Species Movements and Implications for Marine Protected Area (MPA) Network Design

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To set up a network of MPAs that achieves the objective of sustaining and protecting marine populations, we need to take into account when, where, and how far different species move. Movement information will influence where to put MPAs and how big they should be.

Fish and other marine species move from place to place for many reasons—to find food, to seek shelter, and to reproduce. Some species move long distances (over the entire Pacific ocean), whereas others move in much smaller ranges (tens of kilometers), and some species move only a few meters away from where they settled as juveniles. The ways in which species move and use their habitats also differ. Some drift along on ocean currents (e.g., jellyfish and tiny plankton). Some swim (e.g., fish and marine mammals). Some crawl (e.g., crabs and sea stars). Some fly (e.g., sea birds). And some live most of their lives attached to the bottom (e.g., mussels, abalone, and barnacles).

The amount species move and their destinations can change over the course of their life span. For instance, when many rockfish are larvae, they float on open currents. As juveniles, they may use the kelp forest canopy, and as adults they may migrate to deep rocky reefs. Species movements also can vary daily and monthly, as animals seek out food and shelter. Some species move seasonally or make annual migrations (e.g., salmon spawning migrations). Additionally, changing oceanographic and climatic conditions may cause animals to move, because some species will follow the changing temperatures of ocean waters. Over time, species movements vary depending upon population growth or decline, habitat change, and biological and oceanographic conditions.

How Do We Study Fish Movement?

Scientists rely on several different methods to study how species move, including long-term observations facilitated by commercial and recreational fishermen, scientific studies (e.g., tag-and-recapture programs), direct observations through SCUBA surveys or deep-water remotely operated vehicles, surface-based remote sensing observations (e.g., acoustic transmitters and receivers), genetic analyses, and equipment that tracks movements in currents and other oceanographic conditions.

From these data, scientists have determined that many animals have distinct “home ranges,” areas in which they spend most of their time, but will wander outside those territories frequently, visiting a much larger area before returning to their original locations. Scientists also have learned that some species exhibit strong site fidelity and will stay in, or return to, a particular area or point of origin (e.g., a salmon returning to the stream where it was born when it is ready to spawn). New research shows that fish

move around quite a bit each day, but also have more site fidelity than previously thought.

Movements and MPAs

If marine species were randomly distributed, and all species moved the same distance, it would be much easier to determine the size, shape, and location of MPAs for conservation purposes. That is not the case, however. Movements of species vary greatly, almost all species are associated with a particular habitat type, and habitats are patchily distributed in the ocean. The challenge, then, is to provide criteria for sizing and location of MPAs that provides conservation benefits, but does not prevent use of marine resources.

In addition to conservation benefits, many MPAs have an objective of improving the use of marine resources outside MPAs. It has been demonstrated that we can expect an increase in number and size of many fish species inside and MPA. As density of species in MPAs increases, some of the animals are expected to move out of the MPA and are available to be caught in fisheries. This is termed "spillover" from an MPA, and is related to the catch of a species.

If individual fish grow larger inside an MPA, then swim outside the boundary, and are caught, there is potential to increase the overall yield from a species. (Yield from a species is defined as the production from a fishery in terms of numbers or weight.) For highly regulated species, most scientists believe short-term yield is reduced by MPAs, despite any spillover that might occur. In some studies in other parts of the world, however, the spillover from MPAs has actually increased the catch of a species.

Spillover will occur more with some species than with others. The impacts of spillover depend on many variables, such as: how much time a fish spends in an MPA, how much time it spends outside the boundary, what distance it travels when it is outside the MPA, the amount of fishing outside the reserve, the location of fishing effort (e.g., at the edge of the MPA), and the fish's lifespan.

Implications for MPA Design in California

With respect to MPAs in California, some species will always be protected (if they never leave the reserve), some will receive almost no protection (if they only rarely enter MPAs), and some will receive partial protection. The larger the MPA, the more individuals and species will be protected because more habitats will be protected and a smaller proportion of the protected species will move outside the protected area boundaries. In California, rocky areas comprise a smaller proportion of the habitats in deeper water than near the coast. This suggests that MPAs will need to be larger in deeper water to achieve a similar level of protection for species as in shallow waters.

The Science Advisory Team reviewed the literature on movements of marine species in California and identified a range of movements of species that seemed to achieve a

balance of conservation and use of species. Many of the species in California that would benefit most from MPAs have home ranges of less than 20 kilometers (e.g., many rockfishes, lingcod, cabezon, halibut, and various invertebrates such as sea stars and abalone). These species' movements form one of the bases for the SAT recommendation that MPAs should be at least 5-10 km long, but preferably 10-20 km long to encompass a variety of habitats and species, and sufficient individuals of a particular species to be beneficial to the overall population of the protected species. MPAs are not expected to provide significant protection to highly migratory species (such as tuna and whales), unless the MPA encompasses a particular habitat used by a migratory species at critical times (e.g., for spawning or rearing young).

Summary of SAT Recommendations

The Science Advisory Team has recommended the following guidelines for MPAs:

- MPAs should be at least 5-10 km long, preferably 10-20 km.
- MPAs should be located in areas with a diversity of habitats.
- MPAs should be larger in deeper water to account for different distribution of rocky and sandy habitats.
- MPAs should be located in areas with critical time and location (e.g., spawning areas).

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