Science Based Regulation: California's Marine Protected Areas

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Abstract
In 2008, the California Department of Fish and Game (DFG) began a one-year process to develop a preferred alternative for a network of marine protected areas in Southern California. To comply with the state Marine Life Protection Act's mandate for sound science, the DFG appointed marine scientists to a Science Advisory Team to set up guidelines that stakeholders and decision makers could rely upon to determine how well proposals met the goals of the MLPA to provide some protection for marine life. As the final debates over where to draw the lines of the new reserves continue, this article explains the scientific underpinnings of this groundbreaking process.

While various forms of marine protections and reserves exist along the California coast, they were created for discrete purposes and are often too permissive to provide any real protection. As such, human activities over the last century, including water pollution, fishing, and development have severely impacted the marine ecosystem. In 1999, the state of California passed the Marine Life Protection Act (MLPA) to reevaluate and redesign the existing Marine Protected Areas (MPAs) into a comprehensive network to preserve and protect the marine life and habitats along the coast. The MLPA requires the use of the best available science to develop California's new system of MPAs with the assistance of scientists, resource managers, and stakeholders. The process of developing MPAs includes scientific guidelines, which are mandated by the MLPA, to ensure coherent and effective protections for the State's marine ecosystems and natural heritage, while improving recreational, educational, and study opportunities provided by undisturbed habitats.


Kelp Forest

The MLPA has the following six goals that are designed to protect biodiversity:

- Protect the natural diversity and abundance of marine life and the structure, function, and integrity of marine ecosystems.
- Help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that are depleted.
- Improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and manage these uses in a manner consistent with protecting biodiversity.
- Protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value.
- Ensure that California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement that are based on sound scientific guidelines.
- Ensure that MPAs are designed and managed, to the extent possible, as components of a statewide network.

It is important to note that the MLPA is not a fisheries management tool, nor does it address socioeconomic issues associated with MPAs. Traditionally, fisheries management is approached species by species and has the dual goal of simultaneously ensuring the survival of the fish stock and the fishermen. This type of management has repeatedly failed in California and elsewhere. Thus, fisheries management has begun to take an ecosystem approach, as opposed to single species, as is evident by the mandate in the Marine Life Management Act (MLMA), which was also passed in 1999 as sister legislation to the MLPA. Both the MLMA and MLPA were a response to the generally poor and declining health of our state's marine resources. Under the MLMA, regulators set take limits based on the optimal sustainable yield of the fishery, establish size limits to ensure reproduction, and enact gear restrictions to prevent unnecessary harm to other marine life or habitat. Under the MLPA, regulators can close a discrete area to human disturbance (e.g. fishing, dredging, oil extraction) and allow the system within to flourish intact.

Managing ecosystems is a complex scientific endeavor. One of the critical components of successfully implementing the MLPA, was the establishment of a Science Advisory Team (SAT) to develop scientific guidelines for inclusion in the MLPA Master Plan (Master Plan). The SAT's role is to use the best available science to achieve the goals of the MLPA. In the current process, the Regional Stakeholder Group (RSG) creates reserve network designs based upon the SAT guidelines. These networks are then evaluated by the SAT and the evaluations are forwarded to the Blue Ribbon Task Force (BRTF). The BRTF has the responsibility of making a recommendation to the Fish and Game Commission.

In tackling this problem, the first layer of information provided by the SAT as an evaluation criterion concerns the representation of habitats. In the simplest paradigm, to maximize the conservation effects on biodiversity an MPA network and an individual reserve will optimally incorporate as many marine habitats as possible. The SAT identified 22 'key' habitats in the Southern California Bight (Bight) (Table 1). The distribution of all of these habitats was provided in to the RSG in a user-friendly, web-based, interactive GIS system called Marine Map.

Table 1. 'Key' Habitats Identified in the Bight by the SAT

Rocky shore	Kelp	Soft bottom 0-30m
Sandy beach	Rocky reef 0-30m	Soft bottom 30-100m
Surfgrass	Rocky reef 30-100m	Soft bottom 100-200m
Coastal marsh	Rocky reef 100-200m	Soft bottom >200m
Tidal flats	Rocky reef >200m	Upwelling centers
Estuarine waters	Submarine canyons	Retention zones
eelgrass	Pinnacles	River plumes
		Fronts

In the Bight, there are multiple biogeographic regions based upon the transition between the San Diegan (warm temperate) fauna from the south to the Oregonian (cold temperate) fauna to the north. Island and mainland faunas are distinct and there are transitional zones at Santa Barbara, Anacapa, and Santa Cruz Islands. These biogeographic subregions were determined from analyses of nearshore rocky reef surveys conducted by the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) and Cooperative Research and

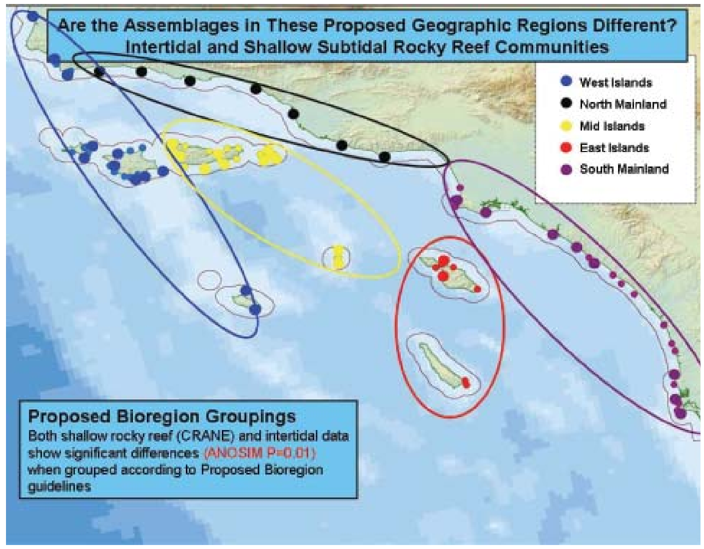

Figure 1. Biogeographic Subregions in the Bight Determined by the SAT from PISCO/CRANE and MARINE Data Sets.

Assessment of Nearshore Ecosystems (CRANE), deep reefs as described by submersible research under the direction of Dr. Milton Love, soft bottom habitats from trawl surveys conducted by the Southern California Coastal Water Research Project (SCCWRP), and rocky intertidal habitats from surveys of community structure conducted by the Multi-Agency Rocky Intertidal Network (MARINe).

The different regions are best displayed by the nearshore and intertidal reef data sets (Figure 1). Santa Monica Bay contains both of the mainland biogeographic zones. The SAT recommended that the optimal reserve network would incorporate each key habitat in all five biogeographic subregions. Since the species assemblage varies within each habitat in each subregion, the SAT recommends that all key habitats be replicated throughout in each region.

The next crucial evaluation criteria, from a scientific perspective, are the size and spacing of the reserves within the network. The size guideline is straightforward. Optimally, a reserve should be large enough to protect adult populations from fishing pressure. If a reserve is too small, the natural movement of animals will take them outside of the reserve boundary and reduce its effectiveness. The SAT calculated the amount of habitat necessary to include 90% of the associated species as a guideline for minimum MPA size using a species-area plot from the aforementioned studies (Figure 2). According to the guidelines in the Master Plan, at a minimum benchmark, reserves should be between 5 to 10 linear km of coastline, but optimally between 10 to 20 km.

Spacing guidelines concern the connectivity of the network. The connectivity of the reserves is determined by the vagility of the taxa or populations within them. Vagility represents

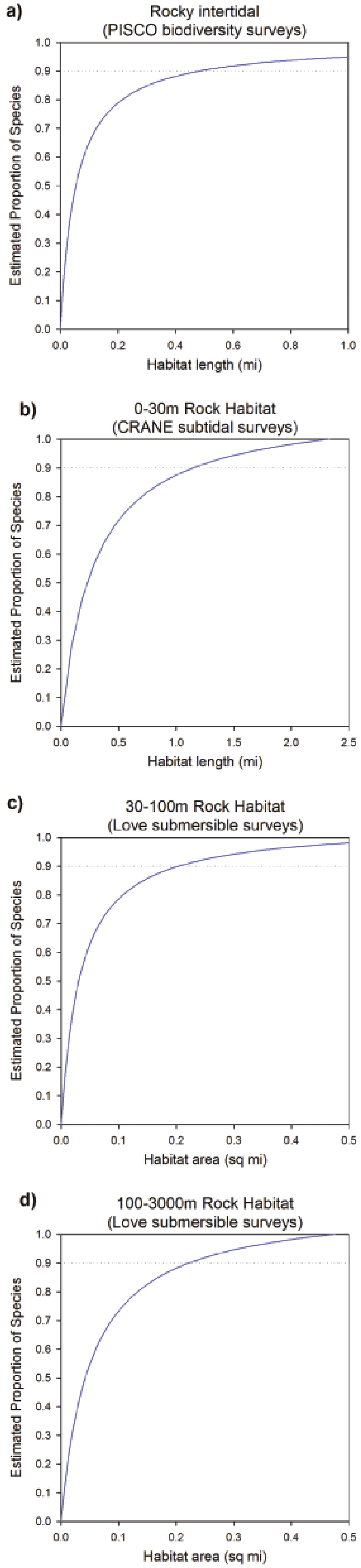

Figure 2. Estimated Proportion of Species per Amount of Rocky Habitat versus the Area or Length of Habitat

a taxa's capacity to move about or disperse in a given environment, typically through two avenues: adult movement and the planktonic larval stages of most fishes, algae, and invertebrates. The size guidelines, coupled with the list of species most likely to benefit from protected areas (discussed below), generally encompass adult movement. Therefore, connectivity is generally viewed as larval connectivity or the connection between different reserves.

Most fishes, algae, and invertebrates have an extended planktonic larval stage, typically between 30 and 120 days. One of the interesting modeling products from the SAT is the adaptation of the Regional Oceanic Modeling System (ROMS) model to include the probability of larval connectivity throughout the Bight. This work is being done in Dr. Dave Siegel's lab in the Institute for Computational Earth System Science and Department of Geography at UC Santa Barbara. The model is based upon CRANE data of larval production by adults along the coastline, spawning period, and larval stage duration. The production of larvae is then modeled using Lagrangian Particle Tracking. An example using kelp bass is shown in Figure 3. This plot shows an unexpected result of the modeling – larvae from the mainland are seeding the islands, but the islands are not a significant source of kelp bass larvae to the mainland. In addition to the connectivity among reserves, larval outputs from reserves could increase the recruitment of organisms in non-reserve areas. Using these types of data products, the SAT developed guidelines for within-reserve habitats at 50 to 100 km apart and determined that spacing should be evaluated for each habitat.

The SAT also generated a list of species most likely to benefit from MPAs based upon the life history characteristics of the taxa. The four major filters used to classify organisms in this list were fishing effects, feature association, adult home range, and whether or not the population level was depressed. These filters were defined as follows:

- Fishing effects refers to species that are actively fished or removed as bycatch by fishers.
- Feature association refers to organisms that are associated with key habitat features during all or part of their life histories. A good example of feature association is recurring spawning aggregations, in which a species uses particular habitat features as a cue for spawning aggregations, which in turn are targeted by fishers.
- Home range size was considered critical to delineate organisms that would likely remain within the confines of a reserve.
- Finally, organisms that had depressed or reduced populations, generally due to overfishing, would be likely to benefit from such closures.

One of the top examples of fish that are most likely to benefit are kelp bass. Kelp bass have a relatively small adult home range, are currently targeted intensively by sportfishers, create spawning aggregations on the outside of kelp beds (where they are targeted), and their population has declined precipitously over the last two decades. This is similar for some invertebrates, for example, all of our abalones (red, pink, white, green, black) scored high in this metric. They have a very small home range, they have been fished out of the Bight to the point that the fishery was closed, they need to aggregate

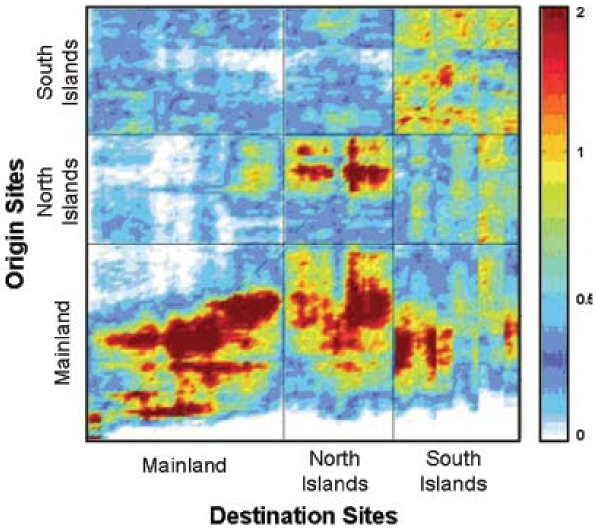

Figure 3 Probability of Dispersal of Kelp Bass Larvae from an Origin Patch to a Destination Patch by Geographical Region.
Note: Color intensity at each point shows the probability of dispersal of kelp bass larvae from an origin patch (vertical axis) to a destination patch (horizontal axis) by geographical region.

to reproduce and they are associated with very specific habitat characteristics of reefs. In fact, the white abalone has been recently listed as an endangered species due to overfishing.

Optimally and practically, a reserve should incorporate as many habitats as possible. The goal of the MLPA is to protect biodiversity, thus the more habitats represented the more species protected. The best reserve network will optimize all three of these parameters: habitat representation, size, and connectivity. From a scientific perspective, the best designs will have multi-habitat reserves that are larger and relatively close together.

As I write this article, the SAT has completed its final evaluations of the RSG proposals and the BRTF recommendation is forthcoming. So, what can we expect for Santa Monica Bay? The most scientifically desirable habitats for MPAs in Southern California are rocky reefs and associated kelp beds. These occupy about a quarter of the nearshore habitat and are separated by large expanses of soft bottom habitats. In addition, most other critical habitats (e.g. rocky intertidal, surfgrass, deep reefs, canyons, upwelling zones) are associated with rocky reefs and kelp beds. Therefore, Santa Monica Bay represents a perfect microcosm of the challenges our coastline. Santa Monica Bay has two major rocky headlands, Malibu and Palos Verdes, separated by a long uninterrupted stretch of sandy beaches. These expansive, world-renowned beaches are the biggest challenge to this process. For example, it is nearly 43 km from Rocky Point to Point Dume. Without accounting for habitat types or size, it is practically impossible to meet the SAT spacing guidelines without proposing an MPA in each of these two regions.

After the establishment of the reserves, it will be critical to evaluate their effectiveness for the entire region. One important component of this objective is the last goal of the MLPA (stated above), which is interpreted as a call for adaptive management. Within the reserve network, there are primarily State Marine Reserves (SMRs) where no extractive activities are allowed. There will also be State Marine Conservation Areas (SMCAs), where some types of fishing and harvesting will be allowed. The SAT evaluated extractive activities, developed a Levels of Protection (LOP) analysis, and ranked each activity from high to low. "High protection activities" were considered unlikely to affect the habitat or population structure of the SMCA, while "low protection activities" alter community structure and damage habitat. SMCAs allow the opportunity to evaluate and study the effects of certain activities in a relatively controlled setting.

To measure effectiveness and manage adaptively, MPAs need to be monitored against a specified set of metrics or goals. This type of monitoring and research dovetails with work the Santa Monica Bay Restoration Commission (SMBRC) MPA Technical Advisory Committee (MTAC) – a subcommittee to the SMBRC Technical Advisory Committee – has already begun. MTAC began studying the nearshore rocky reefs and kelp beds in Santa Monica Bay in both anticipation of the MPA process (data collection and baseline monitoring) and as part of other projects (e.g. the SMBRC's Comprehensive Monitoring Plan and SCCWRP's Bight '08). The Vantuna Research Group at Occidental College, Santa Monica Baykeeper, and Los Angeles County Sanitation Districts have been cooperatively and systematically surveying the rocky reefs of Malibu and Palos Verdes for three years. Each of these research programs has been individually working in the Bay for decades. The coordination of these three research programs will provide the information needed for the optimal management of our nearshore rocky reef resources. We anticipate these steps will enable the effective evaluation and management of our nearshore resource.

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