COMMENT

The role of science in MPA establishment in California: a personal perspective

Introduction

California is establishing marine protected areas (MPAs) in the state waters (up to three miles offshore), and dozens of new MPAs have been designated over *c.* 1500 km of coastline. This may be the largest programme to date of establishing temperate MPAs and other jurisdictions (for example, the UK) may look to the California process for lessons on how to proceed. I was involved in the process through participation in the Science Advisory Team, and this paper is my personal perspective on the lessons learned thus far from the California process.

The process was initiated in 1999, by the passage of the Marine Life Protection Act (MLPA) in the California state legislature . Early attempts at meeting the requirements of the Act were largely a top-down government-directed effort and failed after two attempts, in 2000 and in 2002 (Weible *et al.* 2004; Weible 2007, 2008). The initial process failed because of (1) insufficient financial support, (2) unclear objectives, (3) exclusion of stakeholders, (4) lack of experience of state officials, and (5) polarization of stakeholders into proponents and opponents (Weible 2008).

After arranging funding from foundations, the process was restarted in 2004 (Gleason 2010). The first step was to establish a Master Plan framework (California Department of Fish and Game 2010) that defined both the process and the key elements of design. The California coastline was broken into four regions, and the process moved sequentially from the Central Coast, to the North Central Coast, to the South Coast and finally the North Coast.

There were four key tasks within each region: (1) planning including assembly of data and identification of a Regional Stakeholder Group (RSG); (2) design of alternative MPA proposals by the RSG using guidelines from the Master Plan to determine what was required to meet the objectives of the Act; (3) ranking of alternative MPA proposals by the Science Advisory Team (SAT) based on the guidelines, these evaluations being passed onto the Blue Ribbon Task Force (BRTF) which considered the implications including social and economic impact recommended a single plan; and (4) decision-making on the MPA design by California Fish and Game Commission, based on BRTF recommendations and public hearings.

Evaluating alternative MPA designs

The role of science was primarily to determine if proposed MPA designs met the objectives of the Act. The MLPA laid out the specific objectives to:

(1) protect the natural diversity and abundance of marine life, and the structure, function and integrity of marine ecosystems;

(2) help sustain, conserve, and protect marine life populations, including those of economic value, and rebuild those that were depleted;

(3) improve recreational, educational, and study opportunities provided by marine ecosystems that are subject to minimal human disturbance, and to manage these uses in a manner consistent with protecting biodiversity;

(4) protect marine natural heritage, including protection of representative and unique marine life habitats in California waters for their intrinsic value;

(5) ensure that California's MPAs have clearly defined objectives, effective management measures, and adequate enforcement, based on sound scientific guidelines; and

(6) ensure that the state's MPAs are designed and managed, to the extent possible, as a network.

It is difficult to determine if the legislators envisioned a MPA system that would constitute 1%, 5%, 20% or 80% of the coastline. I will argue below, that the result of this vagueness (Weible 2008) was that it was left to the SAT to make decisions that ultimately determined the proportion of coastline protected, and the BRTF felt constrained by the Master Plan and SAT advice.

The primary scientific task as laid down in the Master Plan was the establishment of the guidelines, and the evaluation of the alternative designs against the guidelines.

Guidelines in the Master Plan

The guidelines required: (1) every 'key' marine habitat to be represented in the MPA network; (2) every 'key' marine habitat to be replicated in multiple MPAs across large environmental and geographic gradients and at least 3–5 replicate MPAs to be designed for each habitat type within a biogeographical region; (3) MPAs to extend from the intertidal zone to deep waters offshore and to have an alongshore span of 5–10 km of coastline (preferably 10–20 km); and (4) MPAs to be placed within 50–100 km of each other (Gleason *et al.* 2010).

Habitat representation and replication guidelines
The first step within each region was identifying the key marine habitats. To fully meet the guidelines, each habitat had to be represented inside a MPA that met the size guidelines within each sub-region. Thus, in theory, the guidelines could be met if a MPA could be found within each sub-region that

captured all the key habitats, provided the distance between these MPAs did not exceed the spacing guidelines. Because there were so many different habitats and all habitats were not often found contiguously in one potential MPA, it was often necessary to specify MPAs to protect individual habitat types to ensure that every habitat was represented in each sub-region. Thus the replication guideline, combined with the definition of sub-regions and key habitats, provided strong constraints on the minimum extent of MPAs.

Across all four study regions, most of the 'key habitats' were based on relationships between fish, invertebrate and algal communities with distinct geological features (for example soft versus hard bottom) and water depth (see Allen *et al.* 2006 for fishes). However, within each region, particular habitat features (oil platforms, jetties and natural oil seeps) were addressed, and the decisions on additional key habitats often reflected the regional expertise of the SAT members. Thus, identification of some key habitats in each region was influenced by the regional composition of the SAT.

Spacing guidelines

The idea that MPAs need to be within networks was explicit in the MLPA and is based on the view that MPAs must be close enough that larvae for most species can disperse between them because there will be few, if any, larvae produced outside MPAs. This, in turn, is based on the assumption that there are few, if any, fish outside of MPAs, and that the MPAs will be the dominant source of larvae (Allison *et al.* 1998; Lubchenco *et al.* 2002).

During the South Coast process, I showed through modelling that the outcome of different MPA designs was independent of their spacing; these results were later confirmed (Moffitt *et al.* 2011) and showed the persistence of species that were systematically overfished depended primarily on the size of reserves, with the spacing between reserves having almost no influence.

I argue that the spacing guidelines were a result of the composition of the initial SAT and, if the initial SAT had been dominated by those who view models as an essential tool in population dynamics, the SAT might have excluded such spacing guidelines. While the concept of network was written into the MLPA itself, modellers would argue that the models implicitly evaluate alternative network designs.

Size guidelines

Given the differential mobility of adults, juveniles and eggs of different species, very large MPAs would be required to protect the most mobile species while sedentary species only require small MPAs. The Master Plan recognized this, and the SAT guidelines on size were a compromise that protected more sedentary species. However a result of the size guidelines as they interacted with the evaluation process, is that there were no benefits (as measured by the guidelines) to establishment of MPAs smaller or larger than the guidelines.

Thus, most MPAs proposed to the RSGs covered *c.* 5–20 km of coastline and, given that most extend out to the state water boundary, the result is that most MPAs are 25–100 km^2.

There are many benefits to both large and small reserves. The Leigh Reserve in New Zealand has been an important site in development of the science and advocacy of MPAs. Established in 1975, it is a very successful tourist and educational destination, receives over 350 000 tourist visits annually and numerous publications have resulted from studies conducted there, yet the Leigh Reserve is only 5.25 km^2, well below the minimum Californian MPA size guideline. Similarly, the Hanauma Bay reserve (Honolulu, Hawaii, USA) receives over three million visitors per year and covers an area of < 1 km^2. I suspect that the MLPA objectives of increased tourism and study opportunity would have been greatly enhanced by many more small MPAs located next to population centres. The MLPA ended up with roughly a dozen such small MPAs, however, because they failed to meet size guidelines and there were no other guidelines or evaluation criteria that gave credit to small MPAs, there were few incentives for the RSG to propose such MPAs.

A totally different approach to size guidelines would have been to specify a mix of large and small reserves. The guidelines might have specified that 10% of the total area in MPAs should be 1–5 km^2, and 40% should be in MPAs > 100 km^2. These smaller MPAs would have benefited the less mobile species, while a few large MPAs would have benefited the more mobile species.

Models as an alternative evaluation tool

In the development of the MLPA process in the initial region (Central Coast), Professor L. Botsford was a SAT member and advocated the use of simulation models to evaluate proposals as a supplement to the guidelines. Botsford was not selected for the SAT after the first region, but continued to be funded by the process for the development of models (White *et al.* 2010*a*, *b*; Gruss *et al.* 2011) When the process moved to the North Central Coast, C. Costello, R. Hilborn and C.J. Walters all joined the SAT team, with the express intent of helping to introduce models to the evaluation process. After initially presenting a range of models, these three ended up converging on a single model that was used in the evaluations for the final three regions. At the same time, Botsford and his team continued development of their model and both the Costello *et al.* and Botsford *et al.* models (White *et al.* 2010*b*) were applied in the last three regions to evaluate alternative RSG designs.

The modelling groups argued that the models could replace the size and spacing guidelines because they explicitly dealt with the 'rule of thumb' elements in the size and spacing guidelines. However, this argument was never accepted by the SAT and the model evaluations became a supplemental, rather than an essential component of the evaluation.

Lessons learned

Based on my experience with the MLPA, I believe three main lessons should be learned.

Allowing for uncertainty

As the MLPA process unfolded, it became very clear that there was great uncertainty about the ultimate impacts of specific patterns of MPAs, and the consequences of allowing different kinds of extractive activities inside the MPAs. Perhaps the greatest uncertainty was associated with the level of exploitation of the species that were targeted by commercial and recreational fisheries and found primarily in state waters. The extent to which different species would be protected by smaller MPAs was also highly uncertain; while diffusive models suggested that larger MPAs were necessary, there is also evidence that many adult fish are largely sedentary and would be protected sufficiently by small MPAs. At every stage in the process, uncertainties were resolved with whatever data were available or with educated scientific guesses.

The Master Plan stated 'The MLPA requires that the master plan include recommendations for monitoring and evaluation in selected areas for adaptive management'. If adaptive management had been actually incorporated into the design process, then there would have been the option of explicitly designing experiments to test uncertainties. A range of sizes of MPAs would have been established to test the hypotheses about what species would be protected by different size MPAs and different kinds of extractive activities would have been allowed within some MPAs to see if these extractive activities affected the structure and function of the MPAs. There was no formal incorporation of experimentation and adaptive management in the process.

Extent of MPAs

The polarization over the design of MPAs can be attributed primarily to two questions: how large an area should be protected and what locations should be protected? I question the ability of science to provide answers to either of these issues. Science can answer specific questions such as: how much of the habitat of species x needs to be protected so that the populations would be self sustaining in the event of sustained overexploitation outside of MPAs? However, because MPAs are an ecosystem management tool, any choice of total area to protect will leave the more mobile species subject to overexploitation outside the MPA system, and science cannot provide information over what overall extent of MPAs is appropriate, nor did the SAT in California have specific information on what species were likely to be overexploited outside MPAs. My recommendation is that legislation in other jurisdictions simply specify the proportion of the marine area to be set aside in MPAs. The decision would, of course, be arbitrary, but it has already been done in the Convention on Biological Diversity, where many countries agreed to set aside 20% of their marine areas in MPAs.

Overcoming the problems of the failed implementation attempts

For the proponents of the MLPA, the process has been successful; while some court challenges remain, the number of MPAs in Californian state waters has been significantly increased. However, if I examine criticism of earlier failed efforts, in some ways little has changed. Weible (2008) highlighted five lessons learned as applicable to other jurisdictions, and I now consider these. (1) Insufficient financial support was provided by the Californian state government, a problem solved by substantial funding from environmental foundations. Data assembly and stakeholder consultation were very expensive and it seems unlikely that the tens of millions of dollars made available in California would be found again repeatedly in other regions, which must budget accordingly. (2) Weible (2008) found statutory objectives were 'unclear, unranked and inconsistent'; as I have argued above, the MLPA process relied on the SAT providing clear objectives in the form of design guidelines. I would suggest that the MLPA should have provided these clear objectives. (3) The application of a science-based process that excluded affected stakeholders was solved with lengthy stakeholder involvement that seems an unavoidable requisite of future marine spatial planning; devolving significant responsibility to regional stakeholders is probably essential for success. (4) Weibel (2008) believed implementing officials lacked expertise in designing and managing political processes; however, that the process was completed suggests that the staff finally assembled did have the expertise to see completion of the process and, for the first region, the director of the MLPA was an individual who had specific experience at implementing laws. Further, many on the BRTF were regional politicians. Other jurisdictions should not underestimate the staffing demands for consultative processes. (5) That stakeholder community were polarized into coalitions of proponents and opponents of MPAs remains unchanged, as indicated by current legal challenges, despite efforts to blend stakeholders from different perspectives into joint teams to design alternatives. It seems highly likely that this polarization will remain entrenched in any similar process.

Recommendations

Based on my experience with the California MLPA process, I recommend that future jurisdictions consider the following changes to the Californian process. Overall the definition of three key groups, namely stakeholders, science and policy choice, seems appropriate and necessary. But I would make some specific recommendations for change.

Legislation must be much more specific about objectives and especially the extent of the marine zone that they envision being set aside in MPAs, ideally as a range of the minimum and maximum proportion of the area. Such guidelines currently exist in treaties signed by many national governments.

Marine ecosystems in California and around the world are threatened by many factors, including, but not limited to, ocean acidification, ocean warming, sea-level rise, dead zones from land-based nutrient runoff, oil and toxic chemical spills, exotic species, illegal fishing and overfishing. The reality is that the only protection the MLPA provides for marine ecosystems is reducing the threat from legal overfishing. The legislation should specifically discuss the range of threats to marine ecosystems and how the MPA process will decrease those threats.

The science team should define, at the outset, the major uncertainties about impacts, and deliberate experimentation and adaptive management should be essential parts of the design. This means that each MPA should have an 'experimental duration' associated with it, the hypotheses associated with each MPA should be explicitly stated and the nature of the tests of these hypotheses defined.

The quantitative modelling framework developed in the MLPA process should replace all size and spacing guidelines for evaluating population level impacts of proposed MPAs. Size guidelines are useful for guiding stakeholder initial designs but, once specific proposals are developed, the models can better evaluate proposals than guidelines. It is possible that by specifying specific objectives the models could be used to generate MPA designs. It may be that the models will find better alternatives than stakeholders sitting around maps.

The development of guidelines for replication and habitat representation should not be confined to a science team. The choices of what are unique habitats and how many replicates there should be are not strictly scientific issues, and a much broader public consultation than was instigated by the Californian MLPA science team should be involved in formulation of such guidelines.

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