Title

Adaptive Management of Marine Protected Areas: Predicting Responses to MPA Implementation for Comparison to Monitoring Data

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Adaptive Management of Marine Protected Areas: Predicting Responses to MPA Implementation for Comparison to Monitoring Data

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Narrative

In 1999 California passed the Marine Life Protection Act (MLPA) mandating an expansion of California's few marine protected areas into a network of marine protected areas along the California coast. In 2005 California began a decision-making process to implement this act, and that process was completed in 2013. One of the tools used by decision-makers and stakeholders in that process was the use of mathematical models to project the effects of various proposed spatial configurations of MPAs in terms of their long-term effects on fishery yield and population biomass of various species of fish. Because of the initial nascent nature of this kind of modeling, the ability to make these projections developed as the process proceeded (Botsford, et al. 2014).

The MLPA mandated that the resulting network of MPAs be managed by adaptive management, which meant that once implemented the MPAs would be monitored to determine whether they were achieving their predicted performance by comparing the results of monitoring to the predicted performance. This presented a problem: we would be monitoring fish populations as they responded to a change in mortality rates, from being fished to not being fished. The predictions of performance, on the other hand, had been made for the long-term. To do adaptive management we needed models to project how populations responded when fishing was suddenly removed. Hence the title of this project.

The state of the science in 2010 from models and data

When we began this project there had been a dramatic increase in the amount of empirical and modeling research, hence our first step was a comprehensive review of those results (White, et al. 2011). We concluded empirical and modeling results would need to be combined for the successful development of MPAs as a management tool (e.g., through adaptive management), and that both were proceeding, but on different time scales, with monitoring focused on the transient increases in fish populations following the implementation of MPAs and modeling focused on the long-term responses. One of the consequences of this mismatch in time scales was that the empirical and the modeling results were not being combined and compared, as they needed to be. This was further justification of the goals of our project.

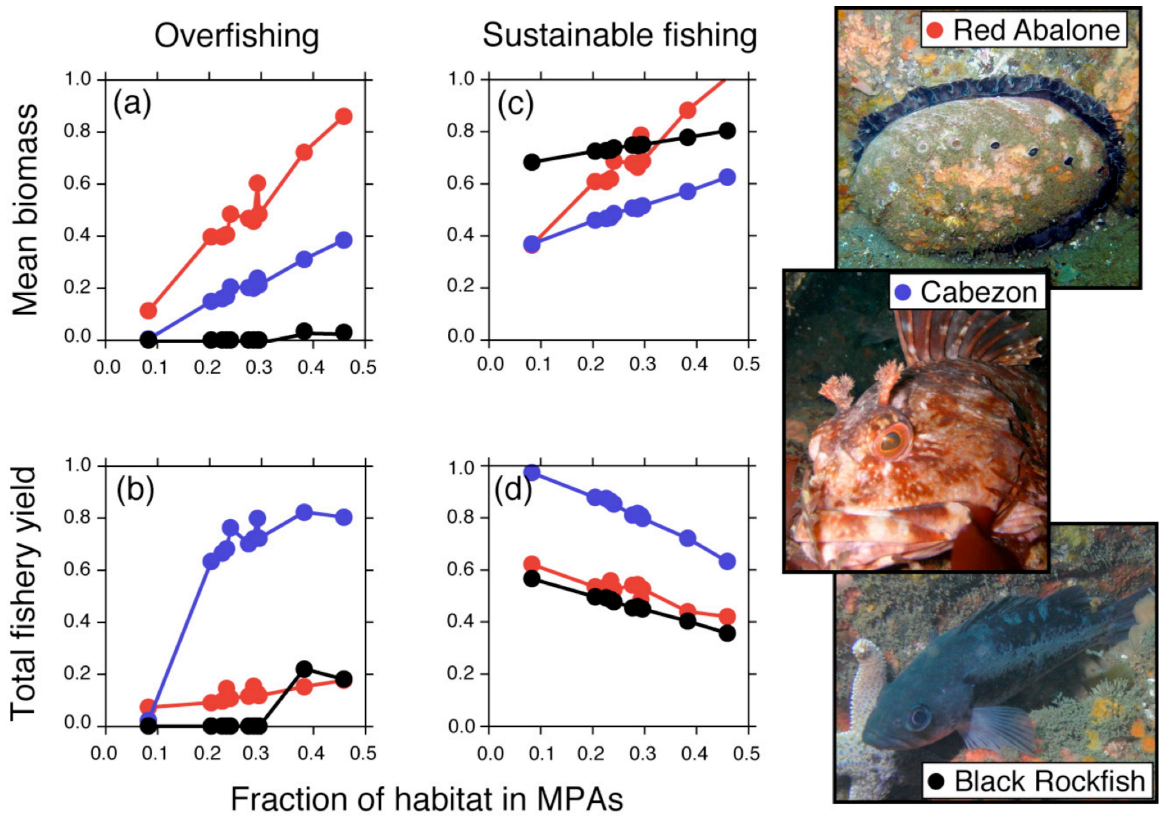

Figure 1. The long-term response of species with different movement rates to MPAs, in terms of yield and biomass, when overfished and sustainability fished (from White, et al. 2011)

Figure 1 from that paper is a good summary of the understanding of the long-term effects of MPAs. It shows the different responses of three different species to the placement of an increasing fraction of habitat in MPAs. The three species compared are a species with low larval dispersal distance and low juvenile/adult movement (red abalone), a species with large larval dispersal distance and low juvenile adult movement (cabezon), and a species with both large larval dispersal distance and large adult home range size (black rockfish). Comparisons are made in terms of an economic benefit, fishery yield and an ecological benefit, biomass, and comparisons are made for two different levels of fishing, sustainable fishing and overfishing. The points on these graphs are taken from modeling results for 11 different proposed alternative networks of MPAs.

These results illustrate the effects of different amounts of movement, and different amounts of fishing on MPA performance. Taking biomass first, under overfishing (upper left, panel (a)), placing increasing area in MPAs causes some increase in biomass for all three species, but greater increase for species with less movement. If these species are sustainably fished, biomass still increases some for all three species, but the most increase is in the species with the least movement. Turning to fishery yield, if the species are overfished (lower left panel (b)), as MPAs increase yield of the cabezon increases dramatically. The yield of red abalone increases at a much lower rate because it produces less spillover. Yield of black rockfish of course cannot increase until there are enough MPAs for it to have non-zero biomass (panel (a)). If these species are sustainably fished (lower right panel (d)), increasing the fraction of MPAs causes a decline in yield because areas of possible sustainable fishing are being removed.

Which species will have been protected by the MLPAs size and spacing guidelines?

Trying to estimate the transient response of near shore communities to the MPAs from the MLPA process is complicated by the fact that we do not know which combinations of species will have been protected by the size and spacing guidelines used in the MLPA decision-making process. Our next step was to try to gain some sense of that. The size guideline was that MPAs should span at least 5-10 km alongshore, and the spacing guideline was that they should be no more than 50-100km apart. This could lead to a fraction of coastline covered ranging from 5 percent to 28 percent. In fact the percentage in no-take MPAs was 9.4 percent, while the fraction including limited take was 16.0 percent (Gleason, et al. 2013).

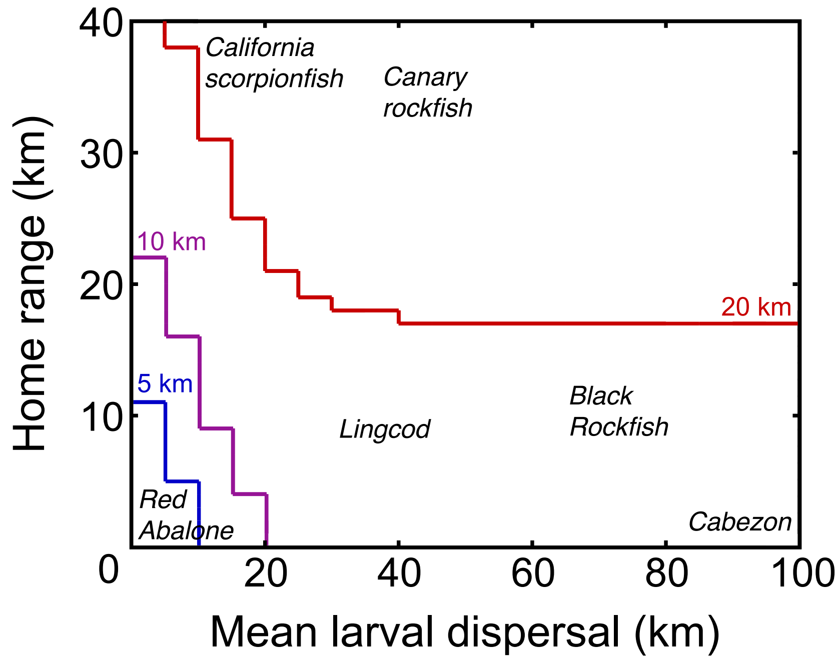

Figure 2. The response of species with different combinations of movement rates to MPAs spaced 50 km apart with different alongshore sizes. Species to the left and below the lines would persist in each size of MPA.

Fig. 2, a summary of the results in our second publication (Moffitt, et al. 2011) indicates how various species with different combinations of larval dispersal distances and home ranges would be protected. In this figure, species to the lower left of the colored lines would be protected in a system of MPAs spaced 50 km apart with alongshore dimension printed near the line. The species names are printed at the combinations of larval dispersal distance and home range we think they have. The key message in this figure is that as the MPAs become larger, and the fraction of coastline covered increases, the number of movement combinations covered initially increases slowly (e.g., from 5 to 10km), then, at some point, it jumps to include all species with home ranges smaller than the home range, regardless of their dispersal distance. This jump occurs when the fraction of coastline reaches a certain value, which we think is around 35 percent. These results were interesting, but they were difficult to carry much further because of their complex dependence on several uncertainties.

Lessons learned from modeling in the MLPA process

Our next contribution to this project was a collaborative publication describing the modeling done in support of the decision-making process for the implementation of the MLPA (White, et al. 2012). This was part of a special issue of Ocean and Coastal Management to describe the “lessons learned” from that process. Perhaps our most important contribution to that volume was the reminder to our colleagues that because we insufficient results from monitoring of the MPA, that lessons learned for the successful implementation of the MPAs, i.e., that they were not necessarily lessons learned for the implementation of successful MPAs. The latter would be possible only after the accumulation of sufficient monitoring data.

The transient response of populations to the removal of fishing