Encyclopedia of Earth

Marine reserves

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Introduction

Marine reserves are areas in the ocean where no extractive activities are allowed. They are also often called ‘no-take zones’, since the killing, harming, or harassing of any plants or animals within the reserve boundaries is not allowed, and they are part of a broader spectrum of marine spatial management tools that fit under the umbrella term ‘Marine Protected Areas’, or MPAs.

The idea of setting aside fully protected regions of the oceans has been around for a long time, but it is only in the past decade or two that marine reserves have become a common tool for managing and protecting marine resources. Most commonly reserves are established for conservation purposes, but strong interest also exists in using them as a fisheries management tool. Even so, a relatively small portion of the world’s oceans to date have been set aside in marine reserves – less that 1%.

The science of marine reserves

Research on how and why marine reserves affect species inside and outside their boundaries has exploded in the past decade (see Fig. 1). This research has focused on a variety of topics, including ecological questions about how different species have responded or are expected to respond to protection and conservation planning questions about how to design reserve networks to maximize benefits while minimizing costs to fishermen and other users of ocean resources. This field of research clearly remains very active, but there are a number of key results and lessons learned that have emerged from the vast amount of past research.

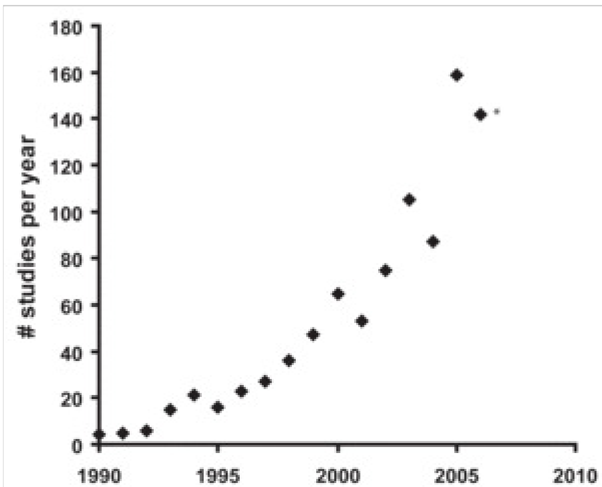

Figure 1: The number of scientific studies on marine reserves has been growing exponentially over the past 15 years, shown here by the number of studies each year that used the term ‘marine reserves’ in the title or abstract of the article. The * indicates that the value for 2006 was estimated based on the number of studies published through September.

Ecological responses to reserve protection

Marine reserves effectively change the mortality rates on key (fished) species within the reserve boundaries, and this higher survival rate has direct consequences for those species and indirect implications for the entire community and ecosystem in which the species live. A large body of research suggests that:

- Because mortality rates are lower within the reserve, species become more abundant and live longer (grow larger), which in turn significantly increases to total biomass of the species.
- Reserve protection also increases the number of species, or biodiversity, found within the reserve compared to nearby fished

areas.

- Species that are targeted by fisheries and that are less mobile (i.e., less likely to swim outside reserve boundaries) are much more likely to respond positively to reserve protection.
- Non-target species, which are often the prey of the target species, often do not respond to reserve protection, and may decrease in abundance due to the greater number of their predators within the reserve. In the most dramatic cases, increases in predator abundances lead to large decreases in their prey which in turn releases plants and algae from consumption, creating a trophic cascade.

In contrast, there are a number of related questions that remain active areas of research and do not yet have clear answers. In particular, what, if any, effect do reserves have on species and biological communities outside reserve boundaries? The answer to this question depends on two variables: how much adult fish swim across (or “spillover”) reserve boundaries, and how much reproductive output from within the reserve is transported to areas outside the reserve. Some initial work on the “spillover” effect suggests that reserves can lead to greater abundances of fish outside reserve boundaries, but the extent of this spillover is likely dependent on the traits of the species of interest and the configuration of habitats and the nature of the oceanography in the area of question. Much less is known about the potential for reserves to export larvae to other locations, mainly because of the difficulty in tracking tiny larvae in vast oceans. Theoretical work suggests that this larval transport could be significant, but it has yet to be confirmed empirically.

Equally important and unresolved is how reserves may affect entire biological communities. The examples of trophic cascades within reserves, mentioned above, suggest that these community-level consequences can be dramatic. Beyond these examples, however we know little about other less dramatic but potentially equally important community responses to reserve protection.

Designing reserves and reserve networks

Much of the research on, and debate about, marine reserves has focused on how to design them to achieve or maximize the management goals for the reserves. There are four key design questions: where should reserves be placed, how big should individual reserves be, how much area should the total reserve network cover, and how much space should be between reserves? Both the mobility of adults and the dispersal distances of larvae greatly influence the answers to these questions, and therefore the design of marine reserves and reserve networks. Because of differences in adult mobility and larval dispersal among species, no single set of answers will likely work for all species or every location in the world. However, research suggests that the following guidelines should work for most species in most locations:

- Individual reserves should be most effective if they are 4-20km wide, although even tiny reserves can produce positive outcomes.
- Reserves should be spaced 20-200km apart.
- A minimum of 20% of each habitat type needs to be protected within reserves to ensure long-term sustainability of marine resources, and in many cases 30-50% should be set aside.
- The best location for marine reserves will depend on local conditions, but protection of critical locations such as spawning grounds and nursery habitats is important.

Real world examples

Marine reserves exist in nearly every country in the world, although many reserves have poor enforcement and are therefore paper parks that offer little real protection. Reserves in which scientific research has been conducted come from a variety of locations (see Fig. 2).

Figure 2: The location of marine reserves in which scientific studies have been conducted. The number in each bubble indicates how many reserves that have been studied are at that location. Data are through the end of 1999.

Two recently created networks of marine reserves – the Channel Islands off the coast of California and the Great Barrier Reef in Australia – have drawn significant international attention due to the size and comprehensiveness of the protection provided by the reserve networks and because they represent the first large-scale reserve networks to have been created. The creation of these reserve networks involved years of planning, a variety of venues for stakeholder involvement, and significant scientific input from many disciplines. In both cases 20-30% of the waters were set aside in protected areas, and the management plans involved a variety of designations that included full protection, partial protection, and areas open to fishing and other human activities.

Further reading

- The consensus statement on marine reserves
- Halpern, B.S. 2003. The impact of marine reserves: do reserves work and does reserve size matter? Ecological Applications 13: S117-S137
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Citation

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