California MLPA Master Plan Science Advisory Team
Bioeconomic Model Evaluations of Round 3 North Coast Regional
Stakeholder Group Marine Protected Area Proposal
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Overview of Modeling Approach

Bioeconomic model analyses of the Round 3 North Coast Regional Stakeholder Group (NCRSG) Marine Protected Area (MPA) Proposal 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] (a measure of conservation value) 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 round 3 modeling evaluation consisted of the standard evaluation of the north coast proposal with all proposed uses, including non-commercial uses intended to accommodate tribal uses (henceforth "NCP"), as well as a supplemental evaluation requested by the Blue Ribbon Task Force in which non-commercial uses intended to accommodate tribal uses were not included ("SUP"). Additionally, Proposal 0 (the existing MPAs) also was analyzed for comparison ("P0"). In previous rounds, the UCSB model analysis had been supplemented with 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. A comparison of those results in rounds 1 and 2 suggested that differences between those two movement analyses were minimal for most species, so for round 3 only the UCSB model analysis was conducted.

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 3 modeling evaluation 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

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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.

management" and "conservative management" scenarios, there were negative correlations between biomass and yield, so the evaluation resulting in higher relative biomass (SUP) also had lower relative fishery yield.

The overall rankings of MPA configuration generally followed these patterns (where > indicates values "greater than", brackets group configurations that are not substantially different in rank):

> Relative biomass:
> SUP > NCP > P0
>
> Relative fishery yield (Unsuccessful Management):
> [NCP, SUP] > P0
>
> Relative fishery yield (MSY-type Management or Conservative Management):
> P0 > NCP > SUP

Results for Dungeness crab biomass followed a pattern similar to that given above, except that SUP and NCP were predicted to have the same biomass. 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 the configuration with greater total area in MPAs and higher levels of protection in those MPAs (SUP) 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 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 configurations 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 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 configurations (P0, NCP, and SUP) 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 under the SUP analysis relative to the standard NCP analysis and the greater number of MPAs in the Round 3 MPA Proposal as compared to P0.

Results for all proposals from rounds 1-3 fall along the same relatively straight lines of correlation between biomass and fishery yield for each management scenario. Results for NCP and SUP were not far above or below this line, so neither configuration 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 both NCP and SUP analyses of the Round 3 MPA 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. Several MPAs in the NCP are predicted to exhibit increased larval production for all of the model species: Sea Lion Gulch SMR, Ten Mile SMR, and South Cape Mendocino SMR. For redtail surfperch, all of the SMRs, with the exception of Reading Rock SMR in the northern bioregion, were predicted to have increased larval production. In general, the Round 3 MPA 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. Reading Rock SMR did not contain very much habitat for the model species, and so was also not predicted to perform well for these species. 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. This also could explain why biomass increased but fishery yield did not increase in the SUP analysis relative to NCP under unsuccessful management. If southern SMRs supply larvae to fished regions in the north, then additional protection in northern SMCAs that occurs in SUP could increase biomass inside those SMCAs, but not greatly increase larval spillover to fished regions in the north. This preliminary interpretation should be reviewed more fully by the modeling work group and the MLPA Master Plan Science Advisory Team (SAT).

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 agree with those of the larval production analysis described above. In the standard evaluation (NCP), Sea Lion Gulch SMR and Ten Mile SMR had the highest contribution under both unsuccessful and MSY-type management. Under unsuccessful management, Sea Lion Gulch SMR, Ten Mile SMR, and Ten Mile Beach SMCA had high efficiency, while efficiency was similar across MPAs under MSY-type management. 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 supplemental analysis in which non-commercial uses intended to accommodate tribal activities were not included, Vizcaino SMCA and Pyramid Point SMCA both greatly increased in contribution and had efficiencies similar to other SMRs in the proposal. By contrast, Samoa SMCA and Reading Rock SMCA continued to have a low contribution and efficiency.

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, averaged across all model species (except for redtail surfperch, which does not have larval dispersal), the Round 3 NCRSG MPA Proposal (NCP), including the supplemental evaluation (SUP), and the no-action alternative (P0) provide relatively low connectivity to the region near Humboldt Bay. This is likely a consequence of the lack of an MPA protecting the relatively small amount of habitat for the model species in that area. In all three configurations, there was predicted to be relatively high connectivity among MPAs to the north of Humboldt Bay as well as among MPAs to the south of Shelter Cove. MPAs near Cape Mendocino are well connected in both directions. However, there appears to be a break in south-to-north connectivity near Shelter Cove, between Vizcaino and Big Flat SMCAs. This break is considerably reduced – but still present – in the standard and supplemental evaluations of the Round 3 NCRSG MPA Proposal relative to P0.

Conclusion

There is a clear and consistent ranking in expected relative biomass in the round 3 evaluation, with the higher levels of protection associated with the supplemental analysis producing higher expected biomass than the north coast proposal with all proposed uses included, 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 north coast proposal, which in turn had higher expected fishery yield than the supplemental analysis. The exception to this generality is that if fishery management is unsuccessful outside

of the MPAs, the north coast proposal and the supplemental analysis have similar expected yields, both of which are higher than proposal 0.