# California MLPA Master Plan Science Advisory Team
## Draft Proposed Concepts for Designing Experimental MPAs to Inform Adaptive Management
### *May 10, 2010 Draft*

With the short history of marine protected areas (MPAs) along the west coast of North America, there is some uncertainty in how design aspects of individual MPAs (e.g., size, shape, allowed activities) and a network of MPAs (e.g., spacing, replication) will translate into individual MPA and overall network performance. The number and diversity of MPAs created by the MLPA, and replication of design aspects across the network, provide managers with an unprecedented opportunity to assess how MPAs perform in meeting their identified objectives and to consider refinements to MPA design to better meet objectives.

**Designing MPA Networks for Adaptive Management**

If the development of an MPA network includes designs for comparing design criteria, such as replication of different sizes or allowed activities, then scientists, managers and stakeholders can consider possible refinements of the design of individual MPAs and their network. This approach, referred to as adaptive management, is the hallmark of informed evolution of a management approach. The MLPA Master Plan Science Advisory Team (SAT) endorses incorporating this approach with designs based upon our current best understanding of design criteria. An adaptive management approach is one in which ecosystems (e.g., kelp forests) and elements of design criteria (e.g., different MPA sizes, different habitat sizes, different allowed activities) are replicated to allow comparison of the average response of selected variables of an ecosystem (e.g., the size and size structure of populations, species richness, productivity, resiliency) to the different levels of the design criterion.

MPAs can provide information for adaptive management in a variety of ways. MPAs that span a gradient in a design criterion (e.g., over a span of MPA or habitat sizes) can inform regression approaches that test for significant directional responses across the gradient. Coupled with additional criteria (e.g., allowed uses), these MPAs can be used to assess the interactive effects of two variables (in, for example, an analysis of covariance). Alternatively, MPAs can be designed to address specific questions, such as the impact of a particular allowed use (species or gear) on an ecosystem. In cases where MPAs are designed to address specific questions, it is important that MPA design manipulates each variable independently and the response of variables to such manipulations are not confounded with other activities that might be allowed in these MPAs. Any ecosystem components that are anticipated to respond to the manipulations must be monitored during the experiment including multivariate responses (e.g., the relative abundance of species in a fish assemblage).

|  | **Use of Gear A** | **No Use of Gear A** |
|---|---|---|
| **Use of Other Gears** | Non-MPA | State marine conservation area that allows all gear except gear A |
| **No Use of Other Gears** | State marine conservation area that allows only the use of gear A | State marine reserve |

One example of adaptive management design that could be fruitful in the MLPA North Coast Study Region is assessment of the relative effects of human take of red sea urchins in shallow kelp forests on a number of ecosystem variables directly related to the goals of the MLPA. In the absence of predatory sea otters (*Enhydra lutris*), both red and purple sea urchins (*Strongylocentrotus franciscanus* and *S. purpuratus,* respectively) have been shown to deforest large areas of shallow rocky reefs in California (Graham 2004, Graham et al 2008). To the extent that human harvest of commercially valuable red sea urchins can prevent deforestation of kelp forests, urchin harvest may protect or enhance the many functional roles of algae, their productivity and diversity of species associated with algal habitats.

On the other hand, many examples of urchin outbreaks (both red and purple urchins) and deforestation occur in regions where both otters and other natural urchin predators are depleted by current or historical harvest. In the north coast study region, sea otters are absent but other natural urchin predators, including the wolf eel (*Anarrhichthys ocellatus*) and sunflower sea star (*Pycnopodia helianthodes*), are not subject to fishing pressure and thus may control urchin populations and prevent kelp deforestation. In particular, predation by the sunflower sea star has been shown to be important in controlling sea urchin populations in cold water ecosystems similar to those founding the north coast study region (Duggins 1983). In fact there is little evidence to suggest that unfished urchin populations create "urchin barrens" with no kelp, devoid of fleshy algae and dominated by encrusting coralline algae in the north coast region (L. Rogers-Bennett, in prep). Moreover, urchins play a complex role in the ecosystem that is not yet fully understood.

Sea urchins compete with other herbivores for both drift and intact algae. They also compete with other species for refuge from predators in cracks and crevices. In particular, sea urchins may compete with adult abalone for both drift algae and refuge space (Karpov et al. 2001). In contrast, red sea urchins serve as nursery sites for other small invertebrates, protecting them from predators during their vulnerable life stages. Young abalone seek shelter beneath the spines of red sea urchins and the density of abalone recruits can be greater in northern California MPAs where red sea urchins are protected from take (Rogers-Bennett and Pearse 2001). Red sea urchins act as habitat for juvenile red sea urchins and a suite of other small invertebrates including snails, crabs and invertebrates particularly in shallow habitats in northern California (Rogers-Bennett et al. 1995) and elsewhere in the world. The protection afforded by red sea urchin spines might be even more important for abalone recruits and other invertebrates in the north coast study region, due to the stronger storms and overall shallower rocky reefs of the region, particularly in comparison to other study regions. Due to the variety and complexity of ecosystem roles played by urchins (e.g. grazer, competitor, facilitator, and prey) there is substantial uncertainty in the ecosystem-wide consequences of urchin harvest.

In order to more fully understand the role that species like sea urchins play in the ecosystem, experimental MPAs can be designed to test hypotheses about the interactions between urchins and other marine organisms. For example, MPAs designed to assess the relative effects of urchin harvest on a variety of ecosystem variables, including the abundance of abalone, would include replicate areas with and without urchin harvest in which none of the response species used to indicate the state of the rocky reef ecosystem (e.g. abalone, kelp, nearshore rockfish) may be harvested.

Comparison of the average response of ecosystem variables (e.g., kelp abundance, productivity, resilience, abundance and larval production of response species) among these states would allow managers to better understand the ecosystem-wide consequences of human take of red sea urchins and the role that urchins play in the nearshore rocky reef ecosystem.

**Design Considerations for Experimental MPAs Designed to Test Adaptive Management Hypotheses**

MPAs proposed to test hypotheses to inform adaptive management require different design guidelines from MPAs designed for conservation of one or multiple ecosystems. Both spatial and temporal design criteria are important considerations. Key criteria for the spatial design include the size of habitat within the MPA, size of the MPA, number of replicate MPAs and the location of these MPAs. The size of habitat necessary in these MPAs will vary, depending on the hypothesis (i.e. management question) to be tested and the area required to test that hypothesis. For example, if the hypothesis is to determine the extent to which removal of one species affects the density of another, then the experimental MPA areas should scale to the larger movement range of the two species of interest. If the hypothesis is to determine the extent to which removal of one species affects multiple ecosystem variables, then the experimental MPA area should be sufficiently large to detect a response in all of the ecosystem variables of interest (e.g. algal abundance and diversity, abundance of nearshore rockfish species, abalone abundance).

As a general guideline, some population and ecosystem-level responses have been detected in small MPAs and other managed areas that have existed within the MLPA North Coast Study Region prior to passage of the MLPA. For example, differences in abalone and urchin abundance as compared to nearby fished areas have been observed in the Caspar Urchin Closure, which extends along roughly 0.9 km (0.6 mi) of coastline and a similar distance offshore and is comprised mostly of shallow rocky reef habitat (Rogers-Bennet and Pearse 2001). Experimental MPA areas proposed to test species responses should be evaluated by the expected density of species supported by habitat within the MPA, the size and shape of the habitat, and the relative movement distance of species to be studied. For these MPAs, the size of the MPA can match the size of the experimental habitat, unless a spatial buffer to fishing effects seems necessary.

The location of the experimental MPA areas should incorporate buffers to facilitate experimental manipulations. For example, if the purpose of the experimental area is to determine the effect of urchin removal on nearshore rocky reef ecosystems, then the experimental area should be separated from areas that prohibit urchin take by a buffer zone in which urchins are harvested.

Experimental areas may be designed in one of two ways: either the experimental manipulations may be included in MPA regulations through a complex of MPAs with different allowable take (Figure 1), or a single larger MPA may be proposed with the intention of allowing experimental take areas within it, after implementation (Figure 2). In the first option, a complex of MPAs with different allowable take, the MPAs themselves would constitute the experimental treatments and these areas would be open to harvest of allowed species by any

individual holding a valid permit for harvest. In this scenario, either the MPA complex that constitutes the experimental treatments is replicated (i.e. two or more state marine reserve (SMR)-state marine conservation area (SMCA) complexes) or the SMR is not replicated and a before-after-comparison-impact (BACI) design is invoked. The levels of protection assigned to the experimental MPAs within this complex would correspond with those assigned by the SAT for recreational and commercial harvest of the species allowed.

In the second option outlined above, a larger MPA area may be designed with the express intention of allowing experimental manipulations of particular species, with appropriate treatment levels (e.g., harvest, non-harvest) and buffer zones within that MPA. In this case, the species targeted for experimental take would not be included in the MPAs allowable take regulations, and thus would not alter the level of protection assigned to the MPA, but would be included under the research and monitoring activities allowed in all MPAs implemented through the MLPA process. After MPA implementation, specific zones and types of experimental take would be considered through the California Department of Fish and Game scientific collecting permit or similar process and only those participating in the experiment would be allowed to harvest in these zones. In this case, the MPA should be designed in such a way that experimental manipulations would not interfere with the MPA's capacity to achieve the goals of the MLPA or compromise the MPA network. Practically speaking, this means that the MPA should encompass enough of the experimental habitat (i.e. shallow rocky reefs if the experiment focuses on urchins) that experimental harvest and buffer zones could be set up within the MPA while still leaving sufficient un-manipulated habitat to constitute a replicate. Furthermore, any non-experimental take allowed within the MPA should be carefully considered to ensure that it does not compromise the results of the experiment (i.e. an MPA designed to assess the effect of urchin abundance on the nearshore rocky reef communities should not allow commercial or recreational harvest of any nearshore rocky reef species).

There are various trade-offs associated with the two types of experimental MPA design outlined above. The first option of multiple MPAs ensures that the experiment will be conducted, because it is written in to the regulations, but cannot ensure that resources will be allocated for monitoring and does not allow control over the level of harvest of experimental species within the experimental MPAs. The second option of a larger MPA that includes experimental zones within it, is subject to the scientific collecting permit process and thus cannot ensure that the experiment will be conducted or that resources will be allocated for monitoring. Furthermore organisms collected under a scientific collecting permit cannot be sold commercially. However, the second option allows for tight control over the level of experimental harvest, as only those participating in the experiment will be allowed to harvest in the area.

**Figure 1. Example schematic of a complex of MPAs designed for assessing the relative effects of urchin harvest on a variety of ecosystem variables.**
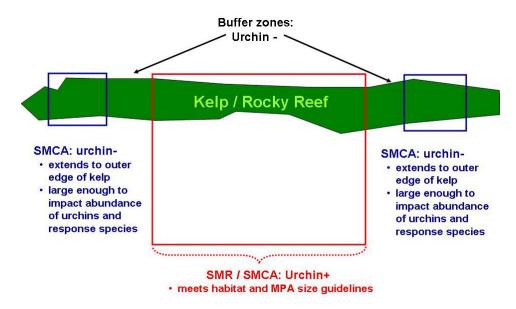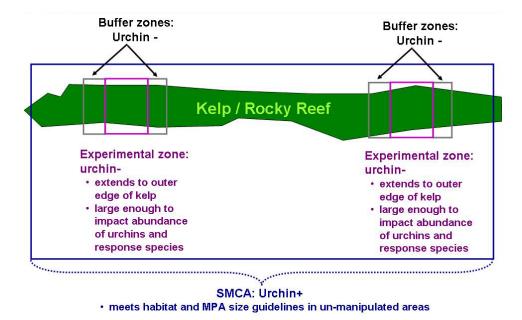


**Figure 2. Example schematic of a single MPA designed for assessing the relative effects of urchin harvest on a variety of ecosystem variables with experimental treatment zones contained within the MPA.**



Replication of these experimental treatments requires replication of these experimental MPAs. The number of replicates depends on criteria used to determine replication for ecological experiments, but is likely to be restricted to only two or three replicates.

The other criterion is the duration of the MPA. The duration of the MPA should be determined by the time period required to test the hypothesis for which the MPA is created. Because response time of response variables measured to test management hypotheses will vary, this time frame will vary on a case-by case basis. For response rates that are difficult to predict (e.g., ecosystem-wide responses), the longevity of the MPA may be extended until a target response level is realized.

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