

Minimum size of no-take marine protected areas to protect coral reef fishes

The problem

No-take marine protected areas (MPAs) are seen as a critical tool to address unsustainable and destructive fishing practices that threaten coral reef biodiversity and fisheries sustainability in many tropical countries. However, the sizes of locally enforced MPAs are often chosen arbitrarily, because information on the movements of fished species is generally unavailable. In recent years, data on the movements of coral reef fishes has become increasingly available (Green et al. 2015, *Biological Reviews*). These data show that the scales of adult movements of most fishery species are restricted to a few km or less. So far, this information has been used to develop ecological guidelines on the reserve sizes needed to ensure effective species protection. The problem is that guidelines tend to be non-rigorous, providing only rough approximations that may fail to achieve effective conservation.

The study

A recent study analysed the home ranges, densities and schooling behaviour of 66 species of coral reef fishes in order to quantify precisely how big a no-take MPA would have to be in order to ensure the effective protection of resident fishery species. The study found that “full” protection, which is equivalent to abundances of fishes in a pristine world without any fishing, might require very large no-take MPAs. “Partial” protection, in contrast, which is a term used to describe any percentage of “full” protection equal to or larger than 50% of the maximum number of protected individuals, can be achieved in much smaller no-take MPAs. Outcomes on protection effectiveness simulated as part of the study were used to conduct simple linear regressions against data on the mean home ranges, mean densities and maximum lengths of simulated fish species. The results (shown in tables on page 2) provide coefficients that allow decision makers to approximate modelling results very closely. Thus, data on the mean home ranges (ideal) or maximum lengths of resident fish species alone can be used to calculate the desirable size of no-take MPAs to ensure variable levels of protection effectiveness.

Application of modelling outcomes

A software package developed based on modelling outcomes and associated regression coefficients will soon be available for download at <https://www.marinespatialecologylab.org/>. The software will allow MPA design practitioners for estimating locally effective MPA sizes based on available or their own data.

Practical application of no-take MPA size predictions

Assuming that fish are equally likely to move in any direction, outcomes from the study represent the conservation effectiveness of the minimum diameter of any existing no-take MPA. However, conservation planners are more likely to apply model predictions in support of decisions on no-take MPA sizes in one specific direction. A recent example of this is the lead author's own experience with the designation of no-take MPAs in Indonesia. Most coral reefs in this study area are fringing reefs, which extend along the coastline. While reef fishes might then have a potentially extensive home range in alongshore direction, their movements across a depth gradient in offshore direction are restricted by the extent of available reef habitat (from lagoons to reef slopes and any offshore reef patches). In consequence, predictions of conservation effectiveness to quantify the consequences of alternative decisions on MPA sizes in alongshore direction, while suitable MPA sizes in offshore direction were assessed based on local reef geomorphology.

Reference

Krueck NC, Legrand C, Ahmadi GN, Green A, Jones GP, Possingham HP, Riginos C, Treml EA, Mumby PJ (in print). Reserve sizes needed to protect coral reef fishes. *Conservation Letters*

Frequently asked questions

1) Does the density of fishery species impact how big no-take MPAs should be?

Home range was found to be the single most important predictor of protection effectiveness. Density was an additional predictor that was found to be important primarily when home ranges were < 200 m.

2) Are calculations based on maximum fish length as precise as those based on mean home range?

No, estimates of minimum no-take MPA sizes based on maximum fish lengths provide a less reliable approximation of than mean home ranges. However, the mean home range of fishes is highly positively correlated with their maximum length, providing a useful proxy to support decisions in the absence of home range data.

3) Will large no-take MPAs for adult protection still export enough larvae to support fisheries?

On coral reefs, even no-take MPAs that are up to 20 km wide should export enough larvae to support the productivity of adjacent fishing grounds.