California MLPA Master Plan Science Advisory Team Proposed Concepts for Designing a Network of MPAs for Adaptive Management

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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 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 levels 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 includes both unprotected (non-MPA) and completely protected (SMR) areas for comparison. Multivariate responses (e.g., the relative abundance of species in a fish assemblage) can be used as response variables in any of these designs.

	Use of Gear A	**No Use of Gear A**
Use of Other Gears	Non-MPA	SMCA that allows all gear except gear A
No Use of Other Gears	SMCA that allows only the use of gear A	State Marine Reserve

One example of adaptive management design that could be fruitful in the MLPA South 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. The red sea urchin, *Strongylocentrotus franciscanus*, has been shown repeatedly to deforest large areas of shallow rocky reefs. To the extent that human harvest of 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 their natural predators have been heavily fished, often depleted, such that the role of urchin harvest could be compensated by protection of the other predators of sea urchins (California sheephead, lobsters, sea stars, and others). Moreover, human harvest and these other predators may compete with one another for sea urchins, such that human harvest can diminish protection for these other species identified for protection within MPAs. Thus, there is substantial uncertainty in the ecosystem-wide consequences of urchin harvest.

An example of MPAs designed for assessing the relative effects of urchin harvest and other urchin predators on a variety of ecosystem variables would include replicate states of each of the following four conditions:

	Take of Urchins	**No-Take of Urchins**
Take of Urchin Predators	Non-MPA	State marine conservation area that allows the take of urchin predators but not urchins
No-take of Urchin Predators	State marine conservation area that allows only the take of urchins, not their predators	State marine reserve

Comparison of the average response of ecosystem variables (e.g., kelp abundance, productivity, resilience, abundance and larval production of urchin predators) among these four states would allow managers to better understand the ecosystem-wide consequences of human take of red sea urchins and their predators.

Design Considerations for 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 smaller the movement range and greater the density of both the extracted and response species, the smaller the habitat necessary to allow the system to reflect the consequences of the manipulation. Therefore, the necessary area of the habitat to include in these MPAs will scale with the movement range and density of the species of interest.

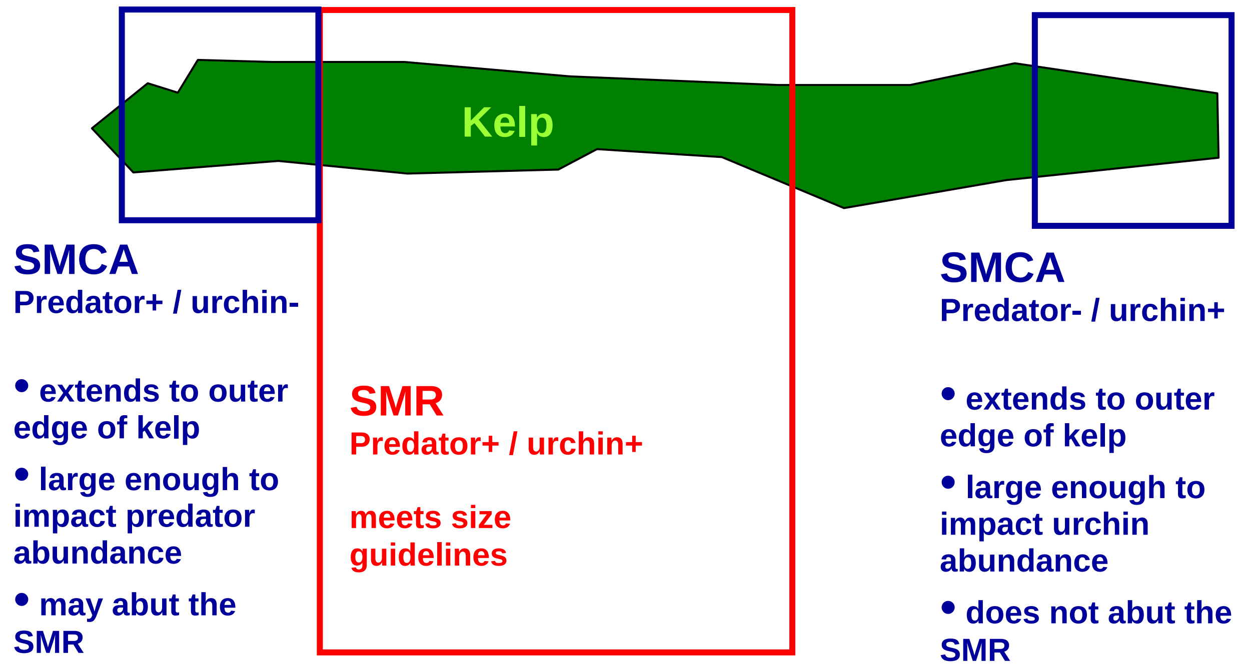
As a general guideline, some population and ecosystem-level responses have been detected in small MPAs that have existed within the MLPA South Coast Study Region prior to passage of the MLPA. The Catalina Marine Science Center Marine Life Reserve, on Santa Catalina Island, is 0.18 square kilometer (km^2) (roughly 1 km alongshore and 100 meters wide) and the average home range of sheephead was 15,134 ± 26,007 square meters (m^2) (Topping et al. 2005). Tetreault and Ambrose detected a significantly greater density of California sheephead in that marine reserve compared to reference sites outside of the reserve, suggesting that within the shape and size of that MPA the rocky reef habitat was sufficient to a produce a population-level response. MPAs 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 MPAs should take advantage of buffers provided by other proposed MPAs that protect the species targeted for protection in the experimental MPAs. For example, if the purpose of the experimental MPA is to determine the effects of natural predators on the density and dynamics of their prey (e.g., sea urchins), then locating an experimental MPA that protects those predators contiguous to an MPA that also protects those predators will enhance the likelihood of achieving the manipulation (Figure 1). In contrast, if the MPA is to assess the effect of removing those predators, then the experimental MPA should be located at more distant from the MPA to take advantage of lower predators densities caused by fishing in the surrounding habitat.

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.

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



References

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