California MLPA Master Plan Science Advisory Team

Draft 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 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 conservation value (i.e., biomass), economic value (i.e., fishery yield), and genetic connectivity 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 the prior round.Primary evaluation results are reported only for the UCSB model to maintain consistency with the round 1 evaluations, 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.

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 the conservation value (biomass) and economic value (fishery yield) of each MPA proposal. By contrast, in the “MSY-type management” and “conservative management” scenarios, there were negative correlations between conservation value and economic value, so proposals with high conservation value had lower economic value. 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 group proposals that are not substantially different in rank, and the names of each round 2 draft MPA proposal developed by the North Coast Regional Stakeholder Group (NCRSG) are abbreviated as "RU1", "RU2", "SA1", and "SA2;" the no action alternative is "P0"):

Conservation Value:
SA1 > [SA2, RU1] > RU2 > P0

Economic Value (Unsuccessful Management) :
SA1 > [SA2, RU1] > RU2 > P0

Economic Value (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 conservation value in all scenarios and greater economic value with unsuccessful fishery management, but lower economic value in other scenarios. Thus, in the two more conservative management scenarios (MSY-type management and conservative management), there is a tradeoff between improving conservation value 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 economic and conservation value in that scenario.

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

Conservation Value:
SA1 > RU1 > RU2 > SA2 > P0

Economic Value (Unsuccessful Management):
SA1 > RU1 > RU2 > SA2 > P0

Economic Value (MSY-type Management or Conservative Management):
P0 > SA2 > RU2 > RU1 > SA1

Effectively, proposal SA2 switches from high to low conservation value 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 economic or conservation value 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 conservation value and fishery yield?

There were tight correlations (both negative and positive) between overall economic value and conservation value 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 economic and conservation value.

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 economic and conservation values) 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 economic and conservation values 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 conservation value 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).

Finally, the genetic connectivity analysis can be used to identify MPAs that are poorly connected by larval dispersal over longer timescales.This complements the MPA spacing evaluation by identifying particular MPA pairs that are poorly connected (controlling for natural levels of connectivity determined by larval dispersal), and can potentially identify alterations to the network that would improve connectivity.All results are expressed as the percent decrease in connectivity, measured as the percentage *increase* in the average number of generations required for a neutral allele to spread between two MPAs.Because the analysis uses stochastic simulations, the results are quite noisy.To focus the evaluation, we only report results in which mean connectivity across all species decreased more than 75%. When interpreting the results, it is important to recall that genetic connectivity is not measured to non-existent MPAs, so proposals with fewer MPAs typically have fewer opportunities to score low connectivity values.

Proposal RU2 had no change greater than 75% in connectivity relative to the unfished case.Proposal RU1 had reduced connectivity in the north-south direction between two of the most distant MPAs: Ten Mile SMCA and Pyramid Point SMCA. This loss in connectivity spans most of the network, and could likely be alleviated only by an overall decrease in MPA spacing.Proposals SA1 and SA2 had some decreases in connectivity between non-neighboring MPAs, primarily in the north-south direction between Ten Mile SMR/SMCA in the south and Big Flat SMCA and Reading Rock SMR/SMCA to the north, and from Big Flat SMCA to Reading Rock SMR in SA1.These low connectivities appear in the SA proposals but not in the RU proposals for two reasons.First, the Ten Mile SMR is larger in RU1, affording greater larval production and connectivity to points north than in SA1 and SA2 (there is no oceanic Ten Mile MPA in the RU2 proposal, so connectivity from that location is not measured).Second, the Reading Rock Offshore SMCA in RU2 has little habitat for the model species, so connectivity is not measured to that location (there was also a slight decrease in connectivity from Ten Mile SMCA to the Reading Rock Offshore SMCA in RU1).Similarly, the Big Flat SMCA does not appear in RU1 and RU2, so connectivity to/from that location is not measured.In general, the low connectivities predicted for RU1, SA1, and SA2 could be alleviated by increasing the size of the Ten Mile SMR in SA1 and SA2, and possibly by decreasing MPA spacing overall between the Ten Mile SMR and the Reading Rock SMR.

Conclusion

There is a clear and consistent ranking in expected conservation value across the four round 2 draft MPA proposals developed by the NCRSG, with proposal SA1 giving the highest expected conservation value under all management scenarios. The ranking for expected economic value 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 economic value (excluding proposal 0) unless management is unsuccessful outside of the MPAs, in which case proposal SA1 had the highest expected economic value. Proposal RU1 tended to exhibit intermediate levels of both conservation and economic value, 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.