California Marine Life Protection Act Initiative
Excerpts from Guiding Documents for Designing a System of MPAs
Revised September 7, 2008

The following excerpts from the Marine Life Protection Act (MLPA) and the *California Marine Life Protection Act Master Plan for Marine Protected Areas* are provided to orient you towards the science guidance provided during the MLPA process. These documents provide guidance, both mandated and recommended, for designing a network of marine protected areas (MPAs). Provided are sections of the MLPA that describe mandatory and recommended features of the MPA program and individual MPAs as well as scientific guidelines for MPA networks and individual MPAs. The following are brief overviews of each.

Marine Life Protection Act

Overview of California Fish and Game Code (FGC) sections:

Section 2853 of the FGC provides the overall goals and elements that must be included in the California Fish and Game Commission's Marine Life Protection Program. As the overall statewide system must work to achieve these goals and include these elements, individual MPAs should each help achieve portions of the goals and elements.

Subsection 2856(a)(2) provides the components that must be included in the master plan, which guides the adoption and development of the Marine Life Protection Program. These components have been incorporated in both the *California Marine Life Protection Act Master Plan Framework*, which was adopted by the California Fish and Game Commission in August 2005, and the current draft *California Marine Life Protection Act Master Plan for Marine Protected Areas*, which guides the present planning process.

Subsections 2857(b) and 2857(c) provide the required objectives and guidelines for developing a preferred MPA network alternative. These objectives and guidelines are specific to individual MPAs within the preferred alternative. It is important to note that subsection 2857(c) is specific to "marine life reserves" which are defined as no-take areas by the MLPA and now classified as "state marine reserves". Subsection 2857(d) makes a simple statement that the existence and location of commercial kelp beds must be taken into account in developing the preferred alternative.

Master Plan Scientific Guidance

The MLPA Master Plan Science Advisory Team (SAT) provided guidance in meeting the MLPA standards which was adopted by the California Fish and Game Commission in the *California Marine Life Protection Act Master Plan Framework*, and has been carried forward in the draft *California Marine Life Protection Act Master Plan for Marine Protected Areas*. The 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 the guidance is not prescriptive, the master plan states that 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. In summary, the guidance states:

- There is not a single optimum network design in all environments.

- Every ‘key’ marine habitat should be represented in the MPA network.
- MPAs should extend from the intertidal zone to deep waters offshore.
- 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.
- 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.
- "Key" marine habitats should be replicated in multiple MPAs across large environmental and geographic gradients.
- At least three to five replicate MPAs should be designed for each habitat type within a biogeographical region.
- 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.
- The network design should account for the need to evaluate and monitor biological changes within MPAs.

Attachments

1. *Sections from the Marine Life Protection Act Addressing Required MPA and MPA Network Features (From Fish and Game Code, 2007)*
2. *Science Guidance on MPA Network Design.* Excerpts from the draft *California Marine Life Protection Act Master Plan for Marine Protected Areas* (January 2008 draft), Pages 34-46

Sections from the Marine Life Protection Act
Addressing Required MPA and MPA Network Features
(From Fish and Game Code, 2007)

[Please note that text in brackets is added for readability purposes only and is not part of the statute]

§ 2853. [Goals and Elements of the Marine Life Protection Program]

(a) The Legislature finds and declares that there is a need 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.

(b) To improve the design and management of that system, the commission, pursuant to Section 2859, shall adopt a Marine Life Protection Program, which shall have all of the following goals:

(1) To protect the natural diversity and abundance of marine life, and the structure, function, and integrity of marine ecosystems.

(2) To help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.

(3) 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.

(4) To protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value.

(5) To ensure that California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, and are based on sound scientific guidelines.

(6) To ensure that the state's MPAs are designed and managed, to the extent possible, as a network.

(c) The program may include areas with various levels of protection, and shall include all of the following elements:

(1) An improved marine life reserve component consistent with the guidelines in subdivision (c) of Section 2857.

(2) Specific identified objectives, and management and enforcement measures, for all MPAs in the system.

(3) Provisions for monitoring, research, and evaluation at selected sites to facilitate adaptive management of MPAs and ensure that the system meets the goals stated in this chapter.

(4) Provisions for educating the public about MPAs, and for administering and enforcing MPAs in a manner that encourages public participation.

(5) A process for the establishment, modification, or abolishment of existing MPAs or new MPAs established pursuant to this program, that involves interested parties, consistent with paragraph (7) of subdivision (b) of Section 7050, and that facilitates the designation of MPAs consistent with the master plan adopted pursuant to Section 2855.

§ 2856. [Master Plan Components]

(a)(2) The master plan shall include all of the following components:

(A) Recommendations for the extent and types of habitat that should be

represented in the MPA system and in marine life reserves. Habitat types described on maps shall include, to the extent possible using existing information, rocky reefs, intertidal zones, sandy or soft ocean bottoms, underwater pinnacles, sea mounts, kelp forests, submarine canyons, and seagrass beds.
(B) An identification of select species or groups of species likely to benefit from MPAs, and the extent of their marine habitat, with special attention to marine breeding and spawning grounds, and available information on oceanographic features, such as current patterns, upwelling zones, and other factors that significantly affect the distribution of those fish or shellfish and their larvae.
(C) Recommendations to augment or modify the guidelines in subdivision (c) of Section 2857, if necessary to ensure that the guidelines reflect the most up-to-date science, including, for example, recommendations regarding the minimum size of individual marine life reserves needed to accomplish the various goals set forth in Section 2853.
(D) Recommended alternative networks of MPAs, including marine life reserves in each biogeographical region that are capable of achieving the goals in Section 2853 and designed according to the guidelines in subdivision (c) of Section 2857.
(E) A simplified classification system, which shall be consistent with the goals of Section 2853 and the guidelines in subdivision (c) of Section 2857, and which may include protections for specific habitats or species, if no system that meets these specifications has already been developed.
(F) Recommendations for a preferred siting alternative for a network of MPAs that is consistent with the goals in Section 2853 and the guidelines in subdivision (c) of Section 2857.
(G) An analysis of the state's current MPAs, based on the preferred siting alternative, and recommendations as to whether any specific MPAs should be consolidated, expanded, abolished, reclassified, or managed differently so that, taken as a group, the MPAs best achieve the goals of Section 2853 and conform to the guidelines in subdivision (c) of Section 2857.
(H) Recommendations for monitoring, research, and evaluation in selected areas of the preferred alternative, including existing and long-established MPAs, to assist in adaptive management of the MPA network, taking into account existing and planned research and evaluation efforts.
(I) Recommendations for management and enforcement measures for the preferred alternative that apply systemwide or to specific types of sites and that would achieve the goals of this chapter.
(J) Recommendations for improving the effectiveness of enforcement practices, including, to the extent practicable, the increased use of advanced technology surveillance systems.
(K) Recommendations for funding sources to ensure all MPA management activities are carried out and the Marine Life Protection Program is implemented.

§ 2857. [The Preferred Siting Alternative]

(b) The preferred alternative may include MPAs that will achieve either or both of the following objectives:

(1) Protection of habitat by prohibiting potentially damaging fishing practices or other activities that upset the natural ecological functions of the area.
(2) Enhancement of a particular species or group of species, by prohibiting or

restricting fishing for that species or group within the MPA boundary.

(c) The preferred siting alternative shall include MPA networks with an improved marine life reserve[1] component, and shall be designed according to each of the following guidelines:

(1) Each MPA shall have identified goals and objectives. Individual MPAs may serve varied primary purposes while collectively achieving the overall goals and guidelines of this chapter.

(2) Marine life reserves in each bioregion shall encompass a representative variety of marine habitat types and communities, across a range of depths and environmental conditions.

(3) Similar types of marine habitats and communities shall be replicated, to the extent possible, in more than one marine life reserve in each biogeographical region.

(4) Marine life reserves shall be designed, to the extent practicable, to ensure that activities that upset the natural ecological functions of the area are avoided.

(5) The MPA network and individual MPAs shall be of adequate size, number, type of protection, and location to ensure that each MPA meets its objectives and that the network as a whole meets the goals and guidelines of this chapter.

(d) The department and team, in developing the preferred siting alternative, shall take into account the existence and location of commercial kelp beds.

1 Marine Life Reserve, as defined by the Marine Life Protection Act is a no-take area now designated as a "State Marine Reserve"

Science Guidance on MPA Network Design
Excerpt from the draft *California Marine Life Protection Act Master Plan for Marine Protected Areas* (January 2008 draft), Pages 34-46

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. (See Appendix R for science methodology specific to each study region).

The science team provides the following guidance in meeting the MLPA standards. 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.

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 nursery or spawning grounds to adult habitats, 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 mi or 2.5-5.4 nmi) of coastline, and preferably 10-20 km (6-12.5 mi or 5.4-11 nmi). Larger MPAs should 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 mi or 27-54 nmi) of each other.

- "Key" marine habitats (defined below) should be replicated in multiple MPAs across large environmental and geographic gradients to protect the greater diversity of species and communities that occur across such gradients, and to protect species from local year-to-year fluctuations in larval production and recruitment.

- 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 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. ***Different marine habitats support particular species and biological communities, which in themselves vary across large-scale environmental gradients*** (see Literature cited in *Master Plan for Marine Protected Areas*)

MPA networks should include "key" marine habitats (defined below), and each of these habitats should be represented in multiple MPAs across biogeographical regions, upwelling cells, and environmental and geographical gradients.

The strong association of most demersal (live on or near the ocean bottom) 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. "Key" habitat types provide particular benefits by harboring a different set of species or life stages, having special physical characteristics, or being used in ways that differ from the use of other habitats. For the purpose of evaluation, key habitat types were considered to be:

• sand beach • rocky intertidal • estuary • shallow sand • deep sand	• shallow rock • deep rock • kelp • shallow canyon • deep canyon

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 Literature cited in *Master Plan for Marine Protected Areas*)

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 and groups of species that have special significance because of their dominant role in ecosystems or their economic importance. Ecologically dominant species play the largest roles in the function of coastal ecosystems, and 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 Literature cited in *Master Plan for Marine Protected Areas*)

The way people use coastal marine environments is highly diversified in method, goals, timing, economic objectives, and spatial patterns. The wide spectrum of environmental uses should be a part of decisions comparing alternative 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 among the various negative and positive impacts 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 (e.g., 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 Literature cited in *Master Plan for Marine Protected Areas*)

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 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 mi or 2.5-11 nmi) or less over the course of a year (Lea, McAllister, and VenTresca 1999). 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 mi or 2.5-5.4 nmi) in extent along coastlines may leave many individuals of important species poorly protected. Larger MPAs, spanning 10-20 km (6-12.5 mi or 5.4-11 nmi) 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 relatively difficult to protect species whose ranges generally extend beyond MPA boundaries. This is due to the fact that highly mobile species will spend the majority of their lives outside the protected area and thus receive little added protection by its establishment. Non-mobile species, conversely, may spend their entire life within the protected area and be completely protected from human take. In light of this, special consideration in MPA network design is paid to species with intermediate mobility, which will not only receive significant protection but also be available for take when outside MPA boundaries. With MPAs spanning 10-20 km (6-12.5 mi or 5.4-11 nmi) 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., bycatch). 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, an 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, species distribution, and relative abundance.

6. ***Spacing between MPAs*** (see Literature cited in *Master Plan for Marine Protected Areas*)

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 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 (31-62 mi or 27-54 nmi) appears common in marine invertebrates (Kinlan, Gaines, and Lester 2005; Kinlan and Gaines 2003; Shanks, Grantham, and Carr 2003; Siegel et al. 2003). For fishes, larval neighborhoods based on genetic data appear generally larger, ranging up to 100-200 km (62-124 mi or 54-108 nmi). For marine birds and mammals, dispersal of juveniles of hundreds of kilometers 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 50-100 km (31-62 mi or 27-54 nmi) a large fraction of coastal species will gain no benefits from connections between MPAs.

Current patterns of 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 few coastal marine species in California that allow these estimates of larval neighborhoods to be made with confidence. Nonetheless, 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.

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 mi (1 and 25 nmi). 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 negative impacts. However, MPAs often become magnets for fishing along their edges. These situations create positive impacts 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, in general, MPAs do not restrict transit.

9. Human activity patterns

Human activities have distinct hotspots where effort is concentrated. In certain cases there may be an ecological benefit from eliminating certain activities while their may be socioeconomic benefit from allowing others. Areas of intense use will not only be those most impacted by human perturbation of the ecosystem, but also those where eliminating certain consumptive uses may cause high levels of short-term economic impact. It is recommended that proposals consider, in their design, areas of intensive human use and the cost and benefit of establishing MPAs in these areas.

Consideration of Habitats in the Design of MPAs (see Literature cited in *Master Plan for Marine Protected Areas*)

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 (0 to 16 fm), 30 meters to 200 meters (16 to 109 fm), and beyond 200 meters (beyond 109 fm). 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 several ways:

1. Based on information about fish depth distributions provided in a new book on the ecology of California marine fishes (Allen, Pondella, and Horn 2006), 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. 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 distinguished these habitat types using the highest resolution bathymetry data available, when calculating percent of each habitat within proposed MPAs. For the purposes of linking habitats within a network or network component, each MPA was characterized by the habitats that it includes in an ecologically meaningful amount. For the purpose of evaluating whether habitats are adequately represented within individual MPAs, the following factors must be

considered: the relative amount of that habitat in the entire region, the overall size of the MPA, and the home range of species likely to benefit from protection in an MPA that rely upon that habitat.

6. In the central coast region, high-resolution bathymetric imagery data were not available for most of the southern half of the region. Coarse-scale bathymetry 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. Maps derived from recreational CPFV (Commercial Passenger Fishing Vessel) fishing data for rockfish trips and maximum extent of kelp should be used to develop proxies for the location of hard-bottom habitat for any region in which high resolution maps do not exist; these in turn should be used for habitat calculations for proposed MPAs.

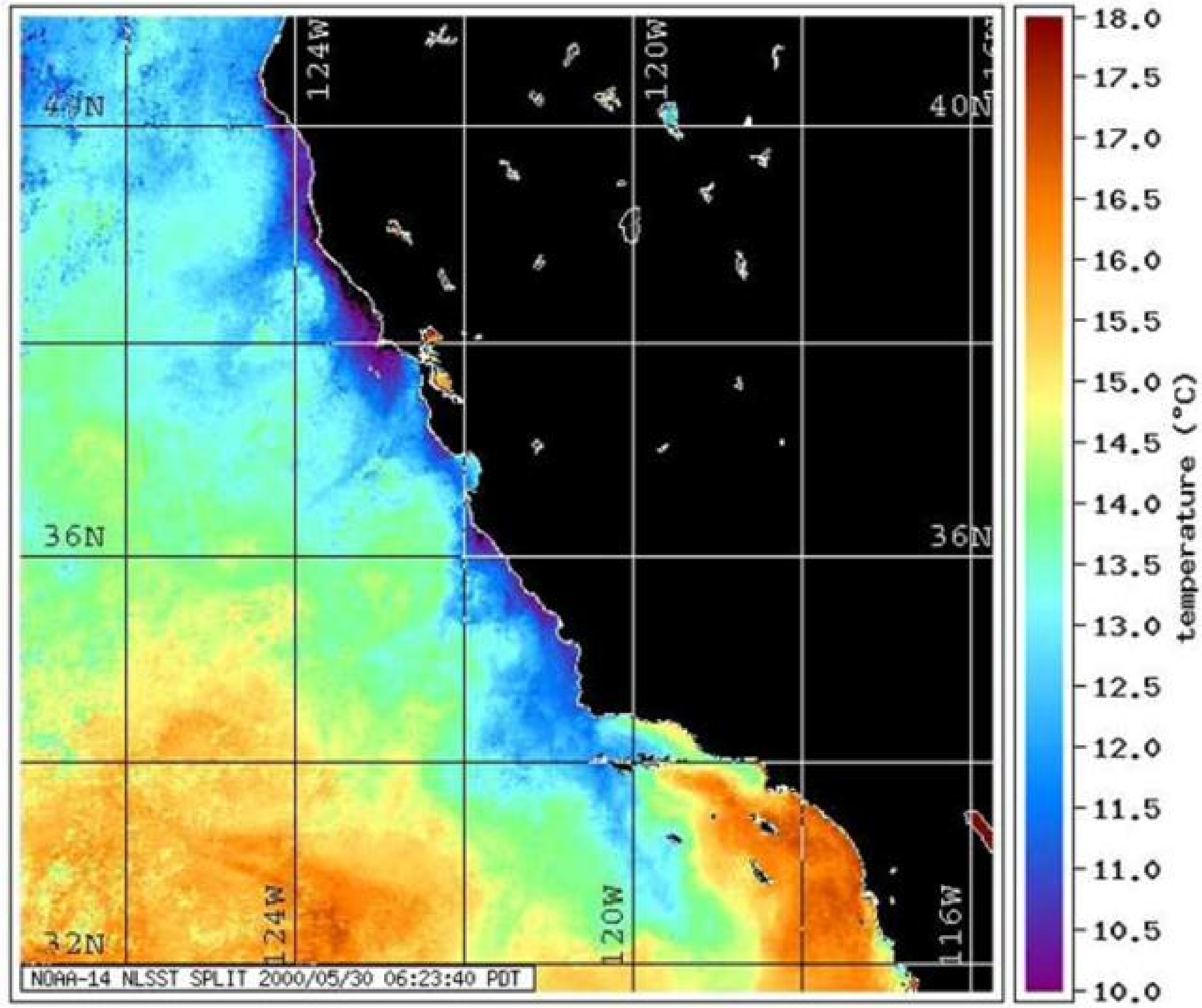
The oceanography of the California coastline is dominated by the influence of the California Current System. On the continental shelf and slope this system consists of two primary currents: the California Current, which flows toward the equator, and the California Undercurrent, which flows toward the North Pole (Hickey 1979, 1998). When present, the undercurrent occurs beneath the southward flowing California Current. North of Point 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, such as points, headlands, and river mouths. 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.

FIGURE 4 An example of sea surface temperature in the California coastal waters, May 30, 2000



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

It is not recommended that such features (some of which are of very large scale) be isolated as habitats to be designated as MPAs or specifically encompassed within MPAs. However, MPAs could be designated that included or benefited from the presence or proximity 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 Point 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 mi or 81 and 108 nmi), 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 regions such as the central California coast south of San Francisco.

Larval Retention Areas (see Literature cited in *Master Plan for Marine Protected 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.

Species Likely to Benefit from MPAs

Recommending the extent of habitat that should be included in an MPA network will require careful analysis and consideration of alternatives. These recommendations may vary with habitat and region, but should be based on the best readily available science. One aspect of determining appropriate levels of habitat coverage is the habitat requirements of species likely to benefit from MPAs in a region. California FGC subsection 2856(a)(2)(B) requires that the master plan identify "select species or groups of species likely to benefit from MPAs, and the extent of their marine habitat, with special attention to marine breeding and spawning grounds, and available information on oceanographic features, such as current patterns, upwelling zones, and other factors that significantly affect the distribution of those fish or shellfish and their larvae."