 1, 2, 3, 4 AND 6)

Summary of Guidelines: Habitat Representation Analyses

In evaluating habitat representation the SAT considers:

- A habitat to be "present" within an MPA if that MPA contains enough habitat to capture 90% of the local biodiversity (this differs by habitat, see Table 3).
- The degree of habitat representation proposed within each of the 3 defined SAT subregions in the North Central Coast Study Region (North, South, and Farallons).
- In the north central coast region, habitats deeper than 100m are generally not available and therefore do not need to be represented.

The Marine Life Protection Act provides guidance that each bioregion should encompass a variety of marine habitat types and communities, across a range of depths and environmental conditions, and that similar habitats should be replicated, to the extent possible, in more than one state marine reserve (SMR). Similarly, the Master Plan states that ~~According to the Master Plan,~~ 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. In addition the Master Plan states that 'key' marine habitats should be replicated in multiple MPAs with 3-5 MPAs containing each habitat type in the biogeographic region. Thus, for the purposes of habitat representation, habitat replication is expressed within the biogeographic region (Point Conception to Oregon) and thus includes habitats replicated within the MLPA Central Coast Study Region. Note that proposals following the size and spacing guidelines (see section 5.0) will result in some habitat replication.

Habitats identified in the Master Plan that exist in the study region include: sandy beach, rocky intertidal, estuary, shallow sand, deep sand, shallow rock, deep rock, kelp, and seagrass beds. In addition, the SAT has 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.

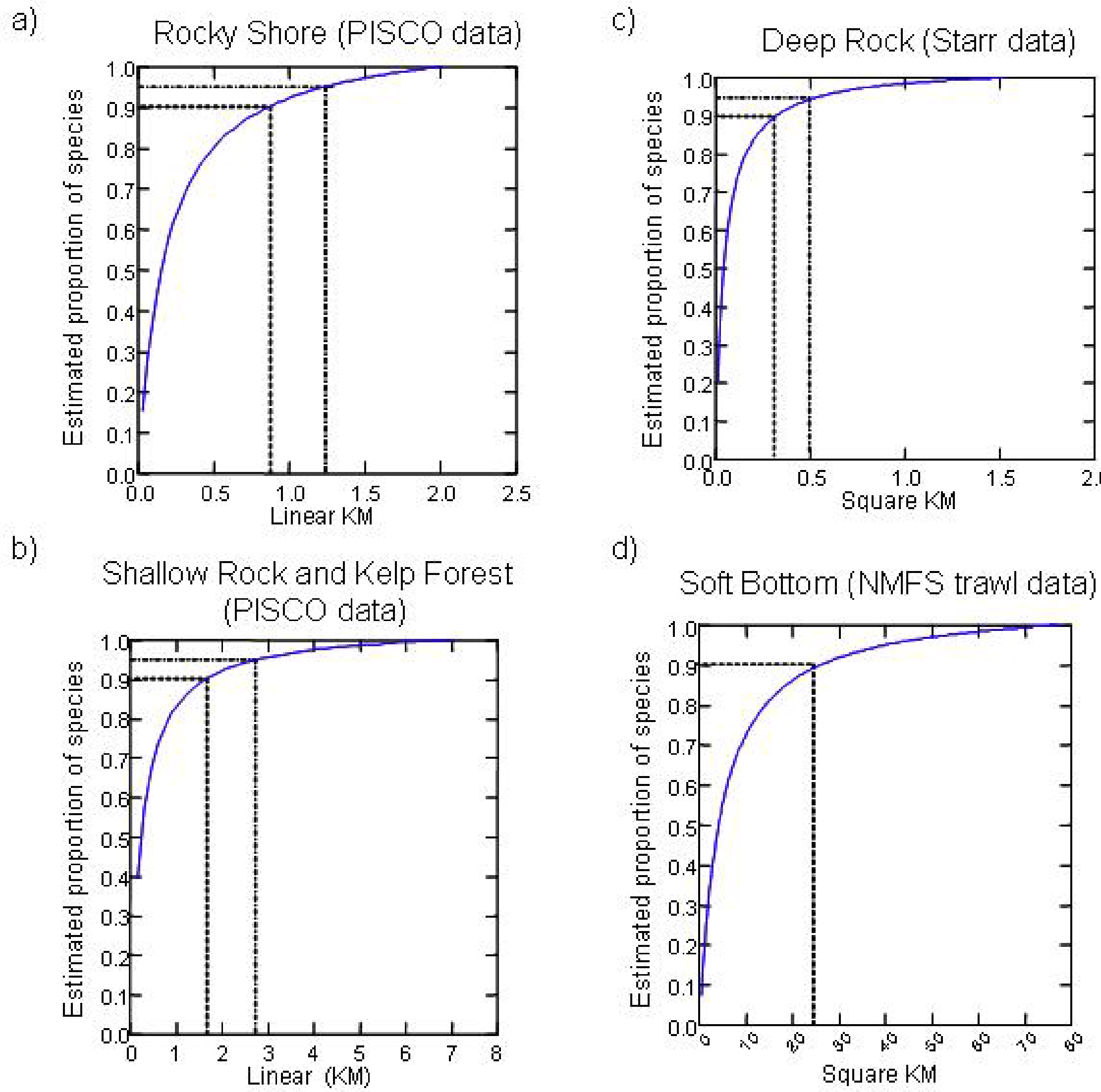
Habitat availability is assessed for each subregion as well as the entire study region. This provides the relative amount of available habitat in the study region and in each subregion as area or linear measurements. Habitats with linear measurements include sandy or gravel beaches, rocky intertidal, coastal marsh, tidal flats, and surfgrass. Habitats with area measurements include estuaries, eelgrass, kelp, and hard and soft bottom at depths of 0-30 m, 30-100 m, 100-200 m, and greater than 200 m. Due to a lack of nearshore substrate data, shallow hard and soft bottom habitats were also estimated as linear measurements by determining the habitat present along a 20 meter depth contour. MPAs in each proposal are assessed for eight habitats, which are considered most relevant for the north central coast study region: hard-bottom substrate 0-30m (approximated as described above using a linear measurement), hard-bottom substrate 30-100m, soft-bottom substrate 0-30m (approximated as described above using a linear measurement), soft-bottom substrate 30-100m, kelp, estuary, sandy beach, and rocky shores.

Replication of habitats in MPAs address goals 1, 2, 3, 4 and 6 of the MLPA as well as other requirements and guidance in the Act, including habitat replication within SMRs. Evaluations of habitat replication include the number of replicates in SMRs, and also the replication of habitats in state marine conservation areas and state marine parks at the various levels of protection. 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.

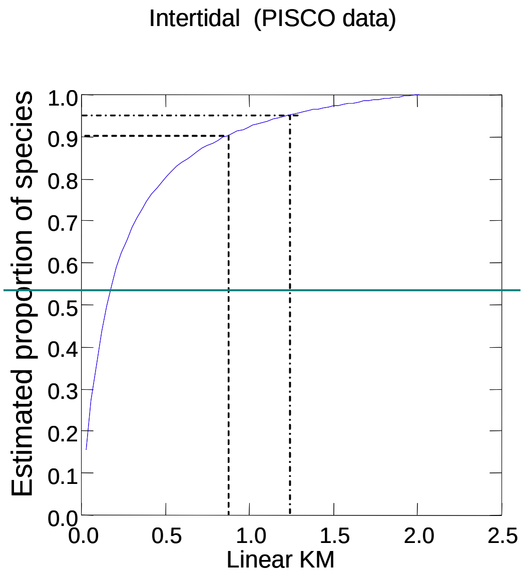
Guidance in the Master Plan requires that habitat be replicated in three to five MPAs in the biogeographic region. However, spacing guidelines (see Section 5.0) may require greater replication of habitats. Benefits of MPAs are largely dependent on the habitat contained in them. An MPA that does not contain appropriate habitat for a particular species (e.g., kelp forest) provides no benefit to that species.

The SAT considered an MPA to include a specific habitat if the MPA encompassed a critical extent of the habitat. This critical extent was defined as an area sufficient to (1) encompass a high proportion of the species known to use the habitat (90%, see table 3) and, (2) sufficient abundance of such species to be resilient to movement and environmental perturbation. To determine the estimated area of habitat needed, the SAT 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 accumulation functions (including Michaelis-Menton) the SAT estimated the amount of area needed to encompass 90% of the biodiversity of each habitat (see figure~~s~~ 1~~ and 2~~). Table 3 indicates that value for six habitat types.

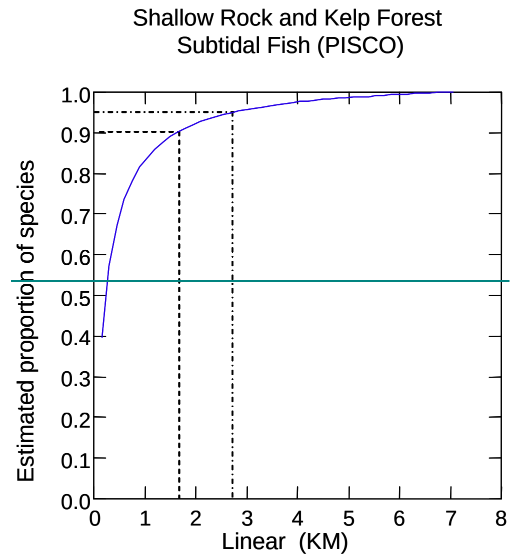
Figure 1. Estimated proportion of species per area of habitat



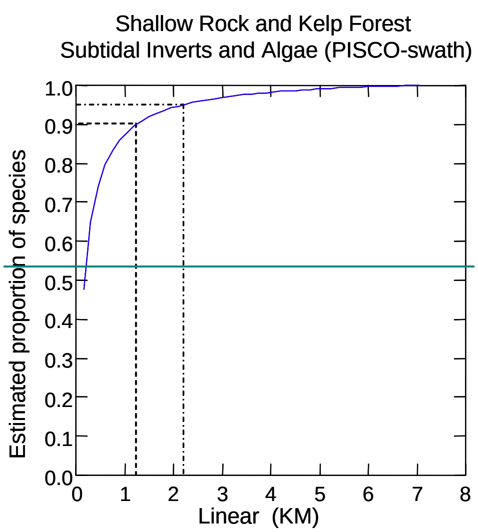
a)
Rocky Shore (PISCO data)
Estimated proportion of species
Linear KM
c)
Deep Rock (Starr data)
Estimated proportion of species
Square KM
b)
Shallow Rock and Kelp Forest (PISCO data)
Estimated proportion of species
Linear (KM)
d)
Soft Bottom (NMFS trawl data)
Estimated proportion of species
Square KM



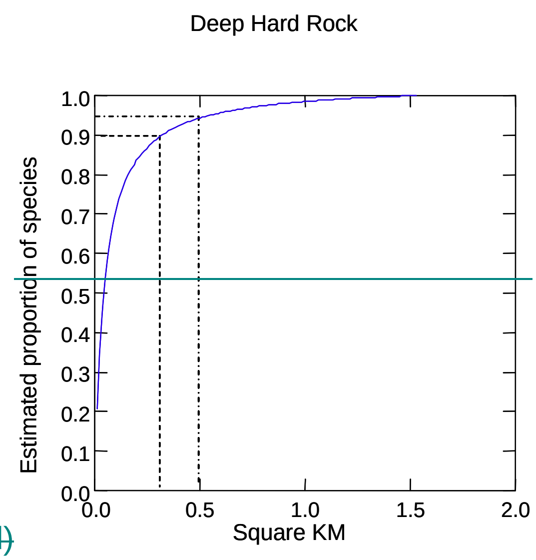
~~a)~~



~~b)~~



~~c)~~



~~d)~~

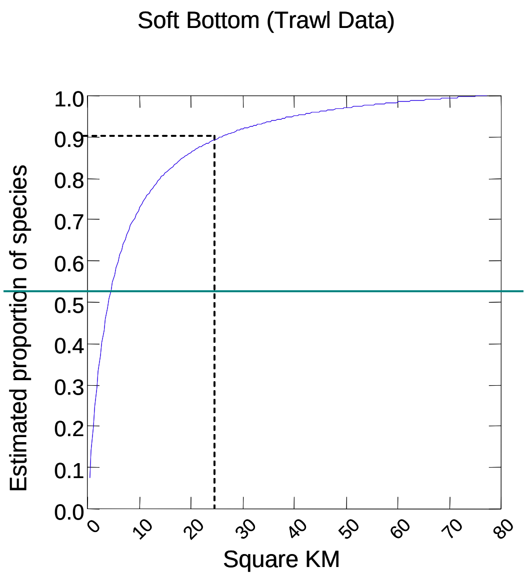
Table 3. Amount of habitat in an MPA necessary to encompass 90% of local biodiversity

Habitat	Representation needed to encompass 90% of biodiversity	Data Source
Rocky Intertidal	**~0.5 linear miles**	**PISCO Biodiversity**

Shallow Rocky Reefs/Kelp Forests (0-30 M)	**~1 linear miles**	**PISCO Subtidal**
Deep Rocky Reefs (30-100 M)	**~0.1 square miles**	**Starr surveys**
Sandy Habitat (30-100 M)	**~10 square miles**	**NMFS triennial trawl surveys 1977-2007**
Sandy Habitat (0-30 M)	**~1 linear miles**	**Based on shallow rocky reefs**
Sandy Beaches	**~ 1 linear mile**	
Estuary	**~0.12 square miles**	

For kelp, shallow sandy and shallow rocky habitats, protection of habitat must extend from shore to the 30 m contour. Survey data from the soft bottom (30-100m) habitat type indicates that a large area would need to be protected to ensure representative biodiversity (see Figure ~~2~~ 1d ~~below~~above). 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, the area of soft 0-30, and 30-100 meter habitat was combined and this combined area was used to assess the percent of biodiversity encompassed by a given MPA.

Figure 2. Estimated proportion of species per sq km of soft bottom habitat



The SAT recommends that wherever possible, a variety of estuarine habitats be protected in close proximity to one another to allow for the movement of species between habitats. Additionally, protection of habitats close to the mouth of an estuary is likely to have greater benefit for species that use both estuarine and open-coast habitats. Minimum areas for estuarine reserves were based upon biological surveys and the SAT estimated the amount of area needed to encompass 90% of the biodiversity in an estuarine ecosystem. The analysis showed that 30 hectares (0.12 sq mi) is sufficient area to capture 90 % of the species across the three main estuarine habitats: eelgrass, tidal flats, and coastal marsh. In order for habitats within an estuary (eelgrass, tidal flats, coastal marsh) to be considered present, a minimum of 10 hectares (0.04 sq mi) of the habitat must be included within an MPA.

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

Soft bottom (0-30m) – the species that are unique to this habitat mainly inhabit the surf zone, therefore the linear extent of shallow soft bottom was used 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 the % of biodiversity was assessed using the area/biodiversity relationship derived from 0-30m rocky reefs (1.0 linear mi = 90% biodiversity). To be considered present this habitat must also extend to the 30 m contour.

Sandy beaches – no data were available to make a scientific assessment of the relationship between beach length and biodiversity. The SAT 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 north central coast 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. ~~The SAT did not evaluate representation or spacing of kelp habitat in MPAs.~~ In places where kelp does appear on CDFG maps, the SAT ~~recommends calculating~~ 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 is present in a given MPA. To be considered present this habitat should also extend to the 30 m depth contour.

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. The SAT assessed the percent biodiversity using the area/biodiversity relationship from the rocky intertidal (0.5 linear mi = 90% biodiversity)

~~**Upwelling** - for the upwelling center habitat category, the SAT 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.~~

5.0 SIZE AND SPACING (GOALS 2 AND 6)

Summary of Guidelines: Size and Spacing Analyses

Size and spacing guidelines were developed to provide for the persistence of important bottom-dwelling fish and invertebrate groups within MPAs and their dispersal among MPAs and to promote connectivity in the network (Goals 2 and 6).

In evaluating the size of MPAs, the SAT~~ considers~~:

- Considers w~~W~~hether MPAs cover an alongshore span of at least 3-6 miles (preferably 6-12 miles) to protect the neighborhood size of adult species, as recommended in science guidelines of the Master Plan
- Considers w~~W~~hether MPAs extend offshore to deep waters, as recommended in the Master Plan science guidelines. The SAT has determined that MPAs that extend to the state water boundary, three miles offshore, best meet this guidance*.*

The SAT makes operational the Master Plan guidance above by using a minimum size threshold of 9 square miles (3 miles alongshore and 3 miles offshore) to evaluate MPAs with regard to goals 2 and 6 of the MLPA. (No MPA that is smaller than 9 square miles could meet both the alongshore and onshore-offshore size guidelines mentioned above.)

In evaluating the spacing of MPAs, the SAT~~ considers~~:

- Considers w~~W~~hether an MPA has sufficient habitat present (see Table 3 above), is of sufficient size (minimum cluster size of 9 square miles), and has at least moderate-high protection level to count toward the spacing analysis.
- Combines a~~A~~djacent MPAs together as a "cluster~~.~~" as long as each has a protection level of moderate-high or higher and are intended by stakeholders to contribute toward population and network goals (goals 2 and 6).
- Determines w~~W~~hether similar habitats within MPAs are spaced within 31-62 miles of one another, as recommended in the Master Plan science guidelines. The SAT has made operational this guidance by considering the distance between MPAs that contain each of the key habitats.~~ The spacing analysis is done separately for each habitat.~~Each habitat is analyzed separately in the spacing analysis.

The spacing analysis is conducted ~~separately for each habitat and~~ with a focus on MPAs at three different levels of protection: at least "moderate-high" protection; at least "high" protection; and, finally, only MPAs with "very high" levels of protection. For example, in the "high" level of protection spacing analysis, only MPAs of at least "high" level of protection are considered (i.e. MPAs with "high" and "very high" levels of protection).

Guidance on spacing found in the Master Plan states:

- "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[32,33,34] 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[35,36,37] and advances in modeling of larval transport[38,39]. 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.

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 analysis was conducted by measuring the distance between habitats in MPA "clusters", or group of MPAs, that meet the minimum SAT size guidelines (see below). Additionally, the spacing analysis was conducted for the three highest levels of protection, very high, high, and moderately high. Thus, in order for an MPA cluster to be counted for spacing for any given habitat at a given protection level, three criteria need to be fulfilled:

1. The habitat must be considered "present" in the cluster (see below for detail).
2. The cluster must be of at least minimum SAT recommended size (9 sq mi).
3. All parts of the cluster must meet at least the desired SAT protection level (moderate-high, high, or very high).

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[32] Botsford, L.W., Hastings, A., and Gaines, S.D. 2001. Dependence of sustainability on the configuration of marine reserves and larval dispersal distance. Ecology Letters 4: 144-150.

[33] Gaines, S. D., B. Gaylord, and J. Largier. 2003. Avoiding current oversights in marine reserve design. Ecological Applications. 13:S32-46

[34] Gaylord, B., S. D. Gaines, D. A. Siegel, M. H. Carr. 2005. Consequences of population structure and life history for fisheries yields using marine reserves. *Ecological Applications*. 15:2180-2191.

[35] Shanks, A.L., Grantham, B.A. & Carr, M.H. 2003. Propagule dispersal distance and the size and spacing of marine reserves. Ecological Applications, **13**, S159–S169.

[36] Kinlan, B. and S. D. Gaines. 2003. Propagule dispersal in marine and terrestrial environments: a community perspective. Ecology. 84:2007-2020.

[37] Kinlan, B. , S. D. Gaines, and S. Lester. 2005. Propagule dispersal and the scales of marine community process. Diversity and Distributions. 11:139-148.2005.

[38] Siegel, D., B. P. Kinlan, B. Gaylord and S. D. Gaines. 2003. Lagrangian descriptions of marine larval dispersion. Marine Ecology Progress Series. 260:83-96.

[39] Cowen, R. K., C. B. Paris, A. Srinivasan. 2006 Scaling of connectivity in marine populations. Science. 311:522-527.

The spacing of habitats in MPAs was compared to the maximum spacing guidelines found in the Master Plan*.*

The SAT guidance in regard to offshore islands, specifically the Farallon Islands, is that current MPA size guidelines should apply, however the spacing guidelines should 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 states:

- "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."
- "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 shows that adult movement varies greatly among California's marine species (Table 4~~11~~). A recent synthesis and analysis of movement information for west coast rocky reef fishes indicates that the range of movement for 75 percent of individuals of a species (the 75th percentile movement range) was 3 km or less for 85% of the 26 species for which data are available[40]. However, the majority of movement data are available for shallow dwelling reef fishes (depth < 30-50m). This synthesis also shows that movement distance was not correlated with days at liberty for eleven species for which data are available, indicating that movement of these species was unlikely a diffusive process (i.e. increasing range with time). The analysis also showed that movement distances for deeper dwelling species (n= 6, 75th percentile = 35 km) was significantly greater than for shallower dwelling species (n= 18, 75th percentile = 2 km).

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 guidelines focus on species in the first three movement categories in Table 4~~11~~. 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.

[40] Jan Freiwald, unpublished dissertation.

Therefore, MPAs that meet the preferable size guideline should protect more biological diversity than MPAs that just meet the less stringent minimum guideline.

Table 4. Scales of adult movement for California coastal marine species ***~~(This table is draft and needs final review by the authors)~~***

SAT Guidelines: Goals 2 and 6

0 – 1 km	1 – 10 km	10 – 100 km	100 – 1000 km	> 1000 km
Invertebrates abalone, mussel, octopus, sea star, snail, urchin **Rockfishes** black & yellow brown, copper, gopher, grass,* kelp, quillback, starry, treefish, vermillion **Other Fishes** cabezon, eels, greenlings, giant seabass, black, striped, and pile perch, pricklebacks	**Rockfishes** black, China, greenspotted,* olive, yelloweye **Other Fishes** walleye perch*	**Invertebrates** Dung. crab** **Rockfishes** blue, bocaccio, yellowtail **Other Fishes** Ca. halibut, lingcod, starry flounder **Birds** gulls, cormorants **Mammals** harbor seals, otter	**Rockfishes** canary **Fishes** anchovy, big skate, herring, Pacific halibut, sablefish,** salmonids,** sole spp., sturgeon **Birds** gulls** **Mammals** porpoises sea lions**	**Invertebrates** jumbo squid** **Fishes** sardine sharks** tunas** whiting** **Turtles**** **Birds** albatross** pelican** shearwater** shorebirds** terns** **Mammals** dolphins sea lions** whales**

* Studies of this species included fewer than 10 individuals
** Seasonal Migration

How Far do Adult Animals Move?

0 – 1 km	1 – 10 km	10 – 100 km	100 – 1000 km	> 1000 km
Invertebrates Abalone, Mussel, Octopus, Sea Star, Snail, Urchin **Rockfishes** Blk. & Yellow Brown, Copper, Grass,* Kelp, Olive, Quillback, Vermillion, Widow, Yelloweye **Other Fishes** Cabezon Greenling Surfperches Eels	**Rockfishes** Blue Bocaccio Gopher Greenspotted* **Other Fishes** walleye surfperch*	**Invertebrates** Dung. Crab** **Rockfishes** Black Yellowtail **Other Fishes** Lingcod, Anchovy, Herring, Sardine, Ca. Halibut **Birds** Gulls, Cormorants **Mammals** Harbor Seal, Otter	**Rockfishes** Canary **Fishes** Big Skate Pacific Halibut Sablefish** Salmonids** Sturgeon Whiting** **Birds** Gulls** **Mammals** Porpoises Sea Lions**	**Invertebrates** Jumbo Squid** **Fishes** Sharks** Tunas** **Turtles**** **Birds** Albatross** Pelican** Shearwater** Shorebirds** Terns** **Mammals** Dolphins Sea Lions** Whales**

* Studies of this species included fewer than 10 individuals
** Seasonal Migration

[EWF1]

~~* studies of this species had fewer than 10 individuals~~

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.

Therefore, *Size Guideline #2 states:* "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 and result in a minimum SAT size guideline of 9 sq mi.

Note that this rationale does not apply for estuarine habitats. Thus, spacing analyses for estuaries were conducted in a similar manner, but using a minimum threshold size of 0.12

square miles (30 hectares) instead of 9 square miles. The SAT has determined that this size will capture 90% of biodiversity for estuarine species.

Components of methodology of SAT analysis of MPAs relative to these size guidelines:

- The alongshore length and area of each proposed MPA was measured.
- When MPAs shared boundaries, the combined contiguous MPAs were considered as a single MPA cluster if both MPAs were intended by stakeholders to contribute toward population and network goals (goals 2 and 6).
- The level of protection in each component of an MPA cluster was considered.
- The size of all MPAs and MPA clusters was tabulated with respect to the Master Plan minimum and preferable guidelines.
- The habitats which were represented in MPA clusters that meet Master Plan minimum and preferable size guidelines were considered.

6.0 PROTECTION OF FORAGING, BREEDING AND REARING AREAS (GOAL 2)

Summary of Guidelines and Evaluation Methods: Marine Birds and Mammals

MPAs ~~can protect~~may benefit marine birds and mammals by protecting their forage base and by potentially reducing human disturbance to roosting sites, haul-outs, breeding colonies, and rookeries. To evaluate the protection afforded by proposed MPAs to birds and mammals the SAT:

- Identifies proposed MPAs or special closures [41] that contribute to protection of birds and mammals.
- Identifies focal species likely to benefit from MPAs and for which data are available.
- Analyzes the proportion (of total numbers of individuals) of breeding bird/mammal at colonies and rookeries potentially benefiting by proposed MPAs.
- Analyzes the proportion of nearby foraging areas protected by MPAs, defined by evaluating protection of buffered areas around colonies.

~~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~~ evaluation specifically focuses on pinnipeds (seals and sea lions) and birds~~birds~~, including seabirds, shorebirds, and waterfowl~~, and mammals.~~ [42]. Population in this evaluation refers to the number of animals that use a site for breeding or resting. Evaluations are focused on each of the three subregions to reflect the different concentrations of marine birds and mammals in each subregion (north of Point Reyes, south of Point Reyes, and the Farallon Islands). Evaluations include numbers of species (species diversity), numbers of individual birds or mammals, and percentages of subregional populations breeding within individual proposed MPAs and within all proposed MPAs. ~~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 subregions identified by the SAT (north of Point Reyes, south of Point Reyes and the Farallon Islands).~~

The SAT e~~E~~valuation for marine birds and mammals ~~will~~ focuses on:

[41] Special closures are not MPAs, but could restrict access to discrete areas to prevent human disturbance to colonies, rookeries, haul-outs, and roosts. Special closures ~~will be c~~may be included in ~~the next~~future rounds of the marine birds and mammals evaluations if included in MPA proposals. They would be evaluated with regard to marine birds mammals using ~~the same~~similar methods as used for MPAs.

[42] Cetaceans are not included in these analyses because they generally range widely at a scale larger than would benefit from coastal MPAs. ~~Otters are mostly associated with kelp beds, and in future analyses of proposals, the SAT could review the spatial extent of kelp beds and potential otter habitat.~~

1. Protection of seabird breeding colonies and pinniped rookeries based on population size, location and species composition

Thi~~e~~s analysis examines 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~~are based on the numbers of animals, ~~or in some cases~~and the proportion of the ~~study~~ subregion population, covered for species likely to benefit with a focus on species most likely to benefit. For specific colony protection, the SAT ~~evaluation will~~ examines whether the proposal ~~provided~~ provides for specific protections, such as no-entry zones or other spatial regulations that would reduce human disturbance and whether or not the MPA or Special Closure ~~protects~~ affects significant numbers of animals. Special Closures would provide maximum benefit by ~~nearly eliminating~~minimizing disturbance caused by boats, irrespective of vessel type. MPAs that restrict fishing or other activities in waters surrounding colonies would provide less ~~of a~~ benefit than no-entry zones but likely would provide a benefit by reducing the numbers of boats approaching and lingering near colonies~~.s might be more appropriate~~. Possible benefits of reduced disturbance include increased bird/mammal productivity, colony/population size, and species diversity[43] [44].

Data used for these assessments ~~mainly would be~~comes from the bird colony count data and GIS layers provided by the NOAA Biogeographic Assessment for the Cordell Bank, Gulf of the Farallones, and Monterey Bay National Marine Sanctuaries, from statewide seabird surveys, from pinniped data compiled from Mark Lowry on NOAA-fisheries and Sarah Allen of the NPS ~~and already~~ contained in the NOAA-CDFG database, and ~~(the SAT is also working with NOAA staff to get updated information), and~~ other sources ~~when necessary~~. The SAT evaluates t~~T~~otal numbers of seabirds and pinnipeds, and the proportions of subregional (i.e., north or south of Pt. Reyes, Farallon Islands) breeding populations~~,~~ for each species, and for all species combined, ~~breeding~~ within each proposed MPA or Special Closure. [45] Special closure size varies by site, but usually ranges between 300 and 1000 ft.~~will be examined to evaluate to level of protection provided and which proposals provide the highest benefit. Level of benefit will then be categorized as: 1) High; 2) Medium; 3) Low; or 4) None. At the large and diverse South Farallon Islands colony, bird and mammal breeding areas 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 MPA and Special Closures would be evaluated based on these maps of distribution.~~

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[43] Carney, K.M. and W.J. Sydeman. 1999. A review of human disturbance effects on nesting colonial waterbirds. Waterbirds 22:68-79.

[44] Rojek, N.A., M.W. Parker, H.R. Carter, and G.J. McChesney. 2007. Aircraft and vessel disturbances to Common Murres *Uria aalge* at breeding colonies in central California, 1997–1999. Marine Ornithology 35: 67–75.

[45] At the large and diverse South Farallon Islands colony, bird and mammal breeding areas 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 MPA and Special Closures ~~would be~~is evaluated based on these maps of distribution.

~~For sea otters, the SAT will utilize data from annual statewide surveys to overlay otter densities and proposed MPAs. Since the otter population has been expanding northward, the SAT 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. Marine b~~B~~ird and mammal resting (roost/haulout/raft) locations based on population size, location and species composition

Many marine birds~~seabirds~~ and pinnipeds require areas close to foraging locations where they can safely come to shore to rest, sleep, dry (i.e., cormorants, pelicans), or molt (some pinnipeds). Frequent disturbance at resting sites results in high levels of energy expenditure that can lead to poor body condition and/or cause animals to abandon the area.[43]

The methods the SAT uses to a~~A~~ssess~~ment of~~ roosting areas and~~or~~ haulout sites ~~will be done using similar methods as~~ are similar to those used for colonies/rookeries. For seabirds, the SAT uses data on major Brown Pelican roosts, which ~~will be utilized and~~ also ~~will~~ serve as a surrogate for other species, unless other specific data are available. For pelicans, major roosts have been categorized as those typically containing: 1) 100-500 birds; 2) 500-1,000 birds; and 3) > 1,000 birds. For pinnipeds, total numbers and the proportions of subregional populations for each species and for all species combined are evaluated.
~~within each proposed MPA or Special Closure will be examined to evaluate to level of protection provided and which proposals provide the highest benefit. Level of benefit will then be categorized as: 1) high; 2) medium; 3) low; or 4) none.~~

3. Marine b~~B~~ird and mammal foraging concentrations based on population size, location and species composition

As upper trophic level predators, seabirds and marine mammals require an abundance of resources for survival and reproduction. With ~~high~~ life expectancies (>20 yrs), low annual productivity, and high site fidelity, these animals are subject to population level impacts from reduced prey supplies or disturbance at foraging areas. High levels of disturbance at foraging areas can cause increased energy expenditure leading to poor body condition; this can be especially detrimental for species with long migration routes that may not have sufficient energy reserves to complete migration. Thus, protection of important prey species and foraging areas could have benefits, especially to species with limited foraging distributions.

For breeding species, the SAT will focus on three seabird and one marine mammal species most likely to benefit based on limited foraging ranges. For birds, this analysis ~~will~~ focuses on the pelagic cormorant, Brandt's cormorant, and pigeon guillemot. For pinnipeds, this analysis ~~will~~ focuses on the harbor seal. These species mainly forage in nearshore waters within a few miles of colonies. However, other species are likely to benefit (e.g., double-crested cormorant, marbled murrelet, harbor porpoise, and Steller sea lion) ~~may also be added to evaluations on a case-by-case basis~~.

Evaluations of benefits to marine birds and mammals near colonies ~~will be~~is based on whether or not proposed regulations may benefit forage species (Table 5) or foraging habitats, how much foraging area will be protected near breeding areas, and how many animals stand to benefit. Zones extending three miles alongshore and to one mile offshore (the main foraging range of these species when breeding) from breeding colonies/rookeries ~~will be drawn to~~are used to examine the numbers of birds/mammals utilizing the area within the proposed MPA. In some cases, at-sea densities for certain species (e.g., Brandt's cormorant, common murre, harbor seal) ~~-~~plotted over proposed MPAs may be used as an additional evaluation tool.

For non-breeding birds (e.g., waterfowl, shorebirds), the SAT ~~will~~ evaluates whether proposed MPAs encompass important concentration areas and what proportion of estimated populations are encompassed within those areas. For waterfowl wintering in the coastal estuaries, the SAT ~~will~~ uses count data provided by the U.S. Fish and Wildlife Service from the annual winter survey (recently provided to MLPA). For each species likely to benefit (e.g., brant, scaup, scoter, bufflehead, goldeneye) and for all species, long-term averages within each estuary ~~will be~~are used.

Because there is no data of precise distribution within the estuaries, evaluations in these areas ~~will be~~are based on numbers counted and proportions of local populations within each estuary, and proportion of each estuary captured in the proposed MPA that contributes to bird protection. For outer coast non-breeding waterfowl, the SAT ~~will~~ focuses on species most likely to benefit: western/Clark's grebes; and surf scoter. For these, the SAT ~~will~~ utilizes a combination of bird density data from the NOAA Biogeographic Assessment and habitat. These species are most common nearshore over soft bottom habitats. ~~Because of the imprecision of density data, benefits to these species will be simply categorized (see below).~~

For migrant and wintering shorebirds, the SAT ~~are~~ is trying to get data provided from recent surveys. These data, if available, would be evaluated using the same methods as for estuarine waterfowl.

~~For all evaluations, the level of benefit to each species within each proposed MPA will be categorized as: 1) High; 2) Medium; 3) Low; or 4) None.~~

Table 5. Known important prey items of Brandt's cormorant, pelagic cormorant, pigeon guillemot, and harbor seal in north-central California. Most fish taken by seabirds are in the juvenile stage.[1]

Species	Fish	Preferred foraging habitat
Brandt's cormorant	**Fish** Short-belly rockfish *Sebastes jordani* Yellowtail rockfish *Sebastes flavidus* Other rockfish *Sebastes* spp. Pacific sandlance *Ammodytes hexapterus* Plainfin midshipman *Porichthys notatus*	Soft bottom

	Speckled sanddab *Citharichthys stigmaeus* *Hemilepidotus* spp. White seaperch *Phanerodon furcatus* Northern anchovy *Engraulis mordax* Pacific herring *Clupea pallasi* Pacific staghorn sculpin *Leptocottus armatus* *Hemilepidotus* spp. (Cottidae) Other sculpins (Cottidae) Pacific tomcod *Microgadus proximus* Northern Pacific hake *Merluccius productus* Shiner perch *Cymatogaster aggregata* Pacific tomcod *Microgadus proximus* Spotted cusk-eel *Chilara taylori* Butter sole *Isopsetta isolepis* Rex sole *Glyptocephalus zachirus* English sole *Parophrys vetulus* **Invertebrates** Market squid *Loligo opalescens*	
Pelagic cormorant	**Fish** Short-belly rockfish *Sebastes jordani* Yellowtail rockfish *Sebastes flavidus* Other rockfish *Sebastes* spp. Sculpins (Cottidae) *Coryphopterus nicholsii* *Chilara taylori* **Invertebrates** Mysid shrimp *Spirontocaris* sp.	Submerged reefs
Pigeon guillemot	**Fish** Rockfish *Sebastes* spp. Pacific sanddab *Citharichthys sordidus* Blennies (Clinidae) Sculpins (Cottidae) Gunnels (Pholidae) Spotted cusk-eel *Chilara taylori* **Invertebrates** Red octopus *Octopus rufescens*	Submerged reefs
Harbor seal	**Fish** Rockfish *Sebastes* spp. Pacific sandlance *Ammodytes hexapterus* Plainfin midshipman *Porichthys notatus* Speckled sanddab *Citharichthys stigmaeus* *Hemilepidotus* spp. Northern anchovy *Engraulis mordax* Pacific herring *Clupea pallasi* Pacific staghorn sculpin *Leptocottus armatus*	

	Hemilepidotus spp. (Cottidae) Other sculpins (Cottidae) Pacific tomcod *Microgadus proximus* Northern Pacific hake *Merluccius productus* Shiner perch *Cymatogaster aggregata* Spotted cusk-eel *Chilara taylori* Butter sole *Isopsetta isolepis* Rex sole *Glyptocephalus zachirus* English sole *Parophrys vetulus* Salmonid Lamprey Hagfish **Invertebrates** Mysid shrimp *Spirontocaris* spp. Market squid *Loligo opalescens*	

[1] Data on seabird prey items from Ainley et al. (1990) and PRBO Conservation Science (unpubl. data). Source for Table 5: Ainley, D.G., C.S. Strong, T.M. Penniman, and R.J. Boekelheide. 1990. The feeding ecology of Farallon seabirds. Pp. 51-127 in (D.G. Ainley and R.J. Boekelheide, eds.), Seabirds of the Farallon Islands: Ecology, Dynamics, and Structure of an Upwelling-system Community. Stanford University Press, Stanford, California. Data on harbor seal prey items from Harvey JT, Helm R, Morejohn G. (1995) Food habits of harbor seals inhabiting Elkhorn Slough, California. Calif. Fish and Game. 81:1-9.

7.0 RECREATIONAL, EDUCATIONAL AND STUDY OPPORTUNITIES (GOAL 3)

Summary of Guidelines and Evaluation Methods: Goal 3 Analyses

MLPA Initiative staff evaluate the potential recreational, educational, and study opportunities provided by each MPA proposal in terms of the MPAs' overall accessibility, proximity to educational institutions, inclusion of existing monitoring sites, and consideration of replication in design.

In evaluating the draft proposals Initiative staff considers:

- Access points within and near MPAs, including proximity to boat launches and ports. Proximity to MPAs that allow many uses versus MPAs that allow few uses may have different effects on different users.
- Inclusion of existing monitoring sites and close proximity to research institutions, which may increase study opportunities.
- Replication of habitats within MPAs, which may contribute to increasing research opportunities.

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*."

To complete the Goal 3 analysis, MLPA Initiative and CDFG staff used simple metrics and available data within geographic information systems (GIS) to evaluate North Central Coast Regional Stakeholder Group (NCCRSG) draft options for MPA arrays and draft external MPA proposals. Access is a key issue for recreational, education and study opportunities; the evaluation focused on proximity of MPAs to access points, boat launches and ports, and marine research institutions. The number of long-term monitoring sites inside MPAs and the replication of habitats within MPAs were also tabulated.

Evaluation of recreational opportunities focused on accessibility of different types of MPAs, specifically:

- *Number of access points within and near proposed MPAs.* This was determined by tabulating the number of access points inside or within 2 miles of a) proposed state marine reserves (SMRs) and high protection state marine conservation areas (SMCAs), and b) proposed moderate and low protection MPAs. Only shoreline MPAs were considered in the evaluation of access.
- *Distance of proposed MPAs to boat ramps/launches/ports*. This was determined by tabulating the number of MPAs within 0-5, 5-15, and 15-50 miles of a boat ramp, launch, or port (excluding major ports). 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 a major port (i.e. San Francisco, Bodega, or Half Moon Bay).

Evaluation of educational and study opportunities focused on:

- *Distance of proposed MPAs from major marine research institutions.* This was determined by tabulating the number of MPAs within 0-15 and 15-50 miles of major marine research institutions in the study region (i.e., Bodega Bay Marine Lab of University of California, Davis and Romberg Tiburon Center for Environmental Studies of San Francisco State University).
- *Number of established long term marine research monitoring sites*. This was determined by tabulating the number of sites monitored by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) within a) proposed SMRs and high protection SMCAs, and b) within proposed MPAs of all protection levels.
- *Replication of habitats within the study region.* Replication of twelve habitats within proposed MPAs was evaluated: sandy beaches, rocky shores, seagrass, kelp, hard substrate (0-30m), hard substrate (30-100m), soft substrate (0-30m), soft substrate (30-100m), and four estuarine habitats (estuaries, eelgrass, coastal marsh, and tidal flats). A habitat was considered to be present within an MPA if a threshold amount of that habitat was present, and the MPA met the minimum size guideline of 9 sq miles (a minimum size of 0.12 square miles was applied to estuarine habitats) based on the Science Advisory Team evaluation. Habitat replication was considered for a) proposed high protection MPAs (very high, high, and moderate- high) and b) for all proposed MPAs. Note that for Goal 3, habitat replication *within the study region* is summarized (as opposed to the replication analysis conducted for habitat representation, which include replication *within the biogeographic region* (Point Conception to the Oregon border)

8.0 COMMERICAL AND RECREATIONALFISHERY IMPACTS

Summary of Guidelines and Evaluation Methods: Fishery Impacts

While fishery impacts are not the focus of the MLPA, they may be considered in designing MPA networks. The evaluation of maximum potential recreational and commercial fishery impacts utilizes region-specific data collected by MLPA contractor, Ecotrust, on areas of importance. Potential impacts to the abalone fishery are based on landings data from CDFG.

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

- Organize impact analyses by port and/or fishery and summarize the impacts by total area or value affected within the study region or in total fishing grounds[46].
- Evaluate the impact of proposed MPAs to abalone index sites and abalone landings

Commercial and recreational fishing

In order to analyze the relative effects of the MPA proposals on commercial fisheries that are conducted in the waters in the North Central Coast Study Region (NCCSR), ~~staff from Ecotrust, contracted by the MLPA Initiative, use~~ data layers characterizing the spatial extent and relative stated importance of fishing grounds of eight commercial fisheries (i.e. California halibut, coastal pelagics, market squid, nearshore rockfish, deep nearshore rockfish, urchin, Dungeness crab and salmon) in the NCCSR are analyzed. This information was collected by Ecotrust (a contractor with the MLPA Initiative) 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.

In addition, ~~staff prepare~~ a similar assessment of the relative effects of the MPA proposals on recreational fisheries, which currently take place in NCCSR waters is prepared. In order to complete this analysis, ~~they use~~ data layers characterizing the spatial extent and relative stated importance of recreational fishing grounds for California halibut, Dungeness crab, salmon, rockfish/lingcod complex, and striped bass (pier\shore only) are used. Recreational ~~fishers~~ activities are also broken out by user group (i.e. commercial passenger fishing vessels, pier/shore based, kayak based and private vessels) and by sub-region (i.e. Region 1 - Ocean Beach in San Francisco County, Region 2 - San Francisco Bay access points to Point Reyes and Region 3 - Point Reyes north to Alder Creek). This information was collected ~~by Ecotrust~~ during interviews in the fall of 2007, using a stratified solicited sample of 101 recreational fishermen whose individual responses regarding the relative importance of ocean areas for each fishery (user group\target specie(s)\region) were standardized using a 100-point scale and normalized to the reported fishing grounds for each fishery.

Using the normalized data described above, staff 1) analyzes and evaluates the potential impacts on the commercial and recreational fishing grounds and 2) analyzes the

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

socioeconomic impacts on commercial fisheries in order to assess the relative effects of the draft MPA proposals. Results are reported at both the study region and port group levels for the commercial fisheries. Port groups have been defined as: Bodega Bay, Point Arena, Bolinas, San Francisco and Half Moon Bay. Recreational fishery results are reported by user group and sub-region.

The draft MPA proposals under review vary according to their spatial extent and the commercial and recreational 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" in evaluation documents) 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 therefore reporting includes the effects both in terms of total fishing grounds ("G" in evaluation documents) 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.

This analysis assumes that each of the MPA proposals 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.”

Each MPA is overlayed with each fishery considered in this study. MPAs are grouped according to level of protection, using the same levels of protection as defined in the Science Advisory Team (SAT) evaluations. In other words, for each MPA and protection level within each proposal, staff assess the commercial fisheries that would be affected are assessed.

Results are compiled by staff in a series of spreadsheets, summarizing the effects of the various MPA proposals on commercial fisheries, both in terms of the area affected and the relative value lost. The same method of analysis as developed in the Central Coast process are used (see Scholz et al., 2006)[47], creating a weighted surface that represents the stated importance of different areas for each fishery. More specifically, these stated importance values are multiplied by the proportion of in-study region landings (by port and by fishery). These estimates then feed into the socioeconomic impact analysis.

Additionally, the staff analysis considers the percentage of area and value affected within the fishing grounds which are constrained by existing fishery management areas closures and/or fishery exclusion zones (e.g. Rockfish Conservation Area). It evaluates and determines

[47] 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.

whether or not there are individuals who would be disproportionately affected (i.e., 100% or a larger portion of their grounds are inside a proposed MPA that would restrict fishing).

For the commercial fisheries staff also calculate the estimated maximum potential economic impact of each MPA proposal. To accomplish this, the maximum potential economic impact for each MPA proposal is estimated using methods similar to those utilized in the Central Coast process by Wilen and Abbott (2006)[48]. This analysis for the NCCSR, however, differs in a very important respect, that is, by having original survey data on fishermen operating costs collected through the interview process.

Also evaluated were the additional impacts to the commercial deeper nearshore and nearshore rockfish fisheries that potentially occur when considering the existing fishery management area closures and/or fishery exclusion zones; specifically the 2007 Rockfish Conservation Area Non-Trawl persistent closure (30 fm – 150 fm) and the closure between the shoreline and 10 fm around the Farallon Islands (Southeast Farallon Island, Middle Farallon Island, North Farallon Island, and Noon Day Rock). To evaluate the impacts to these fisheries with consideration for the existing closures, the fishing grounds that fall inside those areas were removed. The value associated with the removed area was then redistributed to the fishing grounds outside the closed areas proportional to the allocated weights, resulting in what could be considered the existing fishable areas. Using the same method described above, staff determines the change in value as a percentage, by the intersection of each MPA proposal with the total fishing grounds now constrained to areas not inside the closed areas.

The staff analysis also indicates if there are individual fishermen that would be disproportionately affected by any MPA proposal. For the purposes of this analysis, this includes the impacts on an individual's ex-vessel revenues both in terms of the percentage of revenues lost due to fishing grounds made inaccessible by an MPA proposal, and in terms of the dollar amount (in 2006 dollars) that this represents. To assess this impact staff conduct an analysis which removes the area of each proposed MPA from an individual fisherman's fishing grounds as determined from interviews. The individual's North Central Coast (NCC) ex-vessel revenue values and the area of the fishing grounds are summarized after the removal and percentages are calculated to show any potential losses. The "worst-case scenario" still applies in that individual fishermen are assumed not to adjust to different fishing grounds. For this analysis the potential impact is calculated for each fishery as well as for all fisheries.

The methods used to assess the impact to the recreational fisheries for each of the MPA proposals is identical to that used to assess the impact on commercial fisheries with one exception. The commercial fishery analysis assessed impacts by multiplying stated importance values from the interviews by the proportion of in-study region landings (both by landing port and by fishery), and more specifically, by ex-vessel values for those landings. In contrast, no weighting occurs in the calculation of recreational fishery impacts, but rather, the analysis is

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[48] 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)

done using only stated importance values from the interviews. No weighting occurs for the obvious reason that ex-vessel values do not exist for recreational fishery landings.

The percentage change in area for each of the recreational fisheries (both for user group and for sub-region) were determined by the intersection of each MPA proposal and the fishing grounds specific to that fishery. Each MPA within a proposal was classified by whether it would affect the fishery or not. If a fishery was affected by an MPA, the area and value were summarized and then divided by the total area and value for the entire fishing grounds ("G" in evaluation documents), as derived from interviews with fishermen, and the total study area ("SA" in evaluation documents).

Abalone

MPA proposals have the potential to impact the recreational abalone fishery and will be evaluated by MLPA staff for impacts to management and landings.

Data from abalone index sites, fishery dependent creel survey sites and coded landing sites are used to manage the abalone fishery. Index sites are fishery independent survey sites used to provide a relative index of abalone population trends over time. The fishery dependent creel survey sites are specific sites along the coast used to intercept abalone harvesters and collect abalone and harvest data. These data are used in conjunction with the coded landing sites in tracking and estimating abalone harvest. The coded landing sites are specific sites included on each abalone permit report card. Every abalone harvested must be recorded to the nearest coded landing site on the abalone permit report card. There are eight recreational abalone index sites statewide, five of which are located within north central coast study region. Additionally, there are eight creel survey sites in the study region, which date back to 1975. There are twenty eight coded abalone fishery sites in the north central coast region.

Index sites are comprised of high moderate use abalone fishery sites. As noted above population conditions at index sites are used as an indicator of stock status in the absence of broad-scale surveys across the entire fishery range. Further, index sites are long term survey sites and are used in setting total allowable catch for the fishery. The *Abalone Recovery and Management Plan* [49] provides detailed discussion of index sites and management needs. For this reason, an MPA proposed at one of these index sites could potentially affect~~s~~ the continued utility of that site to function as an indicator of stock status. For example, an MPA that prohibits the take of abalone at an index site that was once fished would affect the usefulness of those data to continue to provide an index of abundance for a fished state.

CDFG and MLPA staff evaluates draft MPA proposals relative to their potential impact to the use of index sites for management. Proposed MPAs that encompass an index site will be identified. Changes in the allowance or disallowance of recreational take of abalone at an index site within an MPA will be highlighted. Although index sites are represented as a point, actual survey locations may vary from year to year so where an MPA is situated next to an index site transect locations will be plotted. The percent of the area that is incorporated in a

[49] http://www.dfg.ca.gov/marine/armp/index.asp

MPA will be noted along with the proposed allowable take of abalone. MPAs that change the allowable take of abalone at an index site entirely will be identified.

Additionally, the impacts of MPA proposals on the recreational abalone fishery will be evaluated. Abalone landings are self reported each year through the abalone permit report cards. Abalone harvesters must report every abalone they land. Pre-designated landing sites are listed on the report cards and each abalone landed must be reported by "coding" the harvest to the nearest site. These sites are specific launches or coastal access points; it is possible that abalone may be harvested at locations other than the specific reported location. Nevertheless, the abalone permit report card system generates data that in turn provide a geographic distribution of abalone landings. Proposed MPAs that prohibit abalone harvest will be compared against the reported abalone landings. The percent of the total annual abalone landings will be reported for each MPA that prohibits the harvest of abalone and encompasses a coded landing location. Where a proposed MPA encompasses more than one coded landing location the combined landings will be provided as a percent of the total annual landings. This evaluation will provide an indication of the magnitude of the impact specific MPAs may have on the recreational abalone fishery.

9.0 WATER AND SEDIMENT QUALITY

While water and sediment quality are not subject to management under the MLPA, these factors may be important in designing MPA networks. Where water quality or sediment quality is significantly compromised, marine life may be affected. Effects can be on bioaccumulation, as well as population rate parameters (growth, reproduction, and mortality), influencing population levels and also the ecological community composition through a variety of interactions (e.g., decreased diversity, loss of sensitive species and abundance of tolerant species). Thus, it is recognized that habitat is altered where water quality or sediment quality is degraded.

In the design of MPA networks for the MLPA North Central Coast Study Region, there has been no organized attempt to assess water quality or sediment quality concerns and these factors have not been included in the evaluations of MPA proposals. However, the status of water quality in the NCCSR was presented, for information purposes, to the NCCRSG and BRTF. In general, the various proposals did not site MPAs at the mouth of San Francisco Bay, which is known to emit a variety of pollutants from watershed and other pollution sources within the bay. Many of the proposed MPAs were also located at existing Areas of Special Biological Significance.

Associated with runoff of contaminated waters, there are regions of coastal waters in which water quality and/or sediment quality is impaired. As water and sediment quality are not subject to management under the MLPA, these factors have not been assessed for the MLPA North Central Coast Study Region. Nevertheless, impaired waters or sediments represent habitats that have been changed and, in general, the capacity of these habitats has been reduced. Effects can be on population rate parameters (growth, reproduction, mortality), thus influencing population levels and also the ecological community through a variety of interactions, including potential undesirable changes to community structure and function.

APPENDIX A: SUPPORTING DATA FOR LEVELS OF PROTECTION

Appendix A(1): Salmon

Table A(1)- 1: Associated Catch 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	**2,605,461**	**99.58%**
other (<1% of catch)	10,994	0.42%
Total	2,616,455	

Caught on commercial trips targeting salmon w/ non-troll H&L gear (2000-2006)**	lbs of fish	% of Fish wt caught
salmon	**37,053**	**71.29%**
halibut	10,810	20.80%
rockfish	1,710	3.29%
reef spp.	1,197	2.30%
pelagic spp.	865	1.66%
other (<1% of catch)	342	0.66%
Total	51,977	

* Recreational data are from CRFS surveys and include ocean only catches for all of the Wine and San Francisco districts. The Wine district includes portions of Mendocino County outside of the study region but does not include Tomales Bay.

** Associated catch data for commercial fisheries includes data from the study region only for blocks that are contained within or intersect the state waters. Additionally these data include landed fish only and do not include any discarded catch.

Table A(1)- 2: Summary of CPFV Trips Observed in the NCCSR Using Trolling as the Fishing Mode, 2003 to 2006.

Depth Category Observed Depths	< 50 m 9.14 to 45.72 meters (30-150 feet)			> 50m 51.82 to 243.84 meters (170-800 feet)		
Species Caught	**Total # Observed**	**Total % Observed**	**% Trips Observed**	**Total # Observed**	**Total % Observed**	**% Trips Observed**
Chinook	810	82.82	100	1114	95.54	97.73
coho	24	2.45	15.38	40	3.43	34.09
Pacific mackerel	83	8.49	7.69	0	0.00	0
black rockfish	37	3.78	15.38	0	0.00	0
lingcod	10	1.02	5.77	0	0.00	0
striped bass	5	0.51	5.77	0	0.00	0
blue rockfish	4	0.41	5.77	0	0.00	0
thresher shark	3	0.31	1.92	0	0.00	0
spiny dogfish	2	0.20	1.92	3	0.26	4.55
jack mackerel	0	0.00	0	4	0.34	4.55
Pacific hake	0	0.00	0	2	0.17	2.27
Pacific sardine	0	0.00	0	2	0.17	2.27
steelhead trout	0	0.00	0	1	0.09	2.27
Total # Fish Caught	978			1166		
# of Trips Observed	52			44		

Data was queried from the CRFS database.
Trips were categorized by depths less than 50m and greater than 50m.

The California Recreational Fisheries Survey (CRFS) data in table A(1)-2 were collected using observers on commercial passenger fishing vessel (CPFV) trips taken in the MLPA North Central Coast Study Region (NCCSR) from 2003 to 2006. Data were queried from the CRFS database (extraction date: 12 December 2007).

Data utilized for this analysis included position fishing started and ended (latitude/ longitude), maximum and minimum water depths fished, fishing mode, and the species names and number caught. Only data occurring within the northern and southern bounds of the study region (not including San Francisco Bay) and with trolling as the fishing mode, were included in the analysis.

Observation trips were categorized as having occurred in less than 50 meters or greater than 50 meters of water; the species and number caught were summarized for the two depth categories. Trips with depths occurring in more than one category were not included in the analysis.

More information on the CRFS program and an outline of the protocols used to collect the data can be found on the CRFS website (http://www.dfg.ca.gov/marine/crfs.asp), which includes the CRFS Sampler Manual (http://www.dfg.ca.gov/marine/pdfs/crfs_samplermanual.pdf).

The summary in table A(1)-2 provides the total number and percent of each species caught and sampled by an onboard observer in the study region; it also provides the percent of trips in which a particular species was caught and sampled. These data were combined for the years from 2003 to 2006.

Table A(1) – 3: CPFV Logbook Data for Salmon Mooching

Mooching Only - Summary based on number of species KEPT

	Depth Under 50 m				
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	1284	86%	213	14%	1497
2002	3071	71%	1273	29%	4344
2003	106	56%	82	44%	188
2004	11585	95%	581	5%	12166
2005	1573	42%	2158	58%	3731
2006	152	41%	220	59%	372

	Depth 50 m and Over				
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	13	100%	0	0%	13
2002	1168	94%	78	6%	1246
2003	344	99%	3	1%	347
2004	1732	97%	45	3%	1777
2005	113	100%	0	0%	113
2006	245	100%	1	0%	246

	Depth Data Missing				
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	278	80%	69	20%	347
2002	670	98%	17	2%	687
2003	10	100%	0	0%	10
2004	1184	94%	73	6%	1257
2005	47	100%	0	0%	47
2006	0		0		0

Mooching Only - Summary based on number of species RELEASED

	Depth Under 50 m				
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	90	45%	111	55%	201
2002	80	15%	460	85%	540
2003	8	57%	6	43%	14
2004	1083	94%	68	6%	1151
2005	393	76%	123	24%	516
2006	14	16%	73	84%	87

	Depth 50 m and Over				
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	6	8%	66	92%	72
2002	169	98%	4	2%	173
2003	63	100%	0	0%	63
2004	158	78%	44	22%	202
2005	21	95%	1	5%	22
2006	66	47%	74	53%	140

	Depth Data Missing				
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	26	50%	26	50%	52
2002	38	100%	0	0%	38
2003	3	100%	0	0%	3
2004	30	45%	36	55%	66
2005	26	100%	0	0%	26
2006	0		0		0

The summary tables in Table A(1) – 3 include only trips that operated in the North Central Coast Study Region for which salmon was the sole target species. Only Chinook salmon were considered target species, other salmon species were considered non-salmon catch in this analysis.

Fishing Method: A small number of records indicate that more than one fishing method was used during a single trip. Thus, only trips that indicated either mooching as the sole fishing method were used in these summaries. Trips that used other fishing methods in combination to mooching (trolling, anchored, drifting, diving, light tackle) were excluded from this summary, since in these cases it was not possible to discern what method was in use when individuals were caught.

Depth: The Commercial Passenger Fishing Vessel Logbooks allow only one entry for depth per trip. Thus, it is unclear how well the provided depth data reflects depths at the specific location each individual was caught.

Crabs: Log books sometimes indicate that Dungeness crab, and in a very few cases, rock crabs are caught and reported with these data. The log books do not provide a gear option that is selective for crab. Often CPFV operators will fish for crab on the same day they mooch for salmon, these crab catches appear as if caught while moching Since this is clearly not the case these data are excluded from this summary.

Table A(1) – 4: CPFV Logbook Data for Salmon Trolling

Trolling Only - Summary based on number of species KEPT

Depth Under 50 m					
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	5438	89%	661	11%	6099
2002	8443	95%	489	5%	8932
2003	5301	91%	518	9%	5819
2004	15059	95%	814	5%	15873
2005	11420	83%	2270	17%	13690
2006	7118	59%	4998	41%	12116

Depth 50 m and Over					
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	3484	98%	86	2%	3570
2002	16064	99%	190	1%	16254
2003	14531	99%	131	1%	14662
2004	18183	100%	71	0%	18254

Trolling Only - Summary based on number of species RELEASED

Depth Under 50 m					
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	857	86%	134	14%	991
2002	618	82%	133	18%	751
2003	813	79%	222	21%	1035
2004	1679	79%	453	21%	2132
2005	5282	95%	261	5%	5543
2006	1990	47%	2265	53%	4255

Depth 50 m and Over					
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	3249	83%	678	17%	3927
2002	4153	89%	510	11%	4663
2003	5035	80%	1288	20%	6323
2004	7940	96%	358	4%	8298

2005	8576	99%	48	1%	8624
2006	10583	96%	397	4%	10980

2005	3942	84%	727	16%	4669
2006	3218	60%	2114	40%	5332

Depth Data Missing					
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	2849	92%	257	8%	3106
2002	6945	99%	36	1%	6981
2003	4432	99%	23	1%	4455
2004	228	100%	0	0%	228
2005	273	94%	18	6%	291
2006	204	100%	0	0%	204

Depth Data Missing					
Year	#Salmon (Chinook)	% Salmon	#Non-Salmon	% Non-Salmon	Total # Caught
2001	643	85%	116	15%	759
2002	884	75%	300	25%	1184
2003	1123	89%	144	11%	1267
2004	220	100%	0	0%	220
2005	228	89%	28	11%	256
2006	42	48%	46	52%	88

The summary tables in Table A(1) – 4 include only trips that operated in the North Central Coast Study Region for which salmon was the sole target species. Only Chinook salmon were considered target species, other salmon species were considered non-salmon catch in this analysis.

Fishing Method: A small number of records indicate that more than one fishing method was used during a single trip. Thus, only trips that indicated trolling as the sole fishing method were used in these summaries. Trips that used other fishing methods in combination to trolling (moching, anchored, drifting, diving, light tackle) were excluded from this summary, since in these cases it was not possible to discern what method was in use when individuals were caught.

Depth: The Commercial Passenger Fishing Vessel Logbooks allow only one entry for depth per trip. Thus, it is unclear how well the provided depth data reflects depths at the specific location each individual was caught.

Crabs: Log books sometimes indicate that Dungeness crab, and in a very few cases, rock crabs are caught and reported with these data. The log books do not provide a gear option that is selective for crab. Often CPFV operators will fish for crab on the same day they troll for salmon, these crab catches appear as if caught trolling. Since this is clearly not the case these data are excluded from this summary.

Table A(1) – 5: CPFV Logbook Data for Targeting Chinook and All Salmon

Trolling only based on number kept and released

Depth Under 50 m				Depth 50 m and Over				Data for all depths and no recorded depth			
	Chinook	other	% other		Chinook	other	% other		Chinook	other	% other
2001	6295	795	11%	2001	6733	764	10%	2001	16520	1932	10%
2002	9061	622	6%	2002	20217	700	3%	2002	37107	1658	4%
2003	6114	740	11%	2003	19566	1419	7%	2003	31235	2326	7%
2004	16738	1267	7%	2004	26123	429	2%	2004	43309	1696	4%
2005	16702	2531	13%	2005	12518	775	6%	2005	29721	3352	10%
2006	9108	7263	44%	2006	13801	2511	15%	2006	23155	9820	30%

Trolling only based on number kept and released

Depth Under 50 m				Depth 50 m and Over				Data for all depths and no recorded depth			
	all salmon	other	% other		all salmon	other	% other		all salmon	other	% other
2001	6337	753	11%	2001	7394	103	1%	2001	17306	1146	6%
2002	9138	545	6%	2002	20698	219	1%	2002	37965	800	2%
2003	6265	589	9%	2003	20804	181	1%	2003	32773	788	2%
2004	17091	914	5%	2004	26495	57	0%	2004	44034	971	2%
2005	16874	2359	12%	2005	13197	96	1%	2005	30600	2473	7%
2006	11158	5213	32%	2006	15903	409	3%	2006	27353	5622	17%

Figure A(1) – 1: Catch of Other Species While Trolling for Chinook

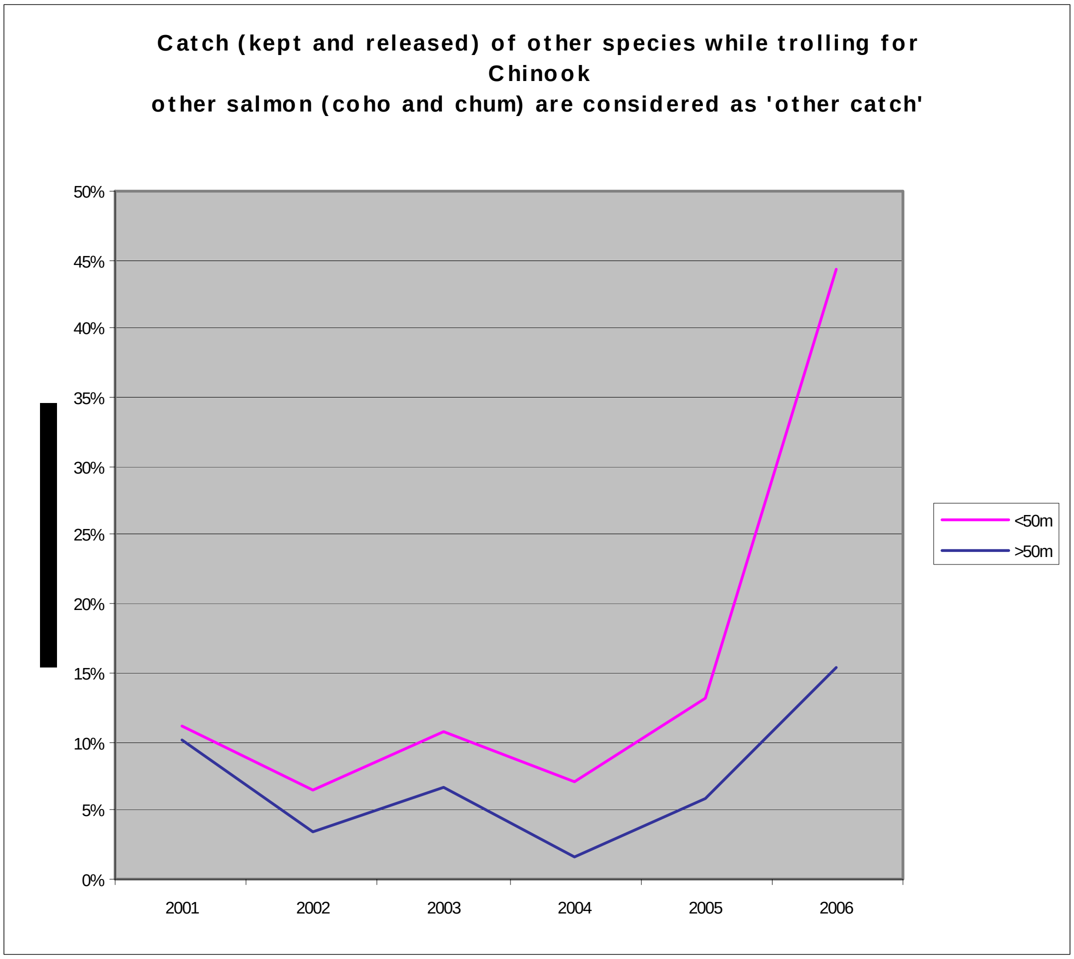
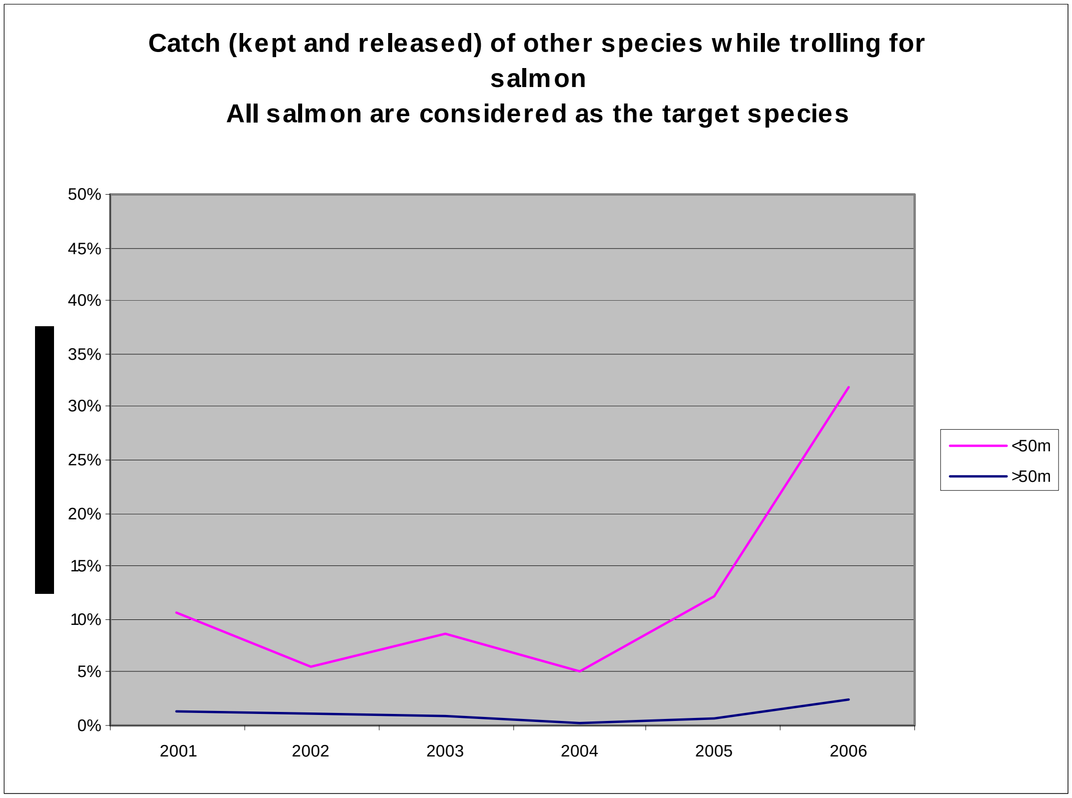


Figure A(1) – 2: Catch of Other Species When Trolling for Salmon



The summary provided in table A(1) – 5, figure A(1) – 1, and figure A(1) – 2 includes similar data conditions for fishing method, depths, and crab as the other data in these summaries These data include 1) Chinook as the only target species, with other salmon such as coho or chum considered as 'other catch' and 2) all salmon combined as the target species. This summary combines kept and released fish. Note that if you consider only kept fish the % of other catch drops substantially. A large portion of the 'other catch' in some years was coho salmon (the take of coho salmon is prohibited) thus inclusion of released fish increases the percent of 'other catch' in this analysis.

Table A(1) – 6: CPFV Logbook Data for Ratios of Non-Salmon to Salmon Catch

Mooching only; Ratios based on KEPT catch on voyages targeting salmon only

Year	*<1%*	*1% to <5%*	*5% to <10%*	*10% to <50%*	*50% to <100%*	*100% and Over*	*Grand Total*
2001	152	1	3	23	10	15	204
2002	271	2	12	24	4	24	337
2003	38	1		1		8	48

2004	451	30	17	20	5	10	533
2005	98		8	23	6	41	176
2006	19				1	4	24

Trolling only; Ratios based on KEPT catch on voyages targeting salmon only

Year	<1%	1% to <5%	5% to <10%	10% to <50%	50% to <100%	100% and Over	Grand Total
2001	987	3	20	49	15	35	1109
2002	1371	5	25	50	12	30	1495
2003	1439	4	17	55	23	43	1581
2004	1412	30	20	32	15	26	1535
2005	1266	9	29	56	23	93	1476
2006	1117	4	8	28	13	71	1241

Figure A(1) – 3: Ratio of Non-Salmon to Salmon Catch for Mooching

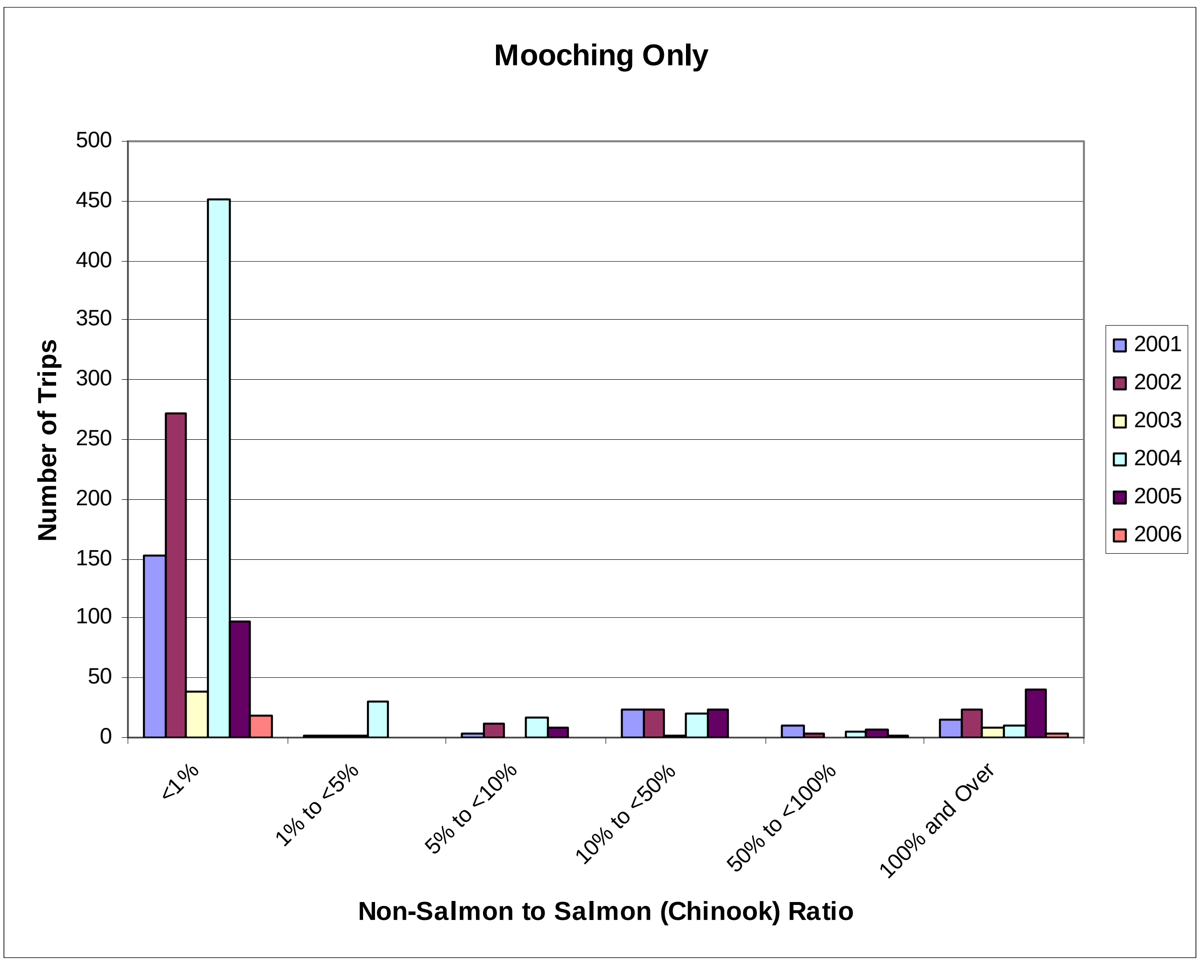
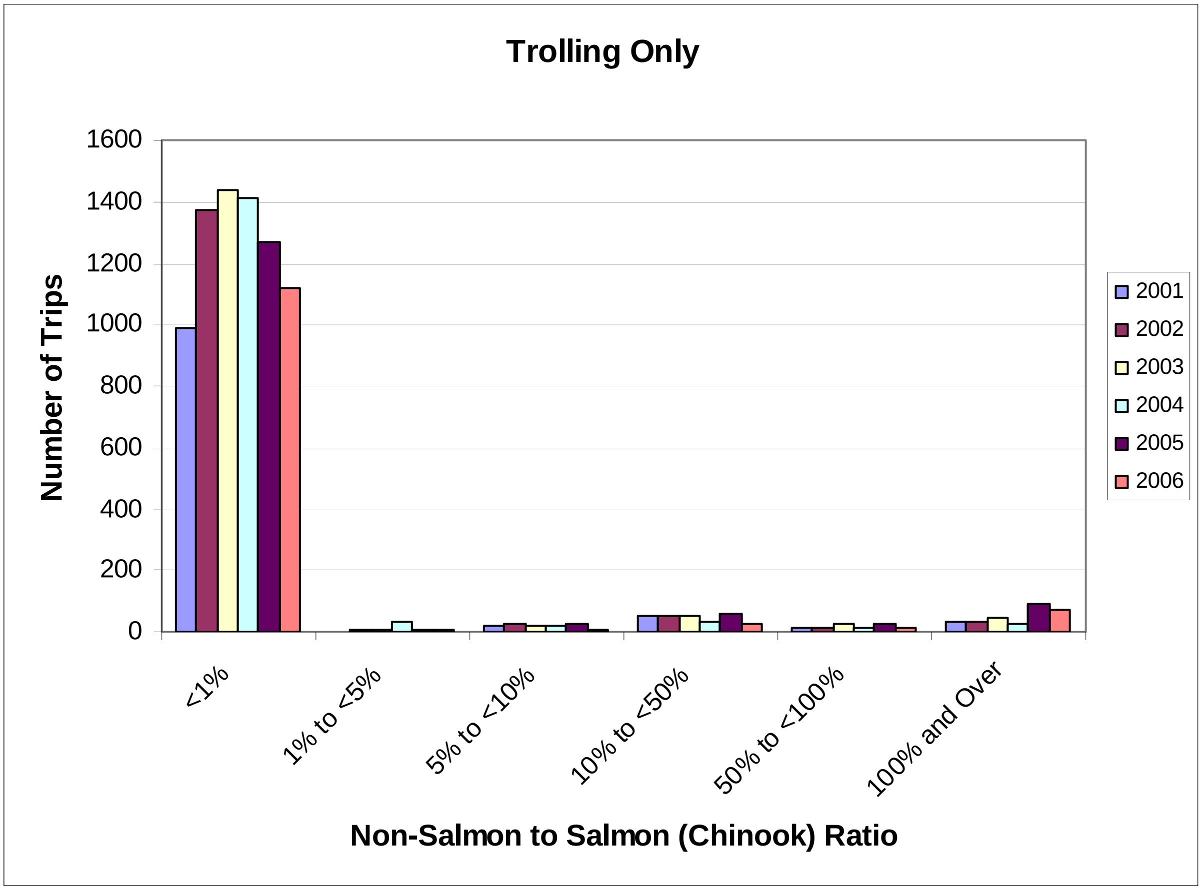


Figure A(1) – 4: Ratio of Non-Salmon to Salmon Catch for Trolling



The summaries provided in Table A(1) – 6, Figure A(1) – 3, and Figure A(1) - 4 include only trips that operated in the North Central Coast Region for which salmon was the sole target species. The summary provided here represents the number of trips each year in which the only target species reported in the log books was salmon taken either only by trolling or only by mooching. Only Chinook salmon were considered target species, other salmon species were considered non-salmon catch in this analysis. The ratio of non-salmon to salmon is represented by a percentage bin. Trips that fell in the bin 100% and over are trips where more non-salmon were kept than salmon.

Fishing Method: A small number of records indicate that more than one fishing method was used during a single trip. Thus, only trips which indicated that trolling or mooching was the sole fishing method were used in these summaries. Trips that used other fishing methods in combination to trolling or mooching (anchored, drifting, diving, light tackle) were excluded from this summary, since in these cases it was not possible to discern what method was in use when specific individuals were caught.

Kept vs. Released Catch: These summaries are based only on retained (kept) catch. Note that the inclusion of discarded (released) catch could change the distribution of trip counts across non-salmon to salmon ratio bins.

Trip Counts: Only trips that retained catch were included in these summaries. Trips that did not retain ANY catch are not included in these summaries, and are not included in trip counts.

Crabs: Log books sometimes indicate that Dungeness crab, and in a very few cases, rock crabs are caught and reported with these data. The log books do not provide a gear option that is selective for crab. Often CPFV operators will fish for crab on the same day they troll for salmon, these crab catches appear as if caught trolling. Since this is clearly not the case these data are excluded from this summary.

Appendix A(2): Urchin

Table A(2) – Associated Catch Estimates for Urchin Fishery

Caught on commercial* dive trips targeting red urchin (2000-2006)	lbs of fish	% of Fish wt caught
Urchin, red	**4,882,050**	**99.96%**
Oyster, California native **	1,658	0.03%
Sea cucumber, giant red **	405	0.01%
rockfish	12	0.00%
Urchin, purple	0	0.00%
Total	4,884,125	

**probably NOT bycatch, but taken by divers

Appendix A(3): Halibut

Table A(3) – 1: Associated Catch 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	**399,356**	**94.77%**
reef spp.	7,923	1.88%
salmon	5,488	1.30%
rockfish	3,639	0.86%
other (<1% of catch)	4,996	1.19%
Total	421,402	

* Recreational data are from CRFS surveys and include ocean only catches for all of the Wine and San Francisco districts. The Wine district includes portions of Mendocino County outside of the study region but does not include Tomales Bay.

** Associated catch data for commercial halibut with H&L gear includes data from the study region only for blocks that are contained within or intersect the state waters. Additionally these data include landed fish only and do not include any discarded catch.

Table A(3) – 2: Associated Catch Estimates for Halibut Trawling

Caught on commercial* trips targeting halibut w/ trawl gear (2000-2006)	lbs of fish	% of Fish wt caught
halibut	**456,419**	**61.24%**
other flatfish	248,130	33.29%
demersal sharks, skates and rays	19,631	2.63%
rockfish	11,523	1.55%
reef spp.	5,803	0.78%
other (<1% of catch)	3,807	0.51%
Total	745,311	

** Associated catch data for commercial halibut with trawl gear includes portions of the blocks intersecting the study region that lie outside state waters. Additionally these data include landed fish only and do not include any discarded catch.

Appendix A(4): Crab

Table A (4) – 1: Associated Catch Estimates for the Crab Fishery

Caught on commercial trips targeting crab with traps/pots (2000-2006)**	lbs of fish	% of Fish wt caught
Dungeness	**5,654,239**	**99.66%**
other crab	14,580	0.26%
octopus	2,780	0.05%
other (<0.1% of catch)	1,910	0.03%
Total	5,673,510	

** Associated catch data for commercial crab trapping includes only data from the study region for blocks that are contained within or intersect the state waters. Additionally these data include landed fish only and do not include any discarded catch.

Potential Impacts of Sex- and Size-Selective Harvesting in Crab Populations

Several studies have ~~shown there potentially can be~~demonstrated potential negative population impacts through sex- and size-selective harvesting of large males (Hines et al. 2003). -These studies have primarily been conducted using blue crabs (*Callinectes sapidus*) and snow crabs (*Chionoecetes opilio*), but it is conceivable that the changes in reproductive success and female survivorship could occur in commercially-harvested crab populations in the NCCSR as well.

Removing male crabs from populations can result in skewed sex ratios and reduced male size (Carver et al. 2005, Sainte-Marie & Lovrich 1994). These results can in turn lead to decreased copulation time (Rondeau & Sainte-Marie 2001), decreased sperm production (Kendall et al. 2002), fewer successful copulations due to exhausted sperm supplies (Carver et al. 2005), decreased female survivorship (Jivoff 1997, Sainte-Marie et al. 1999), and increased female injury (Shirley & Shirley 1988, Rondeau & Sainte-Marie 2001).

Additionally, Smith and Jaimeson (1991a) found that female Dungeness crabs (*Cancer magister*) preferentially mate with males that are larger than they are, leading to decreased mating opportunities for large (and more fecund) females in areas with male-biased fisheries. However, Hankin et al. (1997) found no correlation between male and female size in mating pairs in northern California. They also found females that were larger than the legal size limit that had been mated, presumably by large crabs, and that if large females remained unmated, population egg production was estimated to decrease by 2%-25%. In Alaska, though, areas with intense fishing pressure have virtually no large ovigerous females due to a lack of males large enough for copulation (T. Shirley, pers. comm.). Thus evidence that removing high numbers of large males from crab populations could cause significant reductions in reproductive output is mixed.

Recent evidence suggests that the potential negative impacts of removing male crabs from populations will not be tempered by the movement of crabs into and out of the fished area. Studies of *Cancer magister* in Alaska, British Columbia, and northern California have shown that adult crabs move much less than previously assumed, and could have significant site fidelity and little contact with neighboring populations (Diamond & Hankin 1985, Smith & Jaimeson 1991b, Stone & O'Clair 2001, Stone & O'Clair 2002). These studies are supported by evidence of dramatic increases in the size of male crabs in historically fished areas that are incorporated into marine protected areas (Taggart et al. 2004).

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Appendix A(5): White Seabass

Table A(5) – 1: Associated Catch 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
kelp bass	1,445	34.93%
white seabass	**1,377**	**33.28%**
pelagic spp.	340	8.22%
reef spp.	271	6.55%
rockfish	238	5.75%
shallow sand spp.	157	3.80%
demersal sharks, skates & rays	117	2.83%
halibut	110	2.66%
other (<1% of catch)	82	1.98%
Total	4,137	

* Recreational data are from CRFS surveys and include ocean only catches for all of the Wine and San Francisco districts. The Wine district includes portions of Mendocino County outside of the study region but does not include Tomales Bay.

Appendix A(6): Sardine, Anchovy, Herring

Table A(6) – 1: Associated Catch Estimates for the Wetfish Pelagic Seine Fishery

Caught on Commercial** trips targeting sardine (2000-2006)	lbs of fish	% of Fish wt caught
sardine	**1,938,608**	**96.63%**
anchovy	66,300	3.30%
other wetfish	1,300	0.06%
Total	2,006,208	
Caught on Commercial trips targeting anchovy (2000-2006)**	lbs of fish	% of Fish wt caught
anchovy	**327,500**	**88.92%**
sardine	40,800	11.08%
Total	368,300	

** Associated catch data for commercial wetfish includes only data from the study region for blocks that are contained within or intersect the state waters. Additionally these data include landed fish only and do not include any discarded catch.

Appendix A(7): Squid

Table A(7) – 1: Associated Catch Estimates for the Squid Pelagic Seine Fishery

Caught on Commercial* trips targeting market squid (2000-2006)	lbs of fish	% of Fish wt caught
market squid	**18,561,205.00**	**100.00%**
other wetfish	10.00	0.00%
Total	18,561,215.00	

** Associated catch data for market squid includes only data from the study region for blocks that are contained within or intersect the state waters. Additionally these data include landed fish only and do not include any discarded catch.

Appendix A(8): Striped Bass

Table A(8) – 1: Associated Catch Estimates for the Striped Bass Fishery

Caught on recreational trips targeting striped bass w/ H&L (2000-2007)	# of fish	% of Fish caught
striped bass	**5,318**	**72.98%**
demersal sharks, skates & rays	544	7.47%
shallow mixed habitat spp.	387	5.31%
pelagics wetfish	328	4.49%
shallow sand spp.	215	2.95%
halibut	176	2.42%
surfperch	124	1.71%
rockfish	70	0.96%
other (<1% of catch)	124	1.71%
Total	7,287	

Appendix A(9): Shorefishing

Table A(9) - 1: Reported and Estimated Catch of Rock-Associated Fish Using Shore-Based Hook and Line Methods.

Common Name	**# fish reported (2000-2007) kept and released***	**percent of catch (2000-2007)***	**Estimated # fish kept per year (2004-2007)****	**max PSE (2004-2007)****
SHINER PERCH	5,935	44%	4,464	68%
STRIPED SEAPERCH	1,110	8%	8,074	26%
BLACK PERCH	913	7%	4,624	44%
UNIDENTIFIED ROCKFISH	720	5%	87	100%
UNIDENTIFIED SCULPINS	586	4%	135	87%
SILVER SURFPERCH	550	4%	5,426	60%
WHITE SEAPERCH	449	3%	777	83%

Common Name	# fish reported (2000-2007) kept and released*	percent of catch (2000-2007)*	Estimated # fish kept per year (2004-2007)**	max PSE (2004-2007)**
GRASS ROCKFISH	412	3%	2,147	44%
KELP GREENLING	408	3%	3,573	30%
CABEZON	319	2%	2,070	53%
MONKEYFACE PRICKLEBACK	301	2%	685	75%
BROWN ROCKFISH	243	2%	204	59%
RAINBOW SEAPERCH	236	2%	867	93%
ROCK GREENLING	224	2%	1,600	42%
RUBBERLIP SEAPERCH	210	2%	899	72%
PILE PERCH	184	1%	112	59%
BLACK ROCKFISH	177	1%	2,958	70%
LINGCOD	175	1%	425	96%
SHARPNOSE SEAPERCH	143	1%		
BLUE ROCKFISH	88	1%	7,564	87%
BLACK AND YELLOW ROCKFISH	83	1%	568	61%
UNIDENTIFIED GREENLINGS	44	0%		
GOPHER ROCKFISH	24	0%	225	98%
CHINA ROCKFISH	8	0%		
COPPER ROCKFISH	8	0%		
KELP ROCKFISH	8	0%	207	100%
STRIPETAIL ROCKFISH	8	0%	476	67%
BULL SCULPIN	6	0%		
EEL ORDER	6	0%		
YELLOWFIN GOBY	5	0%		
RED IRISH LORD	5	0%		
VERMILION ROCKFISH	5	0%	413	74%
ONESPOT FRINGEHEAD	4	0%		
UNIDENTIFIED PRICKLEBACKS	3	0%		
BUFFALO SCULPIN	3	0%		
STRIPED KELPFISH	3	0%		
BLUEBANDED RONQUIL	2	0%		
BROWN IRISH LORD	2	0%		
KELP BASS	2	0%		
UNIDENTIFIED SCORPIONFISH	2	0%		
CANARY ROCKFISH	2	0%		
OLIVE ROCKFISH	1	0%	402	77%
WHITESPOTTED GREENLING	1	0%	1	57%
BLACK PRICKLEBACK	1	0%		
ROCK PRICKLEBACK	1	0%		

Common Name	# fish reported (2000-2007) kept and released*	percent of catch (2000-2007)*	Estimated # fish kept per year (2004-2007)**	max PSE (2004-2007)**
BONEHEAD SCULPIN	1	0%		
ROCKWEED GUNNEL	1	0%	71	100%
WOLF-EEL	1	0%		
YELLOWFIN FRINGEHEAD	1	0%		
GREENSPOTTED ROCKFISH	1	0%		
SHORTBELLY ROCKFISH	1	0%		
YELLOWTAIL ROCKFISH	1	0%		

* data are from CRFS surveys and include ocean only catches for all of the Wine and San Francisco districts using all hook and line shore-based fishing modes. These data are the total number of fish recorded by observers and anglers during the period 2000-2007 and include both kept and released fish. The Wine district includes portions of Mendocino County outside of the study region but does not include Tomales Bay.
**based on CRFS estimate of total number of individuals caught and landed (kept) in Wine and SF districts using "beach and bank" fishing mode during the period 2004-2007. These data are expanded for effort.

Table A(9) – 2: Reported and Estimated Catch of Sand-Associated Fish Using Shore-Based Hook and Line Methods.

Common Name	# fish reported (2000-2007) kept and released*	percent of catch (2000-2007)*	Estimated # fish kept per year (2004-2007)**	max PSE (2004-2007)**
WHITE CROAKER	3,407	20%	1,048	90%
PACIFIC SANDDAB	2,102	12%	74	79%
STRIPED BASS	2,067	12%	16,227	74%
WALLEYE SURFPERCH	1,918	11%	3,196	43%
PACIFIC STAGHORN SCULPIN	1,755	10%	27	45%
LEOPARD SHARK	1,261	7%	1,647	100%
BAT RAY	1,019	6%	244	89%
BARRED SURFPERCH	1,008	6%	19,889	71%
REDTAIL SURFPERCH	527	3%	8,725	36%
UNIDENTIFIED SKATES & RAYS	314	2%	6	100%
BROWN SMOOTHHOUND	247	1%		
UNIDENTIFIED SMOOTHHOUNDS	238	1%		
SURF SMELT	199	1%	8,535	81%
UNIDENTIFIED SHARKS	193	1%		
CALIFORNIA HALIBUT	188	1%	210	73%
SPOTFIN SURFPERCH	164	1%		
SANDDAB GENUS	135	1%		
CALICO SURFPERCH	125	1%	2,585	71%
STARRY FLOUNDER	69	0%	1,038	77%
PACIFIC TOMCOD	57	0%		

Common Name	**# fish reported (2000-2007) kept and released***	**percent of catch (2000-2007)***	**Estimated # fish kept per year (2004-2007)****	**max PSE (2004-2007)****
UNIDENTIFIED FLATFISH	54	0%	63	68%
WHITE STURGEON	42	0%	10	100%
SEVEN GILL SHARK	41	0%		
SPINY DOGFISH SHARK	39	0%		
GRAY SMOOTHHOUND	14	0%		
LONGJAW MUDSUCKER	9	0%		
SPECKLED SANDDAB	8	0%		
BAY GOBY	8	0%		
UNIDENTIFIED STURGEON	7	0%		
LONGNOSE SKATE	6	0%		
THORNBACK	6	0%	163	100%
BIG SKATE	5	0%		
BLUNTNOSE SIXGILL SHARK	4	0%		
PACIFIC ANGEL SHARK	3	0%		
UNIDENTIFIED STINGRAY	4	0%		
SHOVELNOSE GUITARFISH	2	0%		
CALIFORNIA SKATE	1	0%		
UNIDENTIFIED SKATE	1	0%		
BUTTER SOLE	1	0%		
DIAMOND TURBOT	1	0%		
UNIDENTIFIED FLOUNDER	1	0%		
SAND SOLE	1	0%		
BARRED SANDBASS	1	0%	16	100%
QUEENFISH	1	0%		
DWARF PERCH	1	0%		

* data are from CRFS surveys and include ocean only catches for all of the Wine and San Francisco districts using all hook and line shore-based fishing modes. These data are the total number of fish recorded by observers and anglers during the period 2000-2007 and include both kept and released fish. The Wine district includes portions of Mendocino County outside of the study region but does not include Tomales Bay.
**based on CRFS estimate of total number of individuals caught and landed (kept) in Wine and SF districts using "beach and bank" fishing mode during the period 2004-2007. These data are expanded for effort.

Appendix A(10): ~~Mariculture~~Mariculture Activity Impacts on Marine Protected Area Level of Protection in the North Central Coast Study Region

~~Mariculture in the NCCSR is currently confined to two estuaries in the Pt. Reyes region (Tomales Bay and Drake's Estero), and farms in these locations are licensed to raise a variety of bivalves. The most extensively farmed species is the Pacific oyster (*Crassostrea gigas*), but several other oyster species are farmed. Oyster mariculture methods are described in the following paragraphs. Manila clams (*Tapes philippinarum* or *Venerupis philippinarum*) are also grown in the study region using the bottom bag technique used for oysters. In most of the~~

~~Pacific Northwest, Manila clams are cultured using open plots and raking, but this technique is not used by growers in the NCCSR. Bay mussels (*Mytilus galloprovincialis*) are also harvested by many growers in Tomales Bay, but the species is not actively cultured. Instead, mariculturists harvest naturally-seeded mussels from their oyster culturing equipment and piers. One grower (Cove Mussel Company) uses longlines placed in the subtidal zone to encourage mussel settlement, but does not actively seed the lines. Point Reyes Oyster Company is licensed to farm rock scallops, but does not currently do so.~~

~~Oysters are cultured in the NCCSR using four methods. All methods currently use mesh bags to contain the oysters, but growers can use cultch methods as well, in which cleaned shells with larval oysters attached are spread on the ground or attached to lines in clumps. In mesh bag culture, bags of oyster spat are either 1) placed above the substrate on wooden racks, 2) scattered by hand haphazardly on intertidal substrate, 3) tethered in lines on intertidal substrate, or 4) suspended from buoyed lines that float at high tide but rest on intertidal substrate at very low tides.~~

~~In the first method, oyster racks are frequently placed in eelgrass beds, although they may be placed in the intertidal or in subtidal regions without eelgrass. Oyster mariculture operations in eelgrass beds can have negative impacts, including preempting eelgrass habitat (Wechsler 2004), altering sedimentation and scour patterns (Forrest & Creese 2006), and altering sediment nutrient content through biodeposition (De Casabianca 1997, Bertin & Chaumillon 2006). Rack operations also create novel three-dimensional habitats that could influence the distribution of mobile species (Dixon 2007), and many racks are built with treated lumber containing highly toxic compounds that can leach into the water and be accumulated in marine organisms or sediments (Weis & Weis 1992, Weis & Weis 1996).~~

~~Oyster bags not placed on racks usually rest on intertidal substrate during low tide, which could have several negative impacts. One potential impact is that bags isolate the sediment from the water column and add nutrients to the sediment, which could potentially change infaunal communities near the sediment-water interface and create anoxic conditions (Dixon 2007). Another concern is that haphazardly scattered bags could be placed or moved into subtidal regions containing eelgrass beds, where they would exclude eelgrass by preempting space.~~

~~Bags also preempt space when placed in the intertidal, and both hand-scattered and tethered bags could have negative impacts on shorebirds and marine mammals. Intertidal bags and racks reduce the available foraging habitat for shorebirds, and although willets appear to be attracted to oyster mariculture in Tomales Bay, western sandpipers and dunlins actively avoid it (Kelly et al. 1996). If large amounts of intertidal foraging areas are covered by oyster mariculture, it could have a negative impact on shorebird foraging success. Likewise, mariculture equipment placed at or near marine mammal haulout sites could reduce the available space for resting and create barriers to movement.~~

~~Like the equipment itself, human activities associated with mariculture operations could have very serious impacts on the marine environment. Placing, maintaining, and collecting bivalves~~

and their associated equipment create disturbances to the substrate through trampling and boat propeller scarring (Zieman 1976). Scarring is particularly damaging in eelgrass beds, where scars could take years to heal (Dawes et al. 1997). Additionally, humans and boats involved in routine mariculture operations could disturb birds and marine mammals, increasing energy demands (Stillman et al. 2007) and decreasing the haulout period (Suryan & Harvey 1999).

Oysters and their associated culturing equipment can also impact marine systems by providing extensive areas of hard substrate that would not otherwise be present in an area. Non-indigenous species are attracted to unnatural hard surfaces such as oyster racks, floats, and pilings, and thus mariculture equipment could help maintain populations of non-indigenous sessile organisms, such as *Didemnum* sp. in Drake's Estero (Bullard et al. 2007). Another consideration is that almost all of the species currently farmed are non-indigenous species; *Mytilus galloprovincialis*, the bay mussel, is considered highly invasive around the world and has been shown to displace native congeners in California (J. Shinen, pers. comm.). This species was imported to mussel farms in Tomales Bay in the 1930's, and is so widespread in that body of water that mussel farmers have stopped seeding their equipment and instead rely entirely on larval recruitment from established feral populations.

The Pacific oyster, *Crassostrea gigas*, is native to Japan, as are Manila clams (*Tapes philippinarum* or *Venerupis philippinarum*). The European oyster, *Ostrea edulis*, is native to most of Europe, and the Eastern oyster, *Crassostrea virginica*, is native to the East Coast of the United States. All of these species are cultured in Tomales Bay. Shipments of non-indigenous oysters have historically contained numerous associated non-indigenous species, some of which have had serious negative impacts on native species. In the NCCSR, the non-indigenous mud snail *Batillaria attramentaria* was introduced through non-indigenous oyster shipments and has led to a serious decline in a similar native species, *Cerithidea californica*, due to exploitative competition (Byers 1999). Likewise, two oyster drills, *Urosalpinx cinerea* from the Atlantic coast and *Ocinebrellus inornatus* from Japan, have been inadvertently introduced with non-indigenous oysters along the Pacific coast, where they consume not only the introduced oysters, but native (and relatively rare) Olympia oysters as well.
This document provides an overview of potential impacts of various mariculture activities with regard to marine protected area (MPA) designation in the north central coast study region of the Marine Life Protection Act (MLPA) Initiative. The intent of this document is to consider mariculture with respect to its effect on the natural ecological functions of an area and with regard to the relative level of protection provided by MPAs that allow or prohibit mariculture. This document is not intended as a complete review of all scientific information on the impacts (positive or negative) of mariculture as an industry. It is not intended to be used for current or future permitting of mariculture activities and does not recommend changes to existing permitting processes or mariculture leases., is not intended to inform current or future permitting of mariculture activities, and does not recommend changes to existing permitting processes or mariculture leases.

Summary

Mariculturists in Tomales Bay and Drake's Estero culture several bivalve species using four main methods. Impacts vary according to method, but a general list of potential impacts is as follows.~~are:~~

- Bivalves and associated farming equipment can reduce eelgrass cover, change species distributions in eelgrass beds, ~~create anoxic conditions,~~ and alter sediment deposition patterns.
- Farming equipment can preempt space in the intertidal, altering shorebird foraging and distributions~~; marine mammal behavior could also be altered~~.
- Maintenance operations can trample sediments, damage eelgrass beds, and disturb shorebirds and perhaps marine mammals.
- Wooden culturing racks are commonly treated with a highly toxic preservative that can leach into the environment and accumulate in organisms and sediments, ~~though the industry recognizes this problem and~~but the use of wooden racks reportedly is being eliminated in the north central coast study region (NCCSR).
- Bivalves and associated farming equipment provide large amounts of hard substrate habitat that may not be naturally present, altering ~~species~~ communities.
- Almost all cultured species are non-indigenous species, and ~~past~~historic shipments of live animals from their native range have accidentally introduced other species to mariculture areas, some of which have had substantial impacts. Mariculture stock is no longer being imported from foreign sources, and disease is carefully monitored to reduce transmission. However, the potential exists for cultured species to provide a foundation for the continued establishment of non-native species that may be introduced via other vectors.
- Bivalves serve a critical ecosystem function by filtering bacteria and phytoplankton which accumulate nutrients and heavy metals from the water. Whether these changes are perceived to be positive or negative is a complex value judgment.

The information provided in this document concerns mariculture practices currently used in the NCCSR. Studies referenced in this document investigated the effects of similar techniques used around the world, and where possible, the few studies that have been conduced within the NCCSR are also cited. However, there is a much larger body of literature concerning the effects of bivalve mariculture activities and practices not currently employed in the NCCSR~~ and the large majority of them show substantial alterations to the ecosystem in the various ways summarized above~~.

Mariculture Activities

Mariculture in the NCCSR is currently confined to two estuaries in the Point Reyes region (Tomales Bay and Drake's Estero), and farms in these locations are licensed to raise a variety of bivalves. The most extensively farmed species is the Pacific oyster (*Crassostrea gigas*), but several other oyster species are farmed. Oyster mariculture methods are described in the following paragraphs. Manila clams (*Tapes philippinarum* or *Venerupis philippinarum*) are also grown in the study region using the bottom bag technique used for oysters. In most of the Pacific Northwest, Manila clams are cultured using open plots and raking, but this technique is not used by growers in the NCCSR. Bay mussels (*Mytilus galloprovincialis*) are also grown by three operations; one relies on naturally-seeded mussels, while two buy seed. Mussels are grown on longlines placed in the subtidal zone. Point Reyes Oyster Company is licensed to farm rock scallops, but does not currently do so.

Oysters are cultured in the NCCSR using four methods. All methods currently use mesh bags to contain the oysters, but growers can use cultch methods as well, in which cleaned shells with larval oysters attached are spread on the ground or attached to lines in clumps. In mesh bag culture, bags of oyster spat are either 1) placed above the substrate on wooden, metal, or PVC racks, 2) placed by hand on intertidal substrate, 3) tethered in lines on intertidal substrate, or 4) suspended from buoyed lines that float at high tide but possibly rest on intertidal substrate at very low tides.

In the first method, oyster racks could be placed in areas that would otherwise be colonized by eelgrass. Oyster mariculture operations in eelgrass beds can have ~~substantial~~ localized impacts, including reducing the extent of eelgrass (e.g. Everett et al. 1995, Wechsler 2005, Wisehart et al. 2007), altering sedimentation and scour patterns (e.g. Everett et al. 1995, Mallet et al. 2006, Forrest & Creese 2006), and altering sediment nutrient content through biodeposition in high-density culture areas (e.g. De Casabianca 1997, Bertin & Chaumillon 2006, Asami et al. 2005). Rack operations also create novel three-dimensional habitats that could influence the distribution of communities (e.g. Nugues et al. 1996, Laffargue 2006), and some racks currently in use were built with treated lumber containing highly toxic compounds that can leach into the water and be accumulated in marine organisms or sediments (Weis & Weis 1992, Weis & Weis 1996). However, the mariculture industry recognizes this problem and the use of wooden racks reportedly is being phased out in the NCCSR.
~~and some racks are built with treated lumber containing highly toxic compounds that can leach into the water and be accumulated in marine organisms or sediments (Weis & Weis 1992, Weis & Weis 1996). However, the mariculture industry recognizes this problem and the use of wooden racks reportedly is being phased out in the NCCSR.~~

Oyster bags not placed on racks can rest on intertidal substrate during low tide, which could have several impacts. One potential impact is that bags isolate the sediment from the water column and add nutrients to the sediment, which could potentially change infaunal communities near the sediment-water interface and create anoxic conditions, though this has not been well studied. ~~There has been one anecdotal report in this region of evidence of anoxic conditions resulting from placing oyster bags directly on the substrate (footnoted in Dixon 2007).~~ Another concern is that there is the potential for bags to be placed or moved into subtidal regions containing eelgrass beds, where they would exclude eelgrass by preempting space.

Bags also preempt space when placed in the intertidal, and both hand-placed and tethered bags could have impacts on shorebirds and marine mammals. Intertidal bags and racks change distributions of sea and shorebirds (e.g. Roycroft et al. 2004, Zydelis et al. 2006). For example, the two studies conducted in the NCCSR found that although willets appear to be attracted to oyster mariculture in Tomales Bay, western sandpipers and dunlins actively avoid it (Kelly et al. 1996, Kelly 2001). If large amounts of intertidal foraging areas are covered by oyster mariculture, it could potentially reduce shorebird foraging success, although one study conducted outside the study region showed some mariculture methods could increase foraging opportunities for shorebirds due to habitat modification by mariculture equipment (Connolly and Colwell 2005). Likewise, it is conceivable that mariculture equipment placed at or near marine mammal haulout sites could reduce the available space for resting and create barriers to movement. However, there is a paucity of evidence documenting this, and pinnipeds reportedly haul out near mariculture operations.

Like the equipment itself, human activities associated with mariculture operations could have serious impacts on the marine environment. Placing, maintaining, and collecting bivalves and their associated equipment create disturbances to the substrate through trampling and boat propeller scarring (e.g. Connolly and Colwell 2005, Forrest and Creese 2006). Scarring is particularly damaging in seagrass beds, where scars could take years to heal (Zieman 1976, Dawes et al. 1997). However, propeller scarring has been poorly studied in the NCCSR.~~Additionally, humans and boats involved in routine mariculture operations potentially could disturb birds and marine mammals. Disturbance events have been shown to increase energy demands of birds (Stillman et al. 2007) and decrease the haulout period of marine mammals (Suryan & Harvey 1999).~~

Oysters and their associated culturing equipment can also impact marine systems by providing extensive areas of hard substrate that would not otherwise be present in an area. Non-indigenous species are attracted to unnatural hard surfaces such as oyster racks, floats, and pilings, and thus mariculture equipment sustains reproductive populations of non-indigenous sessile organisms, such as *Didemnum* sp. in Drake's Estero (Bullard et al. 2007). In other areas, artificial structures such as mariculture equipment have been shown to attract mobile vertebrates and invertebrates, potentially providing food and refugia for numerous species (e.g. Hueckel and Buckley 1987, Meyer and Townsend 2000).

Another consideration is that almost all of the species currently farmed are non-indigenous species; *Mytilus galloprovincialis*, the bay mussel, is considered highly invasive around the world and has been shown to displace native congeners in California (Shinen 2007). This species was imported to mussel farms in Tomales Bay in the 1930's, and is so widespread in that body of water that one mussel farmer has stopped seeding his equipment and instead relies entirely on larval recruitment from established feral populations.

The Pacific oyster, *Crassostrea gigas*, is native to Japan, as are Manila clams (*Tapes philippinarum* or *Venerupis philippinarum*). The European oyster, *Ostrea edulis*, is native to most of Europe, and the Eastern oyster, *Crassostrea virginica*, is native to the East Coast of the United States. All of these species are cultured in Tomales Bay. Shipments of non-indigenous oysters have historically contained numerous associated non-indigenous species, some of which have had substantial impacts on native species In the NCCSR, the non-indigenous mud snail *Batillaria attramentaria* was introduced through non-indigenous oyster shipments and has led to a serious decline in a similar native species, *Cerithidea californica*, due to exploitative competition (Byers 1999). Likewise, two oyster drills, *Urosalpinx cinerea* from the Atlantic coast and *Ocinebrellus inornatus* from Japan, have been inadvertently introduced with non-indigenous oysters along the Pacific coast, where they consume not only the introduced oysters, but native (and relatively rare) Olympia oysters as well. Mariculture stock is no longer being imported from foreign sources, and disease is carefully monitored to reduce transmission. However, the potential for exists for cultured species to provide a foundation for the continued establishment of non-native species that may be introduced via other vectors.The Pacific oyster, *Crassostrea gigas*, is native to Japan, as are Manila clams (*Tapes philippinarum* or *Venerupis philippinarum*). The European oyster, *Ostrea edulis*, is native to most of Europe, and the Eastern oyster, *Crassostrea virginica*, is native to the East Coast of the United States. All of these species are cultured in Tomales Bay. Shipments of non-indigenous oysters have historically contained numerous associated non-indigenous species, some of which have had substantial impacts on native species. In the NCCSR, the non-indigenous mud snail *Batillaria attramentaria* was introduced through non-indigenous oyster shipments and has led to a serious decline in a similar native species, *Cerithidea californica*, due to exploitative competition (Byers 1999). Likewise, two oyster drills, *Urosalpinx cinerea* from the Atlantic coast and *Ocinebrellus inornatus* from Japan, have been inadvertently introduced with non-indigenous oysters along the Pacific coast, where they consume not only the introduced oysters, but native (and relatively rare) Olympia oysters as well. Mariculture stock is no longer being imported from foreign sources, and disease is carefully monitored to reduce transmission. However, the potential exists for cultured species to provide a foundation for the continued establishment of non-native species that may be introduced via other vectors.

Table A(10) – 1: Mariculture Leases and Methods in the NCCSR

	Lease Data			Species		Cultivation Methods				
Lessee	Total Lease Acreage	Estimated Acreage in Use	Area of Lease	Approved Species	Species Cultured*	Racks	Scttrd Bottom Bags	Lngline Bottom Bags	Flotng Bags	Lnglns (mussels)
Charles Friend	62	15	Tomales Bay	Pacific oyster	Pacific oysters			X		
Cove Mussel Company	10	10	Tomales Bay	Pacific oysters; bay mussels	Pacific oysters; bay mussels	X				X
Hog Island Oyster Company	300	160	Tomales Bay	Pacific, European, and Eastern oysters; Manila clams; bay mussels	Pacific, European, and Eastern oysters; Manila clams; bay mussels	X	X	X	X	X
Point Reyes Oyster Company	100	10	Tomales Bay	Pacific, European, and Eastern oysters; Manila clams; bay mussels;	Pacific, European, and Eastern oysters; Manila clams; bay mussels	X	X	X	X	

				~~rock scallops~~						
~~Marin Oyster Company~~	~~30~~	~~10~~	~~Tomales Bay~~	~~Pacific and Eastern oysters; Manila clams; bay mussels~~	~~Pacific and Eastern oysters; Manila clams; bay mussels~~			~~X~~	~~X~~	~~X~~
~~Tomales Bay Oyster Company~~	~~156~~	~~60~~	~~Tomales Bay~~	~~Pacific and Eastern oysters; bay mussels~~	~~Pacific, and Eastern oysters; bay mussels~~	~~X~~	~~X~~	~~X~~	~~X~~	
~~Drakes Bay Oyster Company~~	~~1060~~	~~100~~	~~Drake's Estero~~	~~Pacific and European oysters; littleneck and Manila clams; rock scallops~~	~~Pacific and European oysters; Manila clams; rock scallops~~	~~X~~	~~X~~	~~X~~	~~X~~	

~~*Only Hog Island Oyster Company actively cultures bay mussels; other growers glean feral mussels from oyster growing equipment~~

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APPENDIX B: SOCIOECONOMIC IMPACT ASSESSMENT METHODS

The primary goal of this analysis is to estimate the socioeconomic impact to the commercial fishery sector associated with each of the MPA proposals. To accomplish this, staff from Ecotrust, contractor to the MLPA Initiative, will estimate the maximum potential economic impact for each of the MPA proposals using methods developed in the Central Coast process (see Wilen and Abbott, 2006). This analysis assumes that each of the MPA proposals completely eliminate fishing opportunities in areas closed to specific fisheries and that fishermen are unable to adjust or mitigate in any way (Wilen and Abbott, 2006). The results can then be considered by each group (i.e. stakeholders, SAT, BRTF, Initiative staff, FGC) as trade-offs for protections relative to socioeconomic impacts can be weighed in siting and evaluating MPA proposals. The remainder of this paper describes the steps needed to complete the maximum potential economic impact analysis.

1. Generate Baseline Estimates of Gross Economic Revenue

The first step involves calculating a baseline estimate from which to derive estimates of the socioeconomic impact associated with changes in commercial fisheries that might be induced by each MPA alternative and against which to compare those estimates. The baseline estimate is generated using gross fishing revenues from regional landing receipts. A 7 year average, 2000-2006, derived from the California Department of Fish and Game (CDFG) landing receipts reported for ports in the North Central Coast region is used, and then these values are converted into current dollar values (i.e. 2006 dollars).

More specifically, to generate baseline estimates of gross economic revenue (GER), for any fishery, *f*, $BGER_f$ is the average ex-vessel value of the fishery in 2006 dollars, where

$BGER_f = \sum_{p \in P} BGER(f, p)$, the sum of the baseline estimates of GER for this fishery over all ports.

Staff also define the fisheries specific to each port, or in other words, create a baseline estimate of gross economic revenue for each port. For a specific port, *p*, being considered in the North Central Coast region the baseline estimate ($BGER_p$) can be calculated as the sum of the baseline estimates of GER for this port over all fisheries:

$$BGER_p = \sum_{f \in F} BGER(f, p).$$

The baseline gross economic revenue ($BGER_{TOT}$) for <u>all</u> commercial fisheries ($f \in F$) being considered in the North Central Coast region is therefore

$BGER_{TOT} = \sum_{f \in F} BGER_f = \sum_{f \in F} \sum_{p \in P} BGER(f, p)$ or equivalently,

$$BGER_{TOT} = \sum_{p \in P} BGER_p = \sum_{p \in P} \sum_{f \in F} BGER(f, p).$$

2. Generate Gross Economic Revenue for the Various MPA Alternatives
The next step involves using results from the Ecotrust mapping exercise, specifically stated importance indices from the fishing grounds, to estimate the socioeconomic impact associated with changes in the commercial fisheries that might be induced by each MPA alternative. For a description of the methods used to create stated importance indices, please see Scholz et al. (2006).

For any fishery, *f*, port, *p*, and any MPA alternative, *a*:

$$GER(f,p,a) = BGER(f,p) - GEI(f,p,a)$$

where $GEI(f,p,a)$ is the estimated gross economic impact on fishery, *f*, at any port, *p*, under any alternative, *a*.

Therefore,

$$GER_f(a) = \sum_{p\in P} GER(f,p,a) \text{ and } GER_p(a) = \sum_{f\in F} GER(f,p,a)$$

as well as

$$GEI_f(a) = \sum_{p\in P} GEI(f,p,a) \text{ and } GEI_p(a) = \sum_{f\in F} GEI(f,p,a).$$

Gross economic revenue under any alternative, *a*, ($GER_{TOT}(a)$), for <u>all</u> commercial fisheries ($f \in F$) being considered in the North Central Coast region can be calculated as:

$$GER_{TOT}(a) = \sum_{f\in F} GER_f(a) = \sum_{p\in P} GER_p(a) = \sum_{f\in F}\sum_{p\in P} GER(f,p,a) = \sum_{p\in P}\sum_{f\in F} GER(f,p,a)$$

From this it can be said that, for any MPA alternative, *a*,

$$GEI_{TOT}(a) = BGER_{TOT} - GER_{TOT}(a)$$

where GEI_{TOT_a} is defined as the total gross economic impact on all commercial fisheries under any alternative, *a*. Therefore,

$$GEI_{TOT}(a) = \sum_{f\in F} GEI_f(a) = \sum_{p\in P} GEI_p(a) = \sum_{f\in F}\sum_{p\in P} GEI(f,p,a) = \sum_{p\in P}\sum_{f\in F} GEI(f,p,a).$$

3. Generate Baseline Estimates of Net Economic Revenue
In order to compute net economic benefits, staff 1) estimate the share of gross fishing revenues represented by costs, and 2) scale the baseline estimate (i.e. gross fishing revenues) calculated in Step 1 using the estimated cost shares. In the Central Coast process, an estimate of 65% was used across all fisheries (Wilen and Abbott, 2006). For the North Central

Coast process, several cost related questions were asked during interviews with fishermen in an effort to improve on this estimate as well as allow for the ability to account for cost variability between different fisheries in this analysis. After all interviews are completed, the cost data are broken out by fishery or fisheries. For example, cost data for a fisherman who fished both salmon and crab would be aggregated with only other interviewees participating in both those fisheries. A mean or median cost estimate is then calculated for each category.

Costs will be broken into two categories: fixed costs and variable costs. Fixed costs include costs that are independent of the number of trips a vessel makes or the duration of these trips. For example, vessel repairs and maintenance, insurance, mooring and dockage fees typically considered fixed costs. On the other hand, variable costs include costs that are dependent on the number of trips a vessel makes of the duration of these trips. Variable costs typically include fuel, maintenance, crew share, gear repair/replacement. For the purpose of this study, however, to account for sunk costs, the only variable cost is assumed to be crew wages and fuel costs. All other costs will be considered fixed costs.

For any fishery, *f*, net economic revenue is calculated as:

$$BNER_f = BGER_f - C_{X_f} - C_{V_f}$$

where C_{X_f} is the fixed cost associated with any fishery, *f*, and is set as a fixed dollar value, and C_{V_f} is the variable cost associated with any fishery , *f*, and is a fixed percentage of $BGER_f$. For further explanation, please see the Appendix.

Baseline net economic revenue ($BNER$) for <u>all</u> commercial fisheries ($f \in F$) being considered in the North Central Coast region can be calculated as:

$$BNER_{TOT} = \sum_{f \in F} BNER_f$$

4. Generate Estimates of Net Economic Revenue for the Various MPA Alternatives
In order to compute net economic revenue for each of the various MPA alternatives, staff analysis 1) estimates the share of gross fishing revenues represented by costs under each MPA alternative, and 2) scales the estimated gross fishing revenues for that alternative accordingly. Costs will be calculated using the methods described in Step 3.

For any fishery, *f*, and any MPA proposal, *a*,

$$NER_f(a) = GER_f(a) - C_{X_f} - C_{V_f} \ .$$

For any MPA alternative, *a*, net economic revenue for <u>all</u> commercial fisheries ($NER_{TOT}(a)$) can be calculated as:

$$NER_{TOT}(a) = \sum_{f \in F} NER_f(a)$$

5. Generate Estimate of the Potential Primary Economic Impact for the Various MPA Alternatives

Using the results from the previous steps, the potential primary net economic impact (NEI) of a particular MPA alternative, *a,* on a particular fishery, *f,* can then be calculated as:

$$NEI_f(a) = BNER_f - NER_f(a).$$

The potential primary NEI of any MPA alternative, *a,* on all commercial fisheries ($f \in F$) can then be calculated as:

$$NEI_{TOT}(a) = BNER_{TOT} - NER_{TOT}(a).$$

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Example of Estimate Costs

For fishery *f*, assume the following proportion of gross economic revenue goes to the following costs:

- 20% = fixed costs
- 20% = crew wages
- 10% = fuel costs → 30% = variable costs

Assume that baseline gross economic revenue equals $10,000.00. Under the baseline, fixed costs equal $2,000 and variable costs equal $3,000, resulting in total costs of $5,000. Assume that under MPA alternative *a,* gross economic revenue now equals $5,000. Under this alternative, fixed costs will still equal $2,000; however, variable costs will be recalculated as:

$5,000 * 0.3 = $1,500

This results in total costs of $3,500 under MPA alternative *a.*