# Patterns and mechanisms of spillover from marine reserves

Thesis submitted by
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Rene A. Abesamis

## Abstract

The use of no-take marine reserves (areas closed to fishing) as fishery management tools has been advocated considerably in the past decade. No-take reserves are now often established with an objective of enhancing fisheries. However, the fishery effects of no-take reserves remain controversial. Spillover, or net export of adult biomass, is one potential process of fisheries enhancement by reserves. Few studies have shown convincingly that reserves can develop spillover that benefits local fisheries. The objective of this thesis was to investigate the predicted patterns and proposed mechanisms of spillover from no-take reserves. The no-take reserves studied were on coral reefs in the Philippines that have been well protected for 15 to 20 years.

In the first study, I tested the prediction that gradients of decreasing abundance of target species, from high inside the reserve to low outside, would be present across the boundaries of no-take reserves. Spillover is predicted to produce such patterns. Underwater visual census of fishes was carried out along large transects (each one approximately 1 km long) that crossed the lateral boundaries of each of two no-take reserves and two controls (fished sites) at each of two islands. Patterns of decreasing abundance (density and biomass) of target fishes were found only across one boundary of one no-take reserve, the reserve at Apo Island (Apo Reserve). The patterns of decreasing abundance were limited to within 50-200 m of the boundary. Rates of decrease in abundance across the boundary were two to three times greater for sedentary fishes than for vagile fish. This finding is consistent with the expectation that the spatial extent of spillover would vary according to mobility of fishes. The patterns of decreasing abundance of target fishes were probably not due to gradients in habitat. Furthermore, no pattern of decreasing abundance across the boundary was found for fishes not targeted by fisheries.

In the second study, I investigated the potential mechanisms inducing movement of a targeted planktivorous reef fish, *Naso vlamingii*, from Apo Reserve to adjacent fished areas. Repeated underwater visual census at reserve and fished sites suggested that some adults of *N. vlamingii* could emigrate temporarily from Apo Reserve within the short-term (days). Data from visual census and experimental hook and line fishing suggested that short-term emigration of *N. vlamingii* is related to movement to feeding areas 150-200 m away from reserve boundaries. However, some larger (41-45 cm TL) adults probably tend to stay inside the reserve. Experimental hook and line fishing

adjacent to the reserve also showed that the mean size of *N. vlamingii* captured decreased as one moved up to 300 m away from the boundaries of Apo Reserve. This pattern may have resulted from density-dependent home range relocation of smaller adult *N. vlamingii* over the long term. Competitive interactions between adult *N. vlamingii* were up to twice as frequent, on a per fish basis, inside the reserve than outside. When interacting adults differed in sizes, the larger adult was always observed to chase away the smaller one. The sizes of adults that were chased away (25-35 cm TL) were similar to the sizes of those caught by experimental fishing (26-38 cm TL).

In the third study, I attempted to quantify the contribution of spillover to the yield of the local fishery at Apo Island. Daily fishing effort and yield (biomass and value) of local fishers in relation to Apo Reserve were studied for eight months (July 2003 to February 2004) over two monsoonal seasons. Average catch rates and income rates of fishers were found to be highest near the reserve (within 300 m of reserve boundaries). Catch rates near the reserve were higher than in other areas far from the reserve by a factor of 1.1 to 2.0, depending on the fishing gear. Moreover, the highest average monthly catch rates were always found near the reserve. These findings are consistent with occasional very large catches near the reserve due to spillover. However, fishing effort was often lowest near Apo Reserve. Furthermore, local fishers seemed to have avoided fishing very close to the reserve (within 100 m of reserve boundaries). Most fishing (79% of overall fishing effort) occurred far from the reserve, on the northern fishing grounds of Apo Island. Yields from spillover probably contributed less than 10% of the total yield of the local fishery. Fishing effort near Apo Reserve appears to be limited by 1) weather conditions caused by the monsoons, 2) the traditional importance of the northern fishing grounds, 3) high variability of catch rates and income rates, 4) lower value of target species found near the reserve, and 5) social pressures within the local community.

The results of this thesis provide consistent, yet equivocal, evidence for spillover from Apo Reserve. This study could not provide information on patterns of abundance (density, biomass, mean size or catch rate) and behaviour (movement and aggressive interactions) of target fishes, nor patterns of fishing effort of fishers, before the reserve was established. Nonetheless, research over the last two decades suggests that spillover of target fishes from Apo Reserve has developed over time. Spillover may have produced some of the patterns found in the present study. The main conclusion from

this thesis is that Apo Reserve has probably developed spillover, but has provided very limited direct benefits to the local fishery.

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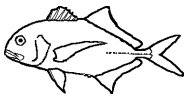

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