MLPA Master Plan Science Advisory Team
Bioeconomic Model Evaluations of Blue Ribbon Task Force Recommended Marine Protected Area Proposals for the North Coast Study Region

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Overview of Modeling Approach

Bioeconomic model analyses of the MLPA Blue Ribbon Task Force (BRTF) recommended marine protected area (MPA) proposals for the North Coast Study Region were performed by the University of California, Santa Barbara (UCSB) modeling research group. A description of the model, the inputs, outputs, and assumptions can be found in Chapter 8 and Appendix A of *Draft Methods Used to Evaluate Marine Protected Area Proposals in the MLPA North Coast Study Region*. Briefly, the model simulated population dynamics and calculated long-term equilibrium estimates of relative biomass[1] and relative fishery yield[2] (a measure of economic value) for each of six species (black rockfish, brown rockfish, cabezon, redtail surfperch, red abalone, and red sea urchin) under three different future fishery management scenarios (unsuccessful management, maximum sustainable yield (MSY)-type management and conservative management). A seventh species, Dungeness crab, also was modeled under a separate scenario representing the unique male-only fishery for that species. The modeling evaluation consisted of the standard evaluation of the Revised North Coast Regional Stakeholder Group Marine Protected Area Proposal (RNCP), as well as the North Coast Enhanced Compliance Alternative Marine Protected Area Proposal (ECA). Additionally, Proposal 0 or P0 (the existing MPAs) also was analyzed for comparison.

The ECA includes nearshore "ribbon" marine protected areas (MPAs) where a variety of uses are proposed to accommodate traditional tribal uses, paired with offshore MPAs that allow uses only at moderate high level of protection (LOP) and above. Because the ribbon MPAs are narrow (from shore to approximately 1,000 feet offshore) relative to the spatial resolution of the model, which has a cell size of one square kilometer, the model was adjusted to ensure the effects of the ribbon MPAs were represented. In the standard evaluation, the model only represents a spatial cell as "protected" by an MPA if that MPA occupies more than 25% of the wet area of the cell. When a single cell intersects with two or more MPAs, the cell is assigned the proposed uses associated with the MPA covering the largest fraction of that cell. To accommodate the proposed uses in ribbon MPAs, the model was altered such that if a ribbon MPA covered more than 25% of the wet area of a cell, the proposed uses associated with the ribbon MPA governed that cell, regardless of the presence of other MPAs in that cell. In practice, this caused the model cells closest to shore and overlapping ribbon MPAs to be assigned proposed uses associated with the ribbon MPAs. Model cells further offshore and overlapping MPAs were assigned the proposed uses associated with the offshore MPAs. It should be noted that the evaluation of the ECA is conservative, in that the effects of the ribbon MPAs are overstated somewhat by assuming they occupy the entire wet area of the nearshore

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[1] Relative biomass is calculated by expressing biomass for each species as the proportion of unfished maximum biomass, then taking the mean of those scaled values.

[2] Relative fishery yield is calculated by expressing fishery yield for each species as the proportion of maximum sustainable yield under Proposal 0, then taking the mean of those scaled values.

model cells that they overlap. This same convention also was applied to the new Stewarts Point Nearshore SMCA, since the model domain also includes portions of the North Central Coast study region and the existing MPAs there.

Detailed, spatially explicit model outputs, including maps for each response variable and sub-regional summaries of key statistics for each species, proposal, and management scenario are available online (www.dfg.ca.gov/mlpa/mpaproposals_nc.asp). Here, we report overall results only, focusing on the mean biomass and fishery yield (averaged across all core species, excluding Dungeness crab) for each MPA proposal under each management scenario.

Key Findings

Results of the modeling evaluation of the BRTF recommended MPA proposals followed the same general trends exhibited in the previous rounds: In the “unsuccessful management” scenario, there was a positive correlation between relative biomass and relative fishery yield. By contrast, in the “MSY-type management” and “conservative management” scenarios, there were negative correlations between biomass and yield, so the evaluation resulting in higher relative biomass (ECA) also had lower relative fishery yield.

The overall rankings of the BRTF recommended MPA proposals generally followed these patterns (where > indicates values “greater than”, brackets group MPA proposals that are not substantially different in rank):

> Relative biomass:
> ECA > RNCP > P0
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> Relative fishery yield (unsuccessful management):
> ECA > RNCP > P0
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> Relative fishery yield (MSY-type management or conservative management):
> P0 > RNCP > ECA

The modeling evaluation also ranked Dungeness crab biomass for the ECA higher than RNCP, which had greater biomass than P0. Dungeness crab yield followed the pattern above for conservative management (ECA > RNCP > ECA). This is consistent with the management regime simulated for Dungeness crab, which is essentially conservative by disallowing fishing on female crabs.

These overall rankings reflect the general trend that proposals with greater total area in MPAs with higher levels of protection had higher biomass in all scenarios and greater fishery yield with unsuccessful fishery management, but lower yield in other scenarios. (Relative to P0 and RNCP, the ECA had greater area in MPAs with higher levels of protection.) This pattern occurs despite the small nearshore ribbon MPAs in ECA with lower levels of protection. Thus, in the two more conservative management scenarios (MSY-type management and conservative management), there is a tradeoff between improving biomass and maintaining fishery yield. This arises because in those scenarios, yield typically would be highest if there were no MPAs at all. By contrast, if fishery management were unsuccessful, overall yield is predicted to be quite low, even with the existing MPAs in Proposal 0, and there is no tradeoff between biomass and fishery yield in that scenario.

It also is important to note that the difference between MPA proposals in either biomass or fishery yield within a given management scenario is dwarfed by the differences among the future fishery management scenarios. Thus, the success of future management outside of MPAs will have a strong bearing on the performance of any MPA network.

How Can Proposal Be Improved to Increase Biomass and Fishery Yield?

There were tight correlations (both negative and positive) between overall biomass and fishery yield across all three management scenarios. In other words, the results from the bioeconomic modeling evaluation of MPA proposals (P0, RNCP, and ECA) fall along a relatively straight line for each management scenario, indicating that there is a direct relationship between biomass and fishery yield. This result reflects the higher levels of protection in MPAs proposed under the ECA relative to the RNCP and the greater number of MPAs in both RNCP and ECA relative to P0.

Results for all proposals from all rounds of planning fall along the same relatively straight lines of correlation between biomass and fishery yield for each management scenario. Results for RNCP and ECA were not far above or below this line, so neither proposal appears to be especially more or less efficient at improving either biomass or yield for the species modeled.

The model produced information about each proposed MPA. The information may be used to evaluate whether a particular MPA is attaining a desired level of biomass (or supporting a desired level of fishery yield nearby). The model also produced two sets of maps showing predicted changes in larval supply for the RNCP and ECA. The first type of map shows the change in larval supply to each location (as a percentage of larval supply predicted for Proposal 0). The second type of map shows the change in larval production at each location; that is, which locations produce higher numbers of larvae that successfully settle to downcurrent locations (again, expressed as a percentage of larval production under Proposal 0). Together, these maps can reveal which MPAs are particularly successful in improving connectivity with the MPA network, and which locations are predicted to benefit most from increased larval production inside MPAs. Diagrams of larval connectivity for each species (available online at www.dfg.ca.gov/mlpa/mpaproposals_nc.asp) can be used to determine sources that likely supply locations that appear to be undersupplied on the maps of larval supply. Increasing the size of MPAs in source areas (or adjusting their boundaries to include more of the suitable habitat type) could improve larval supply to the downcurrent locations, improving the performance of MPA proposals.

Examination of the results for larval production suggests some general conclusions about the performance of particular MPAs. Several MPAs in the RNCP are predicted to exhibit increased larval production for all of the model species: Sea Lion Gulch SMR, Skip Wollenberg/Ten Mile SMR, South Cape Mendocino SMR, and Reading Rock Offshore SMR. Redtail surfperch also had high larval production in Big Flat SMCA. In general, the RNCP proposal had more SMRs in the southern bioregion as compared to the northern bioregion, while most of the MPAs in the northern bioregion were SMCAs that were open to non-commercial harvest of all of the species modeled. The SMRs performed well in the model, while the SMCAs were not predicted to have any benefits for the model species because those species were fished in the SMCAs. Despite this, larval supply was predicted to increase in the northern bioregion, suggesting that the SMRs near Cape Mendocino and further south are providing larval supply to the northern bioregion. In the ECA, all of the MPAs mentioned above continued to exhibit increased larval production, and Vizcaino Offshore SMCA also exhibited increased production for all species. Additionally, for redtail surfperch, Samoa Offshore SMCA, Reading Rock SMCA, and Pyramid Point Offshore SMCA all exhibited increased larval production relative to RNCP.

The model also was used to perform a deletion analysis, in which each MPA in the proposal was sequentially removed, one at a time, and biomass was recalculated. The difference between the biomass *with* and *without* a given MPA is an indication of that MPA's relative ***contribution*** to the MPA network. When this difference is divided by the amount of habitat protected by the MPA, it gives a measure of that MPA's ***efficiency*** in achieving conservation goals. Comparing these “deletion” statistics from MPAs in similar locations across the proposals should reveal whether changing the size, shape, or level of protection in a given MPA could improve its performance and thus its contribution to the network. In particular, high efficiencies indicate areas where protecting an additional unit of habitat is likely to cause relatively large increases in biomass. [See Table 3 in the supporting materials online (www.dfg.ca.gov/mlpa/mpaproposals_nc.asp) to review the results from the deletion analysis.]

The results of the deletion analysis largely are consistent with those of the larval production analysis described above. In the RNCP, Sea Lion Gulch SMR and Skip Wollenberg/Ten Mile SMR had the highest contribution under MSY-type management, and Reading Rock Offshore SMR had high efficiency. MPAs with lower contributions were SMCAs open to a broad array of uses: Pyramid Point SMCA, Samoa SMCA, Reading Rock SMCA, and Vizcaino SMCA (all of these had contribution and efficiency equal to zero). In the ECA, Vizcaino Offshore SMCA and Pyramid Point SMCA both greatly increased in contribution and had efficiencies similar to other SMRs in the proposal.

Finally, the modeling workgroup also undertook a genetic connectivity analysis in order to determine how well the spacing of the proposed MPAs preserved natural (i.e., unfished) levels of genetic exchange among MPAs and fished regions of the coast. This analysis indicates that for widely dispersing species, such as black rockfish, there is not a substantial difference in genetic connectivity among the three proposals. However, for red abalone, which has much more limited dispersal, the ECA offered improved connectivity (relative to RNCP and P0) to the Shelter Cove region and to the area just north of Cape Mendocino from locations south of Shelter Cove. This is likely due to Vizcaino Offshore SMCA in ECA. The other noticeable results were an increase in connectivity from the Reading Rock area to points north for cabezon and brown rockfish in ECA relative to RNCP and P0 (likely due to their protection in the Reading Rock Nearshore SMCA) and an increase in connectivity from the Sea Lion Gulch area to all regions for most species in ECA and RNCP relative to P0 (likely due to the Sea Lion Gulch SMR).

Conclusion

There is a clear and consistent ranking in expected relative biomass in the modeling evaluation of the BRTF recommendation, with the higher levels of protection associated with MPAs proposed in the ECA producing higher expected biomass than the RNCP, which in turn is expected to produce higher biomass that the existing MPAs. The ranking for expected relative fishery yield is not as consistent; it depends on the success of future fishery management. However, the general result is Proposal 0 had higher expected fishery yield than the RNCP, which in turn had higher expected fishery yield than the ECA. This general pattern is reversed if fishery management is unsuccessful outside of the MPAs.