California Marine Life Protection Act
Suggested Text Revisions to Pages 37-47 of the
MLPA Master Plan Framework for Consideration by the
Master Plan Science Advisory Team
February 17, 2006

Note: Suggested new text is underlined and strikeout indicates text that is suggested for elimination.

Science Advisory Team Guidance on MPA Network Design

The MLPA calls for the use of the best readily available science, and establishes a science team as one vehicle for fostering consistency with this standard. The MLPA also requires that the MPA network and individual MPAs be of adequate size, number, type of protection, and location as to ensure that each MPA and the network as a whole meet the objectives of the MLPA. In addition, the MLPA requires that representative habitats in each bioregion be replicated to the extent possible in more than one marine reserve.

The availability of scientific information is expected to change and increase over time. As with the rest of this framework, the following guidelines should be modified if new science becomes available that indicates changes are warranted. Additionally, changes should be made based on adaptive management and lessons learned as MPAs are monitored throughout various regions of the state.

The science team provided the following guidance in meeting the~~se~~ standards of the MLPA. This guidance, which is expressed in ranges for some aspects such as size and spacing of MPAs, should be the starting point for regional discussions of alternative MPAs. Although this guidance is not prescriptive, any significant deviation from it should be consistent with both regional goals and objectives and the requirements of the MLPA. The guidelines are linked to specific objectives and not all guidelines will necessarily be achieved by each MPA. For each recommendation below, detailed references are provided in the bibliography with notation linking them to the appropriate section.

Overall MPA and network guidelines:

- The diversity of species and habitats to be protected, and the diversity of human uses of marine environments, prevents a single optimum network design in all environments.

- For an objective of protecting the diversity of species that live in different habitats and those that move among different habitats over their lifetime, every 'key' marine habitat should be represented in the MPA network.

- For an objective of protecting the diversity of species that live at different depths and to accommodate the ontogenetic 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.

- 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 m or 2.5-5.4 nm) of coastline, and preferably 10-20 km (6-12.5 m or 5.4-11 nm). Larger MPAs would be required to fully protect marine birds, mammals, and migratory fish.

- For an objective of facilitating dispersal and connectedness 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 m or 27-54 nm) of each other.

- For an objective of providing analytical power for management comparisons and to buffer against catastrophic loss of an MPA, at least three to five replicate MPAs should be designed for each habitat type (see pages 43-45) within a biogeographical region.

- For an objective of lessening negative impact while maintaining value, placement of MPAs should take into account local resource use and stakeholder activities.

- Placement of MPAs should take into account the adjacent terrestrial environment and associated human activities.

- For an objective of facilitating adaptive management of the MPA network into the future, and the use of MPAs as natural scientific laboratories, the network design should account for the need to evaluate and monitor biological changes within MPAs.

1. MPAs should be in different marine habitats, biogeographical regions and upwelling cells *(See references noted ~~“ ”~~ “A” in literature cited)*

The strong association of most demersal marine species with particular habitat types (e.g., sea grass beds, submarine canyons, shallow and deep rock reefs), and variation in species composition across latitudinal, depth clines and biogeographical regions, implies that habitat types must be represented across each of these larger environmental gradients to capture the breadth of biodiversity in California's waters.

Different species use marine habitats in different ways. As a result, protection of all the key habitats along the California coast is a critical component of network design. A 'key' habitat type is ~~one~~ that type of habitat which provides ~~distinctive~~particular benefits by harboring a different set of species or life stages, having special physical characteristics, or being used by humans in ways that differ from the use of other habitats. In addition, many species require different habitats at different stages of their life cycle - for example, nearshore species may occur in offshore open ocean habitats during their larval phase. Thus, protection of these habitats, as well as designs that ensure connections between habitats, is critical to MPA success. Individual MPAs that encompass a diversity of habitats will both ensure the protection of species that move among habitats and protect adjoining habitats that benefit one another (e.g., exchange nutrients, productivity). Habitats with unique features (educationally, ecologically, archeologically, anthropologically, culturally, spiritually), or those that are rare should be targeted for inclusion. Habitats that are uniquely productive (e.g. upwelling centers or kelp forests) or aggregative (e.g., fronts) or those that sustain distinct use patterns (e.g. dive training centers, fishing or whale watching hot spots) should also get special consideration in design planning.

2. Target species are ecologically diverse *(See references noted "B" in literature cited)*

MPAs potentially protect a large number of species within their borders, and these species can have dramatically different requirements. As a result, MPA networks cannot be designed for the specific needs of each individual species. Rather, design criteria need to focus on maximizing collective benefits across species by minimizing compromises where possible. Commonly, it is more practical to consider protecting groups of species based on shared functional characteristics that influence MPA function and design (e.g., patterns of adult movement; patterns of larval dispersal; dependence on critical locations such as spawning grounds, mammal haul out areas, bird rookeries). It is also reasonable to emphasize protection of individual species ~~ecologically and economically dominant species groups when siting MPAs~~and groups of species that have special significance because of their dominant role in ecosystems or their economic importance.~~.~~ ~~The former~~Ecologically dominant species play the largest roles in the function of coastal ecosystems, and ~~the latter~~economically important species often experience the greatest impacts from human activities. In addition, knowledge of the distribution of rare, endemic, and endangered species should supplement the use of species groups. Generally, MPAs should not be used solely to enhance single-species management goals.

3. *Uses of marine and adjacent terrestrial environments are diverse* *(See references noted "C" in literature cited)*

The way people use coastal marine environments is highly diversified in method, goals, timing, economic objectives, and spatial patterns~~, etc~~. The wide spectrum of environmental uses should be a part of decisions comparing alternative~~s~~ networks of MPAs. The heterogeneity of uses, both between and within consumptive and non-consumptive categories make it unlikely that any one design will satisfy all user groups. The design will need to make some explicit provisions for trading off ~~between~~among the various negative and positive impacts ~~to~~on user groups. Placement of MPAs should also take into account the adjacent terrestrial environment and associated human activities. Freshwater runoff can be an important source of nutrients but also a potential source of contaminants to the adjacent marine environment. Terrestrial protected areas (e.g., preserves, parks) can regulate human access, restrict discharge of contaminants and provide enforcement support to adjoining MPAs.

4. MPA permanence is especially critical for long lived animals

Two clear objectives for establishing self-sustaining MPAs are to protect areas that are important sources of reproduction (nurseries, spawning areas, egg sources) and to protect areas that will receive recruits and thus be future sources of spawning potential. To meet the first objective of protecting areas that serve as sources of young, protection should occur both for areas that historically contained high abundances and for areas that currently contain high abundances. Historically productive fishing areas, which are now depleted, are likely to show a larger, ultimate response to protective measures if critical habitat has not been damaged. Protecting areas where targeted populations were historically abundant alone is insufficient, however, because the pace of recovery may be slow, especially for species with relatively long life spans and sporadic recruitment (for example, top marine predators). Including areas with currently high abundances in an MPA network helps buffer the network from the inevitable time lag for realizing the responses of some species. The biological characteristics of longevity and sporadic recruitment also suggest that the concept of a rotation of open and closed areas will probably not work well for the diversity of coastal species in California.

5. Size and shape guidelines *(See references noted ~~“ ”~~”D” in literature cited)*

To provide any significant protection to a target species, the size of an individual MPA must be large enough to encompass the typical movements of many individuals. Movement patterns vary greatly among species. Some are completely immobile or move only a few meters. Others forage widely. The more mobile the individuals, the larger the individual MPA must be to afford protection. Therefore, minimum MPA size constraints are set by the more mobile target species. Because some of California’s coastal species are known to move hundreds of miles, MPAs of any modest size are unlikely to provide ~~real~~a high degree of protection for these species. Fortunately, tagging studies indicate that net movements of many of California’s nearshore bottom-dwelling fish species, particularly reef-associated species, are on the order of 5-20 km (3-12.5 m or 2.5-11 nm) or less over the course of a year. ~~T~~Knowledge of these individual adult neighborhood or home range sizes must be combined with knowledge of how individuals are distributed relative to one another (e.g., in exclusive versus overlapping neighborhoods) to determine how many individuals a specific MPA design will protect. Current data suggest that MPAs spanning less than about 5-10 km (3-6 m or 2.5-5.4 nm) in extent along coastlines may leave many individuals of important species poorly protected. Larger MPAs, spanning 10-20 km (6-12.5 m or 5.4-11 nm) of coastline, are probably a better choice given current data on adult fish movement patterns. In an MPA network it is relatively easy to protect non-mobile species, and virtually impossible to protect very wide-ranging species. In light of this, special consideration in MPA network design is paid to species with intermediate mobility. With MPAs ~~of this size~~spanning 10-20 km of coastline, pelagic species with very large neighborhood sizes will likely receive little protection unless the MPA network as a whole affords significant reductions in mortality during the cumulative periods that individuals spend in different MPAs, or unless other ecological benefits are conferred (e.g., protection of feeding grounds, reduction in bycatch). Protection for highly mobile species will come from other means, such as state and federal fisheries management programs, but MPAs may play a role.

Less is known about the net movements of most of the deeper water sedentary and pelagic fishes, especially those associated with soft-bottom habitat, but it is reasonable to suspect that the range of movements will be similar or greater than those of nearshore species. One cause of migration in demersal fishes is the changing resource/habitat requirements of individuals as they grow. Thus, individual ranges can reflect the gradual movement of an individual among habitats, and MPAs that encompass more diverse habitat types will more likely encompass the movement of an individual over its lifetime. Although fisheries may not target younger fish, offshore MPAs that include inshore nursery habitats increase the likelihood of replenishment of adult populations offshore. Such MPAs would also protect younger fish from incidental take (i.e., by-catch). Fish with moderate movements, especially those in deeper water, will require larger MPA sizes. Because several species also move between shallow and deeper habitat, MPAs that extend offshore (from the coastline to the three-mile offshore boundary of State waters) will accommodate such movement and protect individuals over their lifetime.

Typically, the relative amount of higher relief rocky reef habitat decreases with distance from shore. In such situations, a MPA shape that covers an increasing area with distance offshore ~~—.~~ (i.e., a wedge shape) may be an effective design. This shape also better accommodates the greater movement ranges of deeper water and soft-bottom associated fishes and the larval/juvenile stages of nearshore species which may occur offshore during their planktonic phase of life. However, this may conflict with the optimum design for enforcement purposes of using lines of latitude and longitude for boundaries.

Coupling of pelagic and benthic habitats is an important consideration in both offshore and nearshore MPA design. The size of a protected area should also be large enough to facilitate enforcement and to limit deleterious edge effects caused by fishing adjacent to the MPA. MPA shape should ultimately be determined on a case-by-case basis using a combination of information about bathymetry, habitat complexity, ~~and~~ species distribution, and relative abundance.

6. Spacing between MPAs *(See references noted ~~“ ”~~“E” in literature cited)*

The exchange of larvae among MPAs is the fundamental biological rationale for MPA “networks”. Larval exchange has at least three primary objectives: to assure that populations within MPAs are not jeopardized by their reliance on replenishment from less protected populations outside MPAs; to ensure exchange and persistence of genetic traits of protected populations (e.g., fast growth, longevity); and to enhance the independence of populations and communities within MPAs from those outside MPAs for the use of MPAs as reference sites. One role of MPAs ~~For MPAs~~ is to act as reference sites for comparison with less protected populations or communities. For this to occur, MPAs must act independently from areas with less protected populations. Independence is enhanced for MPAs whose replenishment is contributed to by other MPAs.

Movement out of, into and between MPAs by juveniles, larvae, eggs, or spores of marine species depends on their dispersal distance. Important determinants of dispersal distance are the length of the planktonic period, oceanography and current regimes, larval behavior, and environmental conditions (e.g., temperature and sources of entrainment). As with adult movement patterns, the dispersal of juveniles, larvae and eggs varies enormously among species. Some barely move from their natal site. Others disperse vast distances. MPAs will only be connected through the dispersal of young if they are close enough together to allow movement from one MPA to another. Any given spacing of MPAs will undoubtedly provide connectivity for some species and not for others. The challenge is minimizing the number of key or threatened species that are left isolated by widely spaced MPAs.

Based on emerging genetic data from species around the world, larval movement of 50-100 km appears common in marine invertebrates. For fishes, larval neighborhoods based on genetic data appear generally larger, ranging up to 100-200 km. For marine birds and mammals, dispersal of juveniles of hundreds of km is not unusual, but for some of these species, return of juveniles to natal areas can maintain fine-scale population structure. For MPAs to be within dispersal range for most commercial or recreational groundfish or invertebrate species, they will need to be on the order of ~~no more that~~ 50-100 km apart. Otherwise, a large fraction of coastal species will gain no benefits from connections between MPAs.

Current patterns, retention features such as fronts, eddies, bays, and the lees of headlands may create "recruitment sinks and sources". Such spatial variation in recruitment habitat may be predictable - dispersal distances will be shorter where retention is substantial (e.g., lees of headlands). As a result, MPAs may need to be more closely spaced in these settings. Although dispersal data appear to be valid for a wide range of species, there are ~~only a small number of~~few coastal marine species in California that allow these estimates of larval neighborhoods to be made with confidence. Nonetheless, ~~it is the~~ the specific pattern of larval dispersal in any particular species is not as important for network design as the sum of all the patterns of larval dispersal for all the species of concern.
~~distribution of dispersal distances across species that really drives network design rather than the specific patterns for any particular species.~~

7. Minimal replication of MPAs

MPAs in a particular habitat type need to be replicated along the coast. Four major reasons for this are: to provide stepping-stones for dispersal of marine species; to insure against local environmental disaster (e.g. oil spills or other catastrophes) that can significantly impact an individual, small MPA; to provide independent experimental replicates for scientific study of MPA effects; and for the use of MPAs as reference sites to evaluate the effects of human influences on populations and communities outside MPAs. Ideally at least five replicates (but a minimum of three) containing sufficient representation or each habitat type, should be placed in the MPA network within each biogeographical region and for each habitat to serve these goals. For large biogeographical regions, fulfilling the critical stepping stone role may require even more MPA replicates. The spacing criteria discussed above will drive the number of replicates in this situation. To ensure that the effects of MPAs can be quantified, the network should be designed in a way that facilitates comparison of protected and unprotected habitats, and between different degrees of consumptive and non-consumptive uses.

8. Human activities ranges and MPA placement

The geographic extent of human activities is suggestive of size and placement of MPAs. Fishing fleets and other user groups typically have a finite home range from ports and access points along the coast. Many activities, especially in central California, are day-based and conducted from motor, sail or hand powered crafts with ranges between 1 and 29 miles (1 and 25 nautical miles). Historical patterns of fishing activity may have been concentrated much closer to ports than is true today because of declines in target species abundance from activities in the past. If MPAs are designed to limit consumptive uses, MPAs located farthest away from access points will tend to be associated with lower costs. However, MPAs often become magnets for fishing along their edges. These situations create a net benefit for consumptive users by locating MPAs close to ports and coastal access points. Similarly, MPAs designed to facilitate certain non-consumptive types of activities such as diving may be more effective closer to ports and coastal access points. As a general rule, locating MPAs at the outer reaches of the maximum range of any given user group will tend to minimize the impacts on that group, both negative (loss of opportunity) and positive (creation of opportunity). The balance between these influences must be evaluated for specific locations. In addition, if MPAs restrict transit they will carry higher social, economic and, potentially, safety costs for users seeking access to sites beyond the MPA. For these reasons, it is recommended that MPAs do not restrict transit.

9. Human activity patterns ~~and portfolio effects~~

Human activities have distinct hotspots where effort is concentrated. For example, in the northern California urchin fishery, economists at the University of California at Davis have documented area-based fishing strategies ~~around~~for a dozen fishing locations. It is likely that there ~~are~~is a threshold number of these locations below which the fishery would not be feasible. Because an MPA larger than the typical harvest area could potentially eliminate a fishing location, these spatial use patterns should be part of design considerations, especially if establishing one particular MPA would ~~spell the end of a particular activity along the entire coastline~~ have a disproportionately high negative impact on a particular fishery or fisheries. In another example, non-consumptive scuba diving ~~activites~~activities are ~~aften~~often ~~cnetred~~centered near ports or other local coastal access points. This should be considered in designing MPAs which might increase benefits to non-consumptive users.

Consideration of Habitats in the Design of MPAs *(See additional references noted ~~“ ”~~”F” in literature cited)*

The first step in assembling alternative proposals for MPAs in a region and in the context of a statewide MPA network is to use existing information to the extent possible to identify and to map the habitats that should be represented. The MLPA also calls for recommendations regarding the extent and types of habitats that should be represented.

The MLPA identifies the following habitat types: rocky reefs, intertidal zones, sandy or soft ocean bottoms, underwater pinnacles, seamounts, kelp forests, submarine canyons, and seagrass beds. The Master Plan Team convened in 2000 reduced this basic list by eliminating seamounts, since there are no seamounts in state waters. The team also identified four depth zones as follows: intertidal, intertidal to 30 meters, 30 meters to 200 meters, and beyond 200 meters. Several of the seven habitat types occur in only one zone, while others may occur in three or four zones. While pelagic habitats are also important from an ecosystem perspective, they are more difficult to include in a network of MPAs due to the transitory nature of the water and its inhabitants, both of which are not constrained by lines on a map.

The science team recommends expanding these habitat definitions in four ways:

1. Based on information about fish depth distributions provided in a new book on the ecology of California marine fishes (Allen et al. in press), the science team recommends dividing the 30-200 m depth zone into a 30-100 m and a 100-200 m zone. This establishes five depth zones for consideration:

- Intertidal
- Intertidal to 30 m (0 to 16 fm)
- 30 to 100 m (16 to 55 fm)
- 100 to 200 m (55 to 109 fm)
- 200 m and deeper.

2. The habitats defined in the MLPA implicitly focus on open coast ecosystems and ignore the critical influence of estuaries. California's estuaries contain most of the State's remaining soft bottom and herbaceous wetlands such as salt marshes, sand and mud flats, and eelgrass beds. Ecological communities in estuaries experience unique physical gradients that differ greatly from those in more exposed coastal habitats. They harbor unique suites of species, are highly productive, provide sheltered areas for bird and fish feeding, and are nursery grounds for the young of a wide range of coastal species. Emergent plants filter sediments and nutrients from the watershed, stabilize shorelines, and serve as buffers for flood waters and ocean waves. Given these critical ecological roles and ecosystem functions, estuaries warrant special delineation as a critical California coastal habitat.

3. Three of the habitats defined in the MLPA – rocky reefs, intertidal zones, and kelp forests – are generic habitat descriptions that include distinct habitats that warrant specific consideration and protection. In the case of rocky reefs and intertidal zones, the type of rock that forms the reef greatly influences the species using the habitat. For example, granitic versus sedimentary rock reefs harbor substantially different ecological assemblages and should not be treated as a single habitat. Subtidal boulder and cobble fields support different communities than flat rock reefs. Similarly, the term kelp

forest is a generic term that subsumes two distinct ecological assemblages dominated by different species of kelp. Kelp forests in the southern half of the state are dominated by the giant kelp, *Macrocystis pyrifera.* By contrast, kelp forests in the northern half of the state are dominated by the bull kelp, *Nereocystis luetkeana*. In central California, both types of kelp forests occur. These two types of kelp forests harbor distinct assemblages and should be treated as separate habitats.

4. Habitat definitions in the MLPA should be expanded to include ocean circulation features, because habitat is not simply defined by the substrate. Seawater characteristics are analogous to the climate of habitats on land, and play a critical role in determining the types of species that can thrive in any given setting. Just as features of both the soil and atmosphere characterize habitats on land, features of both the substrate (e.g., rock, sand, mud) and the water that bathes it (e.g., temperature, salinity, nutrients, current speed and direction) characterize habitats in the sea. No one would argue that a sand dune at the beach and a sand dune in the desert are the same habitat. Similarly, rocky reefs in distinct oceanographic settings are different habitats that can differ fundamentally in the species that use the reefs.

5. There are often multiple habitat types within a relatively small area, and these are often incorporated into proposed MPAs. The science team distinguishes these habitat types, at the highest resolution possible, when calculating percent of each habitat within proposed MPAs. However, for the purposes of linking habitats within a network component, the science team has used a minimum of 2 ~~quare~~square miles for a particular habitat type to be included in this connectivity.

6. In the central coast region, high-resolution benthic mapping data are not available for most of the southern half of the region. Coarse-scale mapping data indicated that a large portion of the region was soft bottom, yet commercial and recreational fishing effort data for rockfishes associated with hard bottom, as well as anecdotal information from fishermen and other constituents, indicated that considerable hard bottom exists within state waters. The science team used recreational CPFV fishing data for rockfish trips to develop proxies for the location of hard-bottom habitat in this region, which in turn were used for habitat calculations for proposed MPAs.

The oceanography of the California coastline is dominated by the influence of the California Current System. On the continental shelf and slope this system consists of two primary currents - the California Current, which flows toward the equator, and the California Undercurrent, which flows toward the North Pole (Hickey, 1979; 1998). When present, the undercurrent occurs beneath the southward flowing California Current. North of Pt. Conception, the undercurrent may reach the surface as a nearshore, poleward flowing current that is best developed in fall and winter (Collins et al., 2000; Pierce et al., 2000). These currents vary in intensity and location, both seasonally and from year to year.

Organisms will also be affected by the circulation induced by tidal currents. For those living in shallow water habitats very close to shore, inshore of the surf zone, the dominant influence on transport of planktonic eggs and larvae will be the circulation generated by breaking waves.

As can be seen in a satellite image of ocean temperature along the California coastline (Figure 4), the circulation and physical characteristics of the California Current System are exceedingly complex and variable. This is not the image one would expect if ocean currents were analogous to northward or southward flowing rivers in the sea. Rather, ocean flows are greatly modified by variation in the strength and direction of winds, ocean temperatures and salinity, tides, the topography of the coastline, and the shape of the ocean bottom, among several other factors. The end result is a constantly changing sea of conditions.

The patterns are not completely random, however. Many aspects of ocean climates vary somewhat predictably in space, especially ones that are tied to key features of the coastline – points and headlands, river mouths, etc. Locations that share similar ocean climates are typically more similar in the types of species they harbor. Therefore, defining habitats for the MLPA and MPA networks must include habitats defined by coastal oceanography as well as the composition of the seafloor.
Although a wide range of oceanographic habitats could be defined for the California coastline, the science team suggests that three prominent habitats stand out because of their demonstrated importance to different suites of coastal species:

. • Upwelling centers
. • Freshwater plumes
. • Retention areas

The science team is not recommending isolating such features (some of which are of very large scale) as habitats to be designated as MPAs. However, MPAs could be designated that included or benefited from the presence of such features and processes.

Upwelling Centers

Upwelling is one of the most biologically important circulation features in the ocean. Upwelling occurs when deep water is brought to the surface. On average deep water is colder and more nutrient rich than surface waters. When upwelling delivers nutrients to the sunlit waters near the surface, it provides the fuel for rapid growth of marine plants, both plankton and seaweeds. Ultimately the added nutrients can energize the productivity of entire marine food webs. Upwelling regions are the most productive ocean ecosystems. The west coast of North America is one of the few major coastal upwelling regions on the entire planet (Chavez and Collins, 2000; Hickey, 1998). The major driver of upwelling along the California coastline is wind. Winds that blow from the north and northwest parallel to California's generally north-south coastline drive currents at the surface. Because of the complicated effects of friction and the rotation of the earth, surface water is pushed to the right of the direction of the wind (the Coriolis Effect). With winds blowing from the north and northwest, this effect pushes surface waters away from shore. As water is pushed offshore, it is replaced by water that is upwelled from below.

The rate of upwelling depends on many features that vary spatially along the coastline – the strength and direction of the wind, the topography of the shoreline, and the shape of the continental shelf are three of the most important. Capes and headlands play a key feature in all of these drivers of upwelling. They accelerate alongshore winds, and they channel coastal currents in such a way that upwelling intensity can increase dramatically in their vicinity. As a result, major headlands and capes from Pt. Conception north are commonly centers of upwelling associated with strong rates of offshore transport of surface waters, greatly elevated nutrient concentrations, and enhanced productivity offshore (Pickett and Paduan, 2003). Since major capes and headlands tend to be fairly regularly spaced along the California coastline, with an average spacing between 150 and 200 km (93 and 124 m or 81 and 108 nm), these upwelling centers drive cells of ocean circulation with relatively predictable patterns of flow. Enhanced offshore flow and upwelling emanates from headlands, versus eddies and locations of more frequent alongshore flow in the regions between headlands. These filaments of upwelled water are readily identified emanating from key headlands in most satellite images of ocean temperature or biomass of phytoplankton. Because the upwelling centers are locations of more frequent and intense offshore flow near the surface, which moves larvae and other plankton away from shore, and elevated nutrients, which fuels much more rapid algal productivity, these locations represent a distinct oceanographically driven coastal habitat with substantially different species composition and dynamics compared to other coastal locations.

Freshwater Plumes

A second coastal habitat driven by features of the water column is generated by the influence of rivers. Freshwater emerging from watersheds alters the physical characteristics of coastal seawater (especially salinity), changes the pattern of circulation (by altering seawater density), and delivers a variety of particles and dissolved elements, such as sediments, nutrients, and microbes. These effects all arise from the land and can have a profound influence on the success of different marine species. The mouths of watersheds set the locations of low salinity plumes, and the size and shape of the plume vary over time as functions of the volume of flow from the watershed, the concentration of particles, and the nature of coastal circulation into which the water is released. The location of California's freshwater plume habitats can be defined by both satellite and ocean-based measurements. In other parts of the country (e.g. Mississippi River delta) and the state (e.g. San Francisco Bay estuarine complex) the influence of this habitat type is much greater than it is in region~~a~~s such as the central California coast south of San Francisco.

Larval Retention Areas

Since connectivity and movement of larvae, plankton, and nutrients play such an important role in the impact of MPAs on different species, changes in the speed and direction of coastal currents can create very different ecological settings. A number of circulation features can greatly limit the coastal particles. In particular, features characterized by rotational flows, such as eddies, can greatly enhance the length of time that a particle or larval fish stays in a general region of the coastline. Such retentive features have been shown to significantly affect the species composition of coastal ecosystems (Largier, 2004). Since many retention areas are tied to fixed features of coastal topography (e.g., eddies in the lee of coastal headlands or driven by bottom topography), they define unique regions of coastal habitat that can be predictably defined.

Experience in California and elsewhere demonstrates that individual MPAs generally include several types of habitat in different depth zones, so that the overall number of MPAs required to cover the various habitat types can be smaller than the number of total habitats. The Master Plan Team convened in 2000 also called for considering adjacent lands and habitat types, including seabird and pinniped rookeries. Since marine birds and mammals are protected by federal regulations, they are not a primary focus of the MLPA. Nonetheless, these species can play important ecological roles and their success may be impacted by changes in other components of California's coastal ecosystems that are a primary focus of MLPA. Therefore, MPA planning needs to coordinate with other efforts focused on marine birds and mammals.

As noted regarding the design of MPAs, this guidance should be the starting point for regional discussions regarding representative habitats in a region. Although this guidance is not prescriptive, any significant deviation from it should be explained.

California Marine Life Protection Act
Suggested Text Revisions to the MPA Types Section of the
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State Marine Reserve

As defined in the MMAIA, a state marine reserve prohibits injuring, damaging, taking or possessing any living, geological, or cultural resources and must maintain the area "to the extent practicable in an undisturbed and unpolluted state" while allowing "managed enjoyment and study" by the public [PRC subsection 36710(a)]. The responsible agency may permit research, restoration, or monitoring. Such activities as boating, diving, research, and education may be allowed, to the extent feasible, so long as the area is maintained "to the extent practicable in an undisturbed and unpolluted state." Such activities may be restricted to protect marine resources. It specifically allows the agency to permit scientific activities. The definition of "marine life reserve" in the MLPA is consistent with this definition.

The MLPA and MMAIA thus require striking a balance between protection and access in marine reserves. The form that this balance takes in an individual marine reserve will depend upon the goals and objectives of that reserve. While the MLPA specifically precludes commercial and recreational fishing from marine reserves, it also authorizes restrictions on other activities, including non-extractive activities (e.g., diving, kayaking, snorkeling, etc.). Any such restrictions, however, must be based on specific objectives for an individual site and the best readily available science. It is important to note that this statement does not imply that navigation will necessarily be restricted though MPAs or that other non-extractive activities will be regulated, although in some instances the latter may be necessary. For example, it may be necessary to protect populations of sensitive marine birds or mammals in their nesting or breeding areas by prohibiting access to some areas.

The MLPA sets other requirements for the use of marine reserves. At FGC subsection 2857(c)(3), the MLPA requires "[s]imilar types of marine habitats and communities shall be replicated, to the extent possible, in more than one marine life reserve in each biogeographical region." Consistent with this approach, this Master Plan Framework foresees that in each biogeographical region described above, representative habitat across a range of depths should be represented in at least two marine reserves in order to assure the replication of habitats required by the MLPA. It should be noted that several of habitat types occur in only one depth zone, while others may occur in three or four depth zones. Experience demonstrates that individual MPAs generally include several types of habitat in different depth zones, so the overall number of marine reserves required to replicate the various habitat types may be less than the total combination of depth zones and habitats replicated across each region.

State Marine Park

As defined in the MMAIA, a state marine park prohibits injuring, damaging, taking or possessing for commercial use any living or nonliving marine resources. Other uses that would compromise the protection of living resources, habitat, geological, cultural, or recreational features may be restricted. All other uses are allowed, consistent with protecting resources.

State marine parks, hereafter called "marine parks", differ from marine reserves to different degrees in their purposes as well as the type of restrictions. Unlike marine reserves, marine parks allow some or all types of recreational fishing. The types of restrictions on fishing may vary with the focal species, habitats, and goals and objectives of an individual marine park within a region. Where the primary goal is biodiversity conservation, restrictions on fishing may be different from those in a marine park where the primary goal is enhancing recreational opportunities.

State Marine Conservation Area

In a state marine conservation area, activities that would compromise the protection of species of interest, the natural community[5], habitat, or geological features may be restricted. Research, education, and recreational activities, as well as commercial and recreational fishing may be permitted.

State marine conservation areas, hereafter called "marine conservation areas", also differ from marine reserves in their purpose as well as the type of restrictions. This type of MPA allows some level of recreational and/or commercial fishing. The restrictions on fishing may vary with the focal species, habitats, and goals and objectives of an individual MPA within a region, and may, for instance, be in the form of restrictions on the catch of particular species or on the use of certain types of fishing gear. Marine conservation areas may be useful in protecting more sedentary, benthic species, while allowing the harvest of migratory or pelagic species. Another use of a marine conservation area would be to allow the continued use of traps (which typically have relatively low bycatch rates and are more efficient for harvesting invertebrates) while prohibiting the harvest of finfish species of concern by hook-and-line or by trawls (which typically have relatively high bycatch rates). At present the large fishery closures known as the Cowcod Conservation Areas and the Rockfish Conservation Area may function as *de facto* marine conservation areas in that bottom fishing for finfishes is prohibited but other types of fishing are allowed, though the specific regulations in these areas are subject to change dependent on stock assessments.

Levels of Protection for MPA Classifications

The science team ~~regognized~~recognized that there is great variation in the type and magnitude of activities that may be permitted within the three types of MPAs, in particular SMPs and SMCAs. This variety ~~purposely~~intentionally provides designers of MPA network components with flexibility in proposing MPAs that either individually or collectively fulfill the various goals and objectives specified in the MLPA. However, this flexibility can result in complex and possibly confusing levels of protection afforded by any individual MPA or collection of MPAs. In particular, SMCAs allow for many possible combinations of recreational and commercial extractive activities. Therefore, MPA network component 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 network components.

Rationale for categories of protection

As part of the MLPA process, the science team evaluates MPA proposals particularly with respect to five MLPA goals: 1, 2, 3, 4, and 6. **Goal 1** addresses protection of the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems. **Goal 2** aims to help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted. One aspect of **Goal 3** that the science team evaluates is the opportunity to study marine ecosystems that are subject to minimal human disturbances. The science team specifically evaluates these proposals with respect to the replication of appropriate MPA designations, habitats, and control areas. **Goal 4** pertains to the protection of marine natural heritage, including protection of representative and unique marine life habitats in central California waters. **Goal 6** aims to ensure that MPAs are designed and managed, to the extent possible, as a network.

The likelihood that any particular MPA or collection of MPAs will meet any of these five goals is based in large part on the type and magnitude of removal or mortality (collectively referred to as “take”) of living marine resources that occurs within the MPAs. Three forms of take include (1) direct removal of a species from an MPA, (2) unintended incidental removal of a species in the process of targeting another species (referred to as “bycatch”), and (3) perturbation of the ecosystem in such a way that it leads to increased mortality of a species (e.g., alteration of habitat that leads to reduced refuge from predators). Take is not limited to fishing activities. For example, coastal power generating stations impinge fishes and invertebrates and entrain their larvae in the process of drawing ocean water for cooling systems. Likewise, many minor seawater intakes and sewage outfalls occur along the coast. The impacts of seawater intakes and sewage outfalls can be diffuse in nature, and can affect ecosystems both locally and regionally. The extent of these impacts is largely unknown. For example, at Diablo Canyon Power Generating Station, differences in adult populations due to intake effects have not been detected. Therefore, the science team will not evaluate these potential sources of impacts on individual MPAs. Additionally, commercial kelp harvest can reduce habitat availability and may directly and indirectly increase mortality of juvenile fishes. Thus, the level of protection and conservation value afforded by any particular MPA depends very much on the type and magnitude of fishing and other human activities that will be allowed within the marine protected areas.

State ~~M~~marine ~~R~~reserves (SMRs) provide the *greatest level of protection* to species and to ecosystems by allowing no take of any kind (with the exception of scientific take for research, restoration, or monitoring). The high level of protection created by an SMR is based on the assumption that no other appreciable level of take or alteration of the ecosystem is allowed (e.g., sewage discharge, seawater pumping, kelp harvest). In particular, SMRs provide the greatest likelihood of achieving MLPA goals 1, 2, and 4.

State ~~M~~marine ~~P~~parks (SMPs) 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 low 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 ~~M~~marine ~~C~~conservation a~~A~~reas (SMCAs) potentially have the most variable levels of protection and conservation of the three MPA designations because they allow any combination of commercial and recreational fishing, as well as other extractive activities (e.g., kelp harvest). ~~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~~ pelagic species (e.g., albacore, swordfish, pelagic sharks). This has led to proposals of SMCAs that prohibit take of bottom-dwelling species, while allowing the take of transient pelagic species. However, fishing for some pelagic species, like salmon near the bottom or in relatively shallow water, increases the likelihood of taking bottom species that are targeted for protection (e.g., California halibut, lingcod, rockfishes). Rates of bycatch are particularly high in shallow water where bottom fish move close to the surface and become susceptible to the fishing gear. In addition, for recreational salmon fishing, the practice of "mooching" has a potentially higher bycatch rate than that of trolling.

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

SMCA High Protection – These SMCAs protect benthic communities, both directly and indirectly, and allow only the take of highly transient pelagic species. Proposed SMCAs that prohibit take of all species except salmon and coastal pelagics in water depth greater than 50m (164 ft) were placed in this category. SMCAs with High Protection are equivalent to SMRs

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

for protecting many, but not all, species and habitats. However, our understanding of the interactions among pelagic species and the benthic community is incomplete. Moreover, salmon fishing in deep water (>50m) can be conducted near the bottom, resulting in bycatch of benthic species. Therefore these SMCAs do not have as high protection and conservation value as no-take SMRs, and are less likely to achieve MLPA goals 1,2, and 4. Moreover, SMRs are needed to evaluate the effects of SMCAs that allow the take of coastal pelagics (including salmon).

As another example, tThe science team has categorized one proposed MPA in the central coast region as an SMCA with high protection, rather than as an SMR, because of the negative influence of elevated temperature of the cooling water discharged from a nuclear power generating station. Although thermal impact of the cooling water discharge is constrained largely to the intake cove of this power plant and to the intertidal environment roughly 1.4 miles to the north of the intake cove, this is sufficient impact to warrant an SMCA-high designation[2].

SMCA Moderate Protection – These SMCAs protect the majority of benthic species and their habitats while allowing for the take of transient pelagics, selected benthic fishes and invertebrates, and giant kelp (hand harvested only; see kelp harvesting section below). Proposed SMCAs in central California that prohibit take of all species except salmon, pelagic fishes, squid, jacksmelt, butterfish, crab, spot prawn, and giant kelp were placed in this category. A modified list of species may be appropriate in other parts of the state. These MPAs are considered to provide relatively lower protection than SMRs and SMCAs (High) primarily because they allow the take of species (crab, spot prawn and, to a lesser extent, squid) that have direct interaction, as predator, prey or habitat of those species targeted for protection. Thus, removal of these species can potentially affect the overall ecosystem (Goal 1) as well as particular species targeted for protection that feed on or otherwise interact with these species (Goal 2). In addition, take of crabs and spot prawns that live on the seafloor increases the likelihood of bycatch of those bottom-dwelling species that are targeted for protection (i.e. rockfishes).

Although bycatch of bottom-dwelling species in market squid landings is considered minimal, the presence of bycatch has been documented through CDFG's port sampling program. The port sampling program records bycatch (i.e., presence or absence evaluations), but actual amounts of bycatch have not been quantified to date. During 2004, bycatch was present in about forty-nine percent of the observed squid landings, but species that constituted bycatch were primarily other coastal pelagics. Benthic species targeted for protection by MPAs comprised a very small component of the squid fishery (CDFG[3]). Spawning squid occur near the bottom when attaching their egg masses directly onto sand sediment. Occurrence of squid as bycatch in bottom trawls also indicates their presence on or near the bottom and their co-

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[2] Issues and environmental impacts associated with once-through cooling at California's coastal power plants. 2005. California Energy Commission, CEC-700-2005-013. Sacramento, CA. 81 pp + Appendices.

[3] ~~table 7b P. Reilly's information~~ California Dept. Fish and Game, P. Reilly, personal communication)~~(need proper citation)~~

occurrence with benthic species. Landing receipts from the commercial butterfish and jacksmelt fisheries indicate some bycatch of benthic soft-bottom species such ~~aas~~as white croaker.

The magnitude of bycatch in the commercial spot prawn trap fishery[4] was quantified from a CDFG observer program in 2000-2001. In central California (Pt. Conception to Monterey Bay), an average of about 150 pounds of bottom-dwelling fish was taken with every 1000 pounds of spot prawns. Thirty species of finfish were observed as bycatch in the spot prawn trap fishery. The top five species, in decreasing frequency of occurrence, were sablefish, rosethorn rockfish, greenblotched rockfish group (includes greenblotched, greenspotted, and pink rockfish), spotted cusk eel, and filetail catshark, comprising 78% of all fishes in the catch (by weight). Observed bycatch included seventeen species of rockfishes. Sea stars constituted the vast majority of invertebrates taken as bycatch. Other invertebrates included red rock crab, a large sea slug, galatheid crab, urchin, octopus, box crab, hermit crab, decorator crab, brittle star, feather star, and sea cucumber. Most invertebrates and many fish species, other than rockfishes, could be returned to the water alive.

Bycatch associated with the Dungeness crab trap fishery has not been documented. Although some fishes associated with sand sediments are likely caught in this fishery, other crabs (mostly rock crab) are the only species reported in Dungeness crab landings[5].

SMCA Low Protection – These SMCAs protect some benthic species and their habitats. These proposed SMCAs allow various forms of commercial and recreational fishing and kelp harvesting. Both the directed take and potential bycatch from those fisheries will greatly limit the conservation value of these MPAs relative to SMRs and SMCAs of high and moderate protection. Also, mechanical harvest of giant kelp and the harvest of bull kelp by any method result in both direct and indirect take of many invertebrate and fish species (see kelp harvesting section below). As such, these SMCAs are least likely to assist in achieving MLPA goals 1, 2, and 4.

Kelp harvesting – Potential impacts of kelp harvesting depend on the species of kelp, the method of harvest (mechanical or hand collection), and the volume of plant material removed. For both methods, take is constrained by regulations to the upper 1.2 m (4 feet) of the forest canopy formed at the surface of the ocean. Harvest of kelp forests is targeted primarily at the giant kelp, *Macrocystis pyrifera*, and secondarily the bull kelp, *Nereocystis luetkeana*. Importantly, giant kelp is a perennial (individual plants can live multiple years), and reproduction and new growth occur at the bottom of the plant. In contrast, bull kelp is an annual (individuals live only one year), and reproduction and new growth occur at the top of the plant. In addition the gas-filled bladder responsible for keeping the bull kelp erect is

[4] Reilly, P.N. and J. Geibel. 2002. Results of California Department of Fish and Game Spot Prawn Trawl and Trap Fisheries Bycatch Observer Program 2000-2001. Report prepared for the California Fish and Game Commission (July 2002).

[5] ~~Table on crab landings; need proper citation from Paul R~~California Dept. Fish and Game, P. Reilly, personal communication).

located at the surface. Therefore, kelp harvesting, regardless of method, has a greater negative impact on bull kelp than on giant kelp.

Assessments of the impact of harvest (both mechanical and hand) on giant kelp suggest minimal impact to the kelp plants themselves because the plants are not removed entirely and can re-grow rapidly to replace the removed canopy. Moreover, the reproductive portion of the plant is left intact at the bottom of the plant. However, harvest near the end of the summer may result in loss of the canopy for the remainder of the growing season. Whereas the amount of harvested bull kelp is much less than that of giant kelp, no impact assessment of harvesting has been conducted for bull kelp in California. However, negative impact to individuals and populations of bull kelp is likely to be much greater than giant kelp because the reproductive and growth capacity of the plants is terminated with harvest.

Of additional, and perhaps greater, concern with the harvesting of kelp is the (1) loss of habitat provided by the forest canopy for other species, (2) loss of production of plant material that is fed on by numerous grazers and detritivores in kelp forests and other habitats where drift kelp contributes to local productivity (e.g., heads of submarine canyons and sandy beaches), and (3) take (i.e. bycatch) of other species closely associated with the canopy habitat. The two harvesting methods differ markedly with respect to these three impacts. Mechanical kelp harvest is conducted by large, specially designed vessels that remove large volumes of the forest canopy and kill many associated species of fishes and invertebrates (including many species of juvenile rockfishes). Loss of habitat and food provided by kelp canopies translates to changes in growth, survival, and reproduction of those species associated with the canopy. The coastwide impact of this mortality on juvenile rockfishes has not been assessed. However, the impact to an individual kelp forest within a proposed MPA is likely to be substantial, with the loss of large numbers (1,000's) of juveniles. Because of the impacts of mechanical kelp harvest on the well-understood role of kelp to the structure, function, and services provided by kelps to shallow reef ecosystems (Goal 1), and on many species targeted for protection (Goal 2), SMCAs that allow mechanical harvest of kelp, even if no other extractive activities are permitted, are *considered to be of low protection and conservation value*.

Impacts of hand harvest of kelp in support of the abalone mariculture industry have received less attention, in large part because of the presumed lesser impact of this method compared to mechanical harvest. The reduced impact is based in part on the lower volume of plant material removed and the likelihood that juvenile fishes are less likely to be removed with the canopy. However, experiments by CDFG in 1977 indicated that kelp canopy removal might increase the likelihood that young-of-the-year rockfishes are consumed by opportunistic, predatory fishes such as juvenile bocaccio[6]. Repeated collection of the kelp canopy from the same area likely increases local-scale impacts on habitat and food production. Because the impacts of hand harvest on the well-understood role of kelp to the structure, function and services

[6] Houk, J.L. and K. McCleneghan. 1993. Effects of kelp canopy removal on young-of-the-year rockfish abundance, using two census methods. California Dept. Fish and Game, Administrative Report No. 93-5. 29 p

provided by kelps to shallow reef ecosystems (Goal 1), and on many species targeted for protection by MPAs (Goal 2) are less than the impacts from mechanical harvest, SMCAs that allow hand harvest of kelp are *considered to be moderate in their protection and conservation value*.