

Size spectra analysis as a tool to examine management effectiveness of marine protected areas

T. Kartawijaya, R.L. Ardiwijaya, S.T. Pardede, A. Mukminin, S. Campbell

Wildlife Conservation Society – Indonesia Marine Program, Jalan Burangrang 18, Bogor 16151, Indonesia

Abstract. Following extensive community consultation and resource assessments the allowable uses within Karimunjawa National Park (KNP), Indonesia, were re-zoned in 2005. The aim was to improve the health of coral reefs and increase the biomass of reef fish. We evaluated the effectiveness of zoning by comparing the abundance and size of reef fishes among no-take zones (entry prohibited), no-take zones (entry permitted) and fishing zones. The census included all reef fish species and each fish was placed into size class categories of 5cm increments from 0 to 40+ cm. Biomass was calculated using established weight-and-length relationships. The biomass of large fishes was generally higher in no take zones (mean \pm S E: $536 \pm 113 \text{ kg ha}^{-1}$) than in no-take zones (entry permitted) ($353 \pm 63 \text{ kg ha}^{-1}$) and fishing zones ($301 \pm 39 \text{ kg ha}^{-1}$), although the effect was not significant. Size spectra analyses showed that reef fish structure did vary among management zones with reef fishes in size class of 15-20cm and 35-40cm most abundant in the no-take zone (entry prohibited). Fish in the no-take zone (entry prohibited) were mostly of target species, including fusiliers, emperors, snappers and groupers. In contrast, small (5-10cm) non-target species, mainly wrasses and cardinal fishes, were more abundant in the fishing zones. The higher biomass of large sized fishes inside no-take zones (entry prohibited) is most likely because fishing pressure has been reduced. Although enforcement of fishing regulations inside the park remains inadequate, the results suggest that fishing restrictions are receiving support among fishers and if support continues fish stocks in all zones may increase.

Key words : Karimunjawa National Park, effectiveness management, size spectra, biomass.

Introduction

Karimunjawa National Park is one of eight national marine protected areas in Indonesia and is situated 120 km north of Semarang, Central Java, Indonesia (Fig. 1). Based on Indonesia law No. 5/1990 regarding the conservation of natural resources and ecosystems, the national park is managed by a zoning system. A rezoning process was conducted from 2003 to 2005 as part of an effort to design an effective management system by the National Park Authority with the aim of improving health of coral reefs and to increase the biomass of reef fish. We evaluated the effectiveness of zoning by comparing the abundance and size of reef fishes among no-take zones (entry prohibited), no-take zones (entry permitted), and fishing zones.

Material and Methods

The fish community was sampled using visual census methods recording all fish to species level, except for gobies (Gobiidae), blennies (Blenniidae), and triplefins (Tripterygiidae). Fish biomass was calculated using total length (cm) of fish and converted into weight

(kg) using length-weight relationships (Froese and Pauly 2000).

Information on fishing grounds, number of fishers, and type of gears were collected during interviews with fishers in Karimunjawa National Park between March 2005 and February 2006.

Two-way ANOVA were used to test for differences in fish biomass between management zones and size classes and between, management zones and trophic groups. Data were tested for normality and log transformed prior to analysis.

Results and Discussion

Reef fish biomass in no take zones (entry prohibited) was significantly higher than in no take zones (entry permitted) and fishing zones. Size structure also differed between zones with high biomass of fish in size classes from 15 cm to 40 cm in no take zone (entry prohibited) than the other 2 zones. (Fig. 2).

Reef fishes in the no take zone (entry prohibited) and no take zone (entry permitted) had higher size

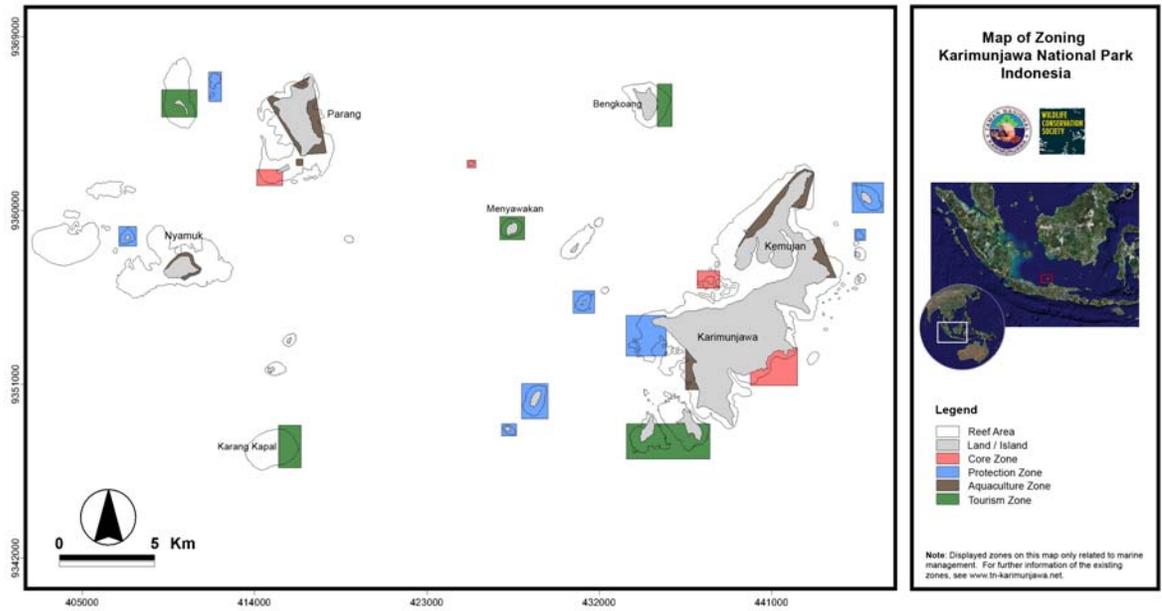


Figure 1. Map of Karimunjawa National Park, Central Java Indonesia.

classes, from 15-20 cm to >40 cm. Most fish in these size classes were fusiliers (Caesionidae), snappers (Lutjanidae), groupers (Serranidae), and emperor (Lethrinidae), which are target species for fisheries in Karimunjawa. The majority of fishes in fishing zones size class consisted of wrasses (Labridae) and cardinal fishes (Apogonidae, Fig. 3).

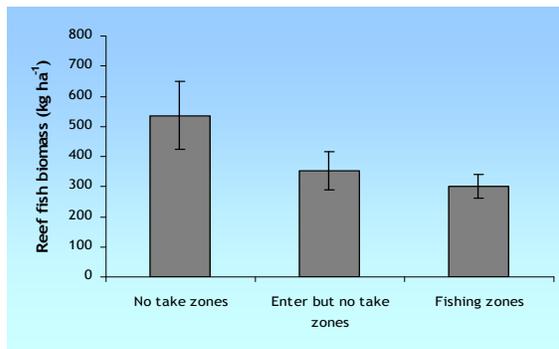


Figure 2. Reef fish biomass in 3 management zones.

Table 1. Two-way ANOVA on fish biomass (kg ha^{-1}) management zones and size structure. Data was log transformed prior to analysis.

Source	df	MS	F	P
Biomass				
Management Zones	4	4.801	3.380	0.010
Size Structure	8	73.501	51.738	0.001
Management Zones x Size Structure	32	1.260	0.887	0.647
Error	342	1.421		

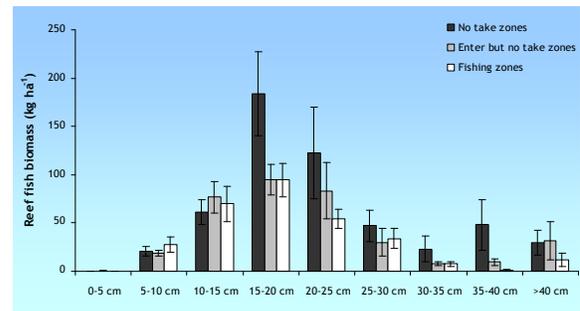


Figure 3. Reef fish biomass (kg ha^{-1}) by size structure in 3 management zones.

Significantly high biomass of planktivore and carnivore were found in the no take zones (entry prohibited) than in the other zones (Table 2). Higher biomass of planktivore and carnivore were found in the no-take zone (entry prohibited) whereas a higher biomass of herbivores was found in fishing zones (Fig. 4).

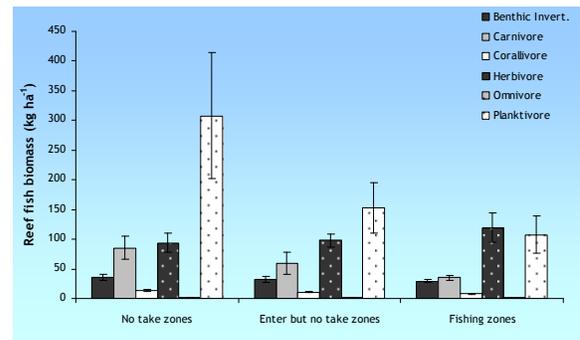


Figure 4. Reef fish biomass (kg ha^{-1}) by trophic groups in 3 management zones.

Table 2. Two-way ANOVA of on fish biomass (kg ha^{-1}) management zones and trophic groups. Data was log transformed prior to analysis.

Source	df	MS	F	P
Biomass				
Management Zones	4	0.904	1.759	0.138
Trophic Groups	5	67.807	132.007	0.001
Management Zones x Trophic Groups	20	0.803	1.564	0.064
Error	21	0.514		

Fishing Intensity

The numbers of fishing trips in each zone revealed that the fishing pressure in the no take zone (entry prohibited) and no take zone (entry permitted) were lower than in the fishing zone (Figure 5).

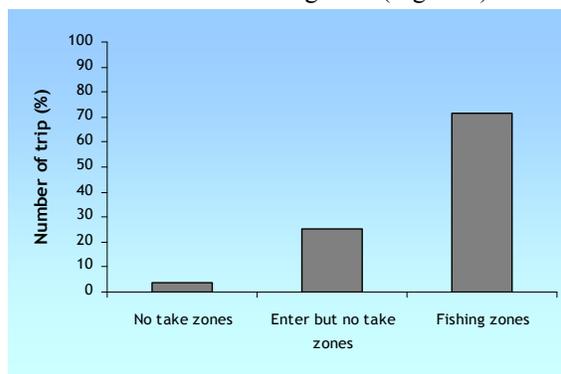


Figure 5. Fishing pressure in 3 management zones.

Conclusions

- Reef fish biomass in the no take zones (entry prohibited) was higher than in no take zones (entry permitted) and the fishing zones.
- Medium and large size classes of target species were most abundant in the no-take zone (entry prohibited).
- Reef fish condition will be improved if all stakeholders and fishers have awareness of sustainable fisheries practices to achieve better management in Karimunjawa National Park.

Acknowledgement

The authors are grateful to the financial contribution of the David and Lucille Packard Foundation, the logistical support provided by staff of the Karimunjawa National Park Authority. The collection of fisheries data would not have been possible without the kind cooperation of local fishing communities in Karimunjawa. Ripanto collected fisheries data.

Reference

Froese R, Pauly D. 2000. FISHBASE 2000. concepts, design and data sources. Philippines, ICLARM. 344pp