California MLPA Master Plan Science Advisory Team

Summary of Bioeconomic Model Evaluations of Round 2 NCRSG Draft Marine Protected Area Proposals for the MLPA North Coast Study Region

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Overview of Modeling Approach

Bioeconomic model analyses of the Round 2 draft marine protected area (MPA) proposals for the MLPA 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 *Draft Methods Used to Evaluate Marine Protected Area Proposals in the MLPA North Coast Study Region* [Chapter 8 and Appendix A]. Briefly, the model simulated population dynamics and calculated long-term equilibrium estimates of relative biomass[1] (a measure of conservation value) and relative fishery yield[2] (a measure of economic value) for each round 2 draft MPA proposal (including Proposal 0, the existing MPAs) and 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 Round 2 modeling evaluation consisted of the standard UCSB model analysis, plus a second set of results in which the movement of adult fishes and invertebrates was represented in a manner consistent with the University of California, Davis (UCD) model used in Round 1. Primary evaluation results are reported only for the UCSB model to maintain consistency with the Round 1 evaluation, but key differences observed in results obtained from the UCD home range module also are noted, when applicable. Additionally, models were run in Round 2 with two sets of assumptions regarding proposed MPAs. In the first case, it was assumed that no uses were permitted in proposed MPAs unless they were described by species and gear types. In the second case, it was assumed that all recreational uses were allowed in MPAs that proposed traditional tribal uses. These two sets of assumptions reflect the uncertainty about the proposed uses that are consistent with traditional tribal gathering. Unless otherwise noted, results reported here were generated using the first assumption.

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 draft MPA proposal under each management scenario.

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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.

Key Findings

Results of the Round 2 modeling evaluations followed the same general trends exhibited in the previous round: In the “unsuccessful management” scenario, there is a positive correlation between relative biomass and relative fishery yield of each MPA proposal. By contrast, in the “MSY-type management” and “conservative management” scenarios, there were negative correlations between biomass and yield, so proposals with higher relative biomass had lower relative fishery yield. These patterns were consistent across both models, using the original UCSB model and the UCSB model with the UCD home range module.

The overall rankings of draft MPA proposals generally followed these patterns (where > indicates values “greater than”, brackets indicate proposals that are not substantially different in rank, and the names of each Round 2 draft MPA proposal developed by the MLPA North Coast Regional Stakeholder Group (NCRSG) are abbreviated as "RU1", "RU2", "SA1", and "SA2;" the no action alternative, existing MPAs, is "P0"):

Relative biomass:
SA1 > [SA2, RU1] > RU2 > P0

Relative fishery yield (Unsuccessful Management) :
SA1 > [SA2, RU1] > RU2 > P0

Relative fishery yield (MSY-type Management or Conservative Management):
P0 > RU2 > [SA2, RU1] > SA1

Results for Dungeness crab biomass followed the same pattern given above, and Dungeness crab yield followed the pattern given above for conservative management. 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 had higher biomass in all scenarios and greater fishery yield with unsuccessful fishery management, but lower yield in other scenarios. 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 is 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.

The results shifted somewhat if it was assumed that all recreational uses were allowed in MPAs that proposed traditional tribal uses:

Relative biomass:
SA1 > RU1 > RU2 > SA2 > P0

Relative fishery yield (Unsuccessful Management):
SA1 > RU1 > RU2 > SA2 > P0

Relative fishery yield (MSY-type Management or Conservative Management):
P0 > SA2 > RU2 > RU1 > SA1

Effectively, proposal SA2 switches from high to low biomass if recreational uses are allowed in MPAs that proposed traditional tribal uses. The large effect on SA2 appears to reflect the fact that all MPAs in the northern portion of the study region propose tribal uses, which was not the case for the other proposals.

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, future management success will have a strong bearing on the performance of any MPA network.

How Can Proposals 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 both models. In other words, the results from the bioeconomic modeling evaluation of NCRSG proposals 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 fundamental similarity across the proposals in terms of MPA placement (i.e., most proposals have MPAs in similar locations). The differences in proposal performance (relative to biomass and fishery yield) appear to reflect differences in the relative sizes and levels of protection of the MPAs in those locations. For example, under MSY-type management, a proposal which protects large amounts of habitat will tend fall along one end of the continuum (i.e., with higher fish biomass and lower fishery yield), while a proposal with less habitat protected will tend to fall along the opposite end (i.e., with lower fish biomass and greater potential fishery yield).

Results for all proposals from rounds 1 and 2 fall along the same relatively straight lines of correlation between biomass and fishery yield for each management scenario. No proposal was far above or below this line, so none of the proposals appear to be especially more or less efficient at improving either biomass or yield.

The model produces information about each MPA in each proposal. 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 produces two sets of maps showing predicted changes in larval supply for each proposal. 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. Some MPAs that appear in multiple proposals are especially effective in all of those proposals, in the sense of contributing to a large increase in larval productivity. These include Vizcaino SMCA, Petrolia Lighthouse SMCA, and Ten Mile SMR. Other MPAs are not especially effective, in the sense that there is a small increase in successful larval production. These include the Big Flat SMCA (likely due to the small amount of suitable habitat for model species in that MPA) and the Pyramid Point SMR/SMCA (likely due to location on the northern edge of the study region, so that most larvae are exported out of the study region).Finally, some MPAs perform better in some configurations than in others. In particular, the Reading Rock SMR/SMCA in the Sapphire proposals has higher larval productivity for the model species than the Reading Rock Offshore SMCAs in the Ruby proposals. The latter MPAs include very little suitable habitat for the model species, precluding a large increase in larval production of those species.

The model also is used to perform a deletion analysis, in which each MPA in a proposal is sequentially removed, one at a time, and biomass is 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.

The results of the deletion analysis largely agree with those of the larval production analysis described above. The Petrolia Lighthouse SMR/SMCA had a high contribution in all MPAs, the Vizcaino SMCA had high contribution in RU1 and RU2, and the Reading Rock SMR/SMCA had high contribution in SA1 and SA2, respectively (the Reading Rock SMR in SA2 also had high efficiency).These results appear to be due to the large amount of rocky habitat in the Petrolia Lighthouse region, and the 'stepping stone' role played by the Reading Rock MPAs in linking distant MPAs. Other MPAs had near-zero contributions. These were typically small MPAs with little habitat for the model species, and included the Pyramid Point SMCA (RU1, RU2, SA1), Reading Rock Nearshore SMCA (RU2), Point Cabrillo SMCA (SA1, SA2), and MacKerricher SMCA (SA1).

Conclusion

There is a clear and consistent ranking in expected relative biomass across the four Round 2 draft MPA proposals developed by the NCRSG, with proposal SA1 giving the highest expected biomass under all management scenarios. 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 that proposal RU2 had the highest expected fishery yield (excluding proposal 0) unless management is unsuccessful outside of the MPAs, in which case proposal SA1 had the highest expected fishery yield. Proposal RU1 tended to exhibit intermediate levels of both biomass and yield, regardless of future management. The results for proposal SA2 were uncertain and depended heavily on the manner in which proposed tribal uses were represented in the model.