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Marine Protected Areas Along California's Central Coast: A Multicriteria Analysis of Network Design

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Introduction

The purpose of our project was to apply principles of conservation planning, as well as lessons learned from past marine protected area (MPA) design challenges, in the context of the Marine Life Protection Act (MLPA) Initiative to design a network of MPAs for the Central Coast Study Region of California (Central Coast). In order to develop potential networks of MPAs, data are needed on the distribution of habitat types and species of interest. One also needs to consider how to minimize the negative socioeconomic impacts of MPAs. Additionally, MPAs will only meet conservation goals when user groups comply with MPA regulations. Thus, compliance and enforcement mechanisms are critical elements of network design. All of these considerations are essential to successfully designing and implementing a network of MPAs for the MLPA and were used in developing our project's goals and objectives.

Our analyses provided members of the MLPA Initiative process with the only tool that integrates both biophysical features and socioeconomic considerations. Our work on enforcement and education/outreach could aid in the revision of proposals and the implementation of the resulting network. In addition, our analyses and results have the potential to aid in the design and evaluation of future network proposals along California's north and south coasts, as well as in other regions of the United States.

Background

In 1999, the California Legislature responded to declines in the health of the state's marine environment by adopting the MLPA. The MLPA directs the state to design and manage a network of MPAs to protect marine life and habitats, ecosystems, and natural heritage, as well as improve recreational, educational, and study opportunities provided by marine ecosystems (1). In the process of recommending a preferred siting alternative for a statewide network of MPAs, the MLPA calls for an analysis of the state's current MPAs. The Initiative is fulfilling the MLPA one region at a time within California State waters, beginning with the Central Coast from Pigeon Point to Point Conception (Fig. 1).

Figure 1: Central Coast Study Region

The Initiative Process

The Initiative is a cooperative effort between the California Resources Agency and California Department of Fish and Game (CDFG), strengthened by the advice of scientists, resource managers, experts, stakeholders and members of the public. The Initiative established a Blue Ribbon Task Force (BRTF) that is responsible for guiding the implementation process, a stakeholder group, and a science advisory team. The Science Advisory Team (SAT) assisted the BRTF in developing a Master Plan Framework (Framework). Additionally, the SAT helped the stakeholder group develop alternative MPA proposals. The Central Coast Regional Stakeholder Group (CCRSG) members are responsible for working with the SAT, professional staff, and CDFG to help improve the design and management of the Central Coast network of MPAs. Additionally, the CCRSG, in consultation with the SAT, is responsible

for developing proposals for potential MPAs. The six proposal packages as of February 9th 2006 include three proposals from the CCRSG, one from an external group, one that comprises existing MPAs only, and the package developed and recommended by MLPA Initiative staff.

Goals and Objectives of our Project

Our project goal was to integrate biological, physical, and socioeconomic data with policy to help the BRTF evaluate and recommend a network of MPAs for the Central Coast Study Region. In consultation with the SAT, we identified key objectives based on the needs of the Initiative and used the objectives outlined in Box 1 to guide our analyses.

Box 1. Key Objectives

- Compile reliable data on species likely to benefit from the establishment of an MPA network in the Central Coast Study Region.
- Through modeling, identify areas of conservation value, taking into account socioeconomic data, in the Central Coast Study Region between Pigeon Point and Point Conception within California state waters. Identify and map biophysical, recreational, research, and educational conservation targets and weigh them against socioeconomic considerations.
- Identify key features of MPAs that maximize compliance, evaluate proposed networks, and make recommendations for improved MPA design based on those features.
- Attend SAT, BRTF, and CCRSG meetings in order to follow the process and provide results of the above analyses as needed. Provide results of our analyses in forms useful to the SAT in the MLPA Initiative process for the Central Coast, as well as in the future for Northern and Southern California.

Species Likely to Benefit

The MLPA requires that the Master Plan Framework includes, "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" (1). The SAT prepared a master list that was used in the Initiative to identify species found in each region and within each proposed MPA network during the development of a recommended network of MPAs. Our group was asked to help formulate a revised list of such species. We provided the SAT with specific life history characteristics, habitat and depth zone boundaries, and species status. Additionally, we helped the SAT re-categorize their initial species list to correspond to the habitat definitions in the MLPA Framework, as well as those used by the MLPA Initiative's Geographic Information System team. Furthermore, our addition of mammals and birds to the species list may have prompted the inclusion of a "Special Status Species" section in the Central Coast Regional Profile (Regional Profile).

Biophysical Considerations

Conservation targets, identified in the MLPA and by the SAT, encompass a variety of habitats, depth zones, and species and are included in the Framework (2). In addition, the CCRSG identified areas of biodiversity significance and a list of species with special status within the study region (3) for the Regional Profile. Spatial data, which were available for many of these biophysical considerations, were used in our analysis of optimal MPA locations. We conducted our biophysical and socioeconomic analyses using MARXAN software (5, 6), which helped us identify potential MPA sites that represent a portion of the biophysical conservation targets identified in the Framework and Regional Profile. MARXAN examines the values of individual planning units and then adds and removes planning units in an attempt to meet user-defined conservation targets while minimizing costs and reserve-system boundary length (4). The resulting output is one possible "solution" to meeting the targets while minimizing costs. For each analysis, we ran MARXAN 100 times; our output maps provide an irreplaceability index for each planning unit. The irreplaceability index represents the frequency that the microblock was chosen out of 100 individual solutions. The higher the irreplaceability index, the more likely the microblock will be required as part of a network of MPAs that meet the conservation goals.

The CDFG divided the study region into one nautical mile microblocks, which we used as planning units in our MARXAN analysis. Several parameters must be defined before running MARXAN, including the degree to which selected microblocks should be clustered and the proportion of each target that should be included in the solution. As we increased the clustering factor, or "boundary length modifier" (BLM), the total area of microblocks chosen by MARXAN increased and the perimeter decreased,

even while keeping the proportion of biophysical features conserved (conservation proportion) constant. With increases in conservation proportion while keeping the BLM constant, both area and perimeter increased. We focused our analyses on a conservation proportion of 30% with BLMs of 0 and 0.0001. Running the model with a BLM of 0 allows it to select microblocks that are richest in biophysical features without spatial constraints. A BLM of 0.0001 produces solutions that are more likely to meet standards for management, enforcement, and monitoring. For our biophysical analyses, we defined the cost of selecting each microblock as the area of the microblock to account for the uneven sizes of the microblocks. Our biophysical output maps identified areas in the Central Coast of high conservation value; these were planning units that were chosen repeatedly by MARXAN to fulfill conservation targets we input, without regard for socioeconomic considerations. An example biophysical output map for a conservation proportion of 30% and BLM of 0 is in Figure 2.

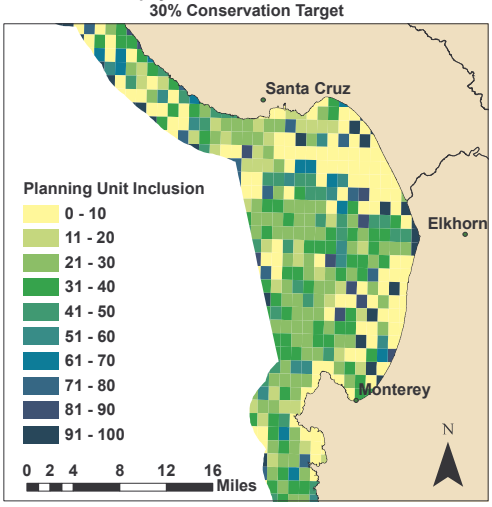

Figure 2: Biophysical Output

Socioeconomic Considerations

We used the *Adopted Regional Goals and Objectives Package* developed by the CCRSG to determine which socioeconomic targets to include in our analysis and to identify the best available data to quantify these targets for MARXAN analysis. We designed our analysis to incorporate several socioeconomic considerations along with the biophysical targets:

- First analysis – We ran MARXAN with the biophysical targets and added the presence of monitoring sites, adjacency to research institutions and adjacency to population centers as conservation targets, collectively referred to as infrastructure. We used area as cost in this analysis.
- Second analysis – In addition to area, we added recreational fishing effort to represent the cost associated with selecting microblocks in MARXAN.
- Third analysis – The relative importance of a microblock to commercial fishermen was added to area as cost.
- Fourth analysis – Recreational and commercial fishing were combined to direct MARXAN to reach our conservation goals at the lowest potential impact to both industries.
- Fifth analysis – Adjacency to shoreline parks was included as a target providing an output integrating all of our targets and "costs."

In our first analysis, the addition of infrastructure targets with a BLM of 0 and a conservation target of 30% did not change regional patterns of the results substantially, but led to local shifts in microblock selection. The addition of recreational fishing in the

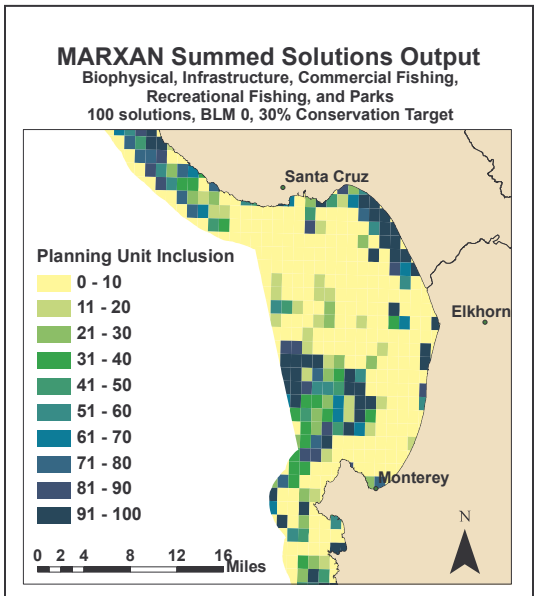

Figure 3. Socioeconomic output

cost function produced an output in which most microblocks were clearly defined as having either very high or very low irreplaceability and significant clumping of microblocks. Clumping also occurred in our third analysis, which included commercial fishing alone. Locations of clumping varied significantly between these two analysis, which is likely to due to differing locations of recreational and commercial

fishing within the study region. Combining recreational and commercial fishing in the cost function resulted in spatial patterns of microblocks that resembled a blend of the patterns seen with recreational and commercial fishing alone. Including shoreline parks did not result in substantial change in the number of times microblocks were chosen. With a BLM of 0.0001 in each of our analyses, even more distinct clustering was evident. An example output map for a conservation proportion of 30% and BLM of 0, including biophysical considerations, infrastructure, commercial and recreational fishing, and parks is in Figure 3 above.

Enforcement and Compliance Considerations

The MLPA calls for adequate enforcement, the CCRSG developed several design considerations to address enforcement issues, and the BRTF has indicated that compliance considerations should be a priority. This prompted us to evaluate and make recommendations for improvement of the proposed MPA networks with respect to enforcement and compliance factors, and to make network implementation recommendations based on a literature search and communication with stakeholders and enforcement officials.

We summarized our findings in a comprehensive list of design considerations to reduce the burden on enforcement agencies, and we evaluated the extent to which MPA network packages proposed by stakeholders address these considerations. Box 2 highlights some of these considerations. We concluded that the design of MPA boundaries is the factor that can most easily be adjusted on MPA network proposals to increase compliance and ease enforcement along the Central Coast. Additionally, we provided several recommendations to improve the efficiency of enforcement efforts for the Central Coast. An interagency memorandum of agreement (MOA) for enforcement between CDFG and the US Coast Guard (USCG), National Oceanographic and Atmospheric Administration (NOAA), the state parks, and any other state or federal agency with an appropriate mandate should be created before a new network is implemented. In addition, CDFG should increase the numbers of boats and staff along the Central Coast to provide adequate enforcement. Also, in the early stages of implementation, CDFG and enforcement partners should issue warning citations coupled with educational information in order to inform users of the new regulations. Lastly, we introduced education and outreach partnerships as a cost-effective potential tool for the CDFG to encourage compliance, and we provided a list of potential outreach partners for the Central Coast.

Box 2. MPA Design Considerations

- Clear boundaries
- Distance from harbors
- Adjacency to shore
- Adjacency to land parks
- Shape
- Size
- Proximity to one another

Conclusions and Application to the MLPA

The goal of our project was to integrate biological, physical, and socioeconomic data with policy to help the BRTF establish a network of MPAs in accordance with the MLPA Initiative. Our list of species likely to benefit provided the SAT with detailed information on species ranges, distributions, habitat preferences, and life history. Our MARXAN analyses provided the SAT, BRTF, and MLPA staff with the only tool in the MLPA Initiative that considered both biophysical features and socioeconomic considerations. Our compliance analyses and recommendations will be submitted to the BRTF to assist them in determining which network proposal package(s) lend themselves to increased compliance and will be easiest to enforce, and we will provide our enforcement and education/outreach recommendations to the CDFG. Time constraints and the limited availability of data early in the MLPA process restricted our ability to provide analyses that could have been used in the design phase – rather than the evaluation phase – of the process. We therefore recommend that MARXAN analyses as well as enforcement considerations be used in the early stages of designing MPA network proposals for the Northern and Southern Study Regions.

References:

1. MLPA, California Marine Life Protection Act, Chapter 10.5, Fish and Game Code 2850-2863 (1999).
2. CDFG, California Marine Life Protection Act Initiative Draft Master Plan Framework: A Recommendation to the California Fish and Game Commission by the California Department of Fish and Game (2005).
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6. H.P. Possingham, I.R. Ball, S. Andelman. Mathematical methods for identifying representative reserve networks. Quantitative methods for conservation biology. Springer-Verlag, New York, pp. 291-305.