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Towards an ecosystem approach to small island fisheries: A preliminary study of a balanced fishery in Kotania Bay (Seram Island, Indonesia)

B.G. Hutubessy [a,b,*], J.W. Mosse [a], P.A.M. van Zwieten [b], P. Hayward [c]

[a] *Fisheries and Marine Science Faculty, Pattimura University, Indonesia*
[b] *Wageningen University and Research Centre, Netherlands*
[c] *School of Arts and Social Sciences, Southern Cross University, Australia*

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Abstract The Ecosystem Approach to Fisheries (EAF) is a holistic one as EAF considers all species as important elements within the eco-system. An EAF requires that community and ecosystem structure should be maintained by harvesting fish communities in proportion to their natural productivity, thereby sustaining the balance of species and sizes in a community. This article draws from research on the reef fish community and catch in Kotania Bay on Seram Island in Maluku, Indonesia, an area of approximately 6000 ha. Based on the trophic guild (ie the aggregation of species utilizing similar food resources) on the reef, the biomass of predator fish currently being captured now represents 40.4% of the total catch biomass. Members of the grouper family, the humphead wrasse (*Cheilinus undulatus*) and trevally (*Caranx melampygus*) in particular, have become targeted for sale in fish markets. If these predators are selectively targeted and exploited, the overall reef fishery and the human populations that depend on it may become imperilled, given these species' significant roles in controlling those lower in the food chain. This study thereby emphasizes the need for balanced fisheries informed by the EAF model in small island fisheries management in order to sustain food security in such regions.

Introduction

Traditional fisheries management is largely based on single species stock assessment. Within this perspective the concept of 'overfishing', referring to loss of yield, has been recognized since the 1950s (Schaefer, 1954). It has, for instance, resulted in prescriptions against harvesting juveniles in order to allow fish to reproduce at least once before harvest (Sissenwine and Shepherd, 1987). Increasing concern about the small size of fish being captured in many fisheries has also led to improving selectivity in order to achieve a cleaner catch of "target species and size" with higher value (Broadhurst, 2008). While this single species assessment approach has had substantial impact on

* Corresponding author at: Fisheries and Marine Science Faculty,

E-mail address: grace.hutubessy@yahoo.com (B.G. Hutubessy).
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many fish stocks it has substantial shortcomings in that it focuses on isolated aspects (ie single species and size) rather than the function of size categories of species within a broader ecosystem. By contrast, the Ecosystem Approach to Fisheries (EAF) is a holistic management approach based on the entire ecosystem (including humans) (Pikitch et al., 2004; Bellido et al., 2011). Although he did not use the specific terminology, the need for an EAF was first broached in the 1930s and 1940s by Ricketts (1947, 1948) with regard to the fisheries of Monterey Bay in California and the viability of the area's sardine fishery in particular. The goal of an EAF is to sustain marine ecosystems and the fisheries that occur within them in a productive, healthy and resilient condition sufficient to provide for human demand (www.fao.org/fi/glossary/default.asp). A key goal of the EAF that is particularly pertinent to our study is that of sustaining the structure of fish communities in marine eco-systems that are affected by fishing and by other land activities in coastal areas. Related to this, and with regard to areas where the eco-system has been substantially altered in recent times by (over-) fishing, Pitcher and Pauly (1998) also suggest the re-building of fish communities as one of the most important goals of fisheries management.

The goals of Indonesian fisheries management, as determined by the Indonesian Directorate General of Fisheries and the Ministry of Fisheries and Marine Affairs, revolve around the concept of Maximum Sustainable Yield (MSY). This approach was developed on an analysis of annual catch and effort data. Some arguments about the effectiveness of the MSY approach arose in Indonesia after indications of overexploitation by five Indonesian fisheries (Widodo, 2003) and the concept of MSY has proven to be ineffective in guiding fisheries management more generally (Mous et al., 2005). Scientific recommendations made by researchers from the Badan Riset Kelautan dan Perikanan (a marine research institution under the Ministry of Fisheries and Marine Affairs), including closing fishing grounds, limiting the issue of fishing licenses, creating minimum catch size rules and lowering fleet capacity, were offered to the government (Widodo, 2003). In response, in 2004, the Ministry of Fisheries and Marine Affairs issued a regulation (No. 45) regarding the minimum size of fish captured that was subsequently renewed in 2009. Once again, a single species based approach was applied to fisheries management without any means of monitoring and/or enforcing its provisions. As a result of ineffective policies and enforcement, Indonesian fisheries have faced certain depletion (Heazle and Butcher, 2007).

The existing crisis in Indonesian fisheries' management, most manifest in western and central Indonesia, suggests that extending current approaches to the eastern part of the national archipelago is likely to replicate unsustainable fishing practices. In this regard, the national government's designation of Maluku and North Maluku provinces as fish *lumbung* (a term that literally translates as 'barns' – implying an abundant resource) in 2010 and 2012 (respectively) is of particular concern. One aspect of the identification of regional *lumbung* is the establishment of marine protected areas (MPAs) within them in an attempt to compensate for increased fishing activity in the regions. While this represents a proactive approach to protecting fish stocks, previous experience with MPAs in other parts of Indonesia indicates that MPAs create conflict between communities, fishers, NGOs and industry groups (Morishita, 2008). Similarly, establishing *lumbung* areas without adequate management at the same time as increasing government subsidies to expand fishing fleets is highly problematic.

Fishing leads to a reduction in the abundance, biomass (Jennings et al., 1995) and mean size of species targeted by the fishery (Jennings et al., 1995). Increasing selective fishing pressure contributes to the truncation of age structure (Hsieh et al., 2006) and changes the composition of reef fish communities (Pinca, 2011). The impacts of fisheries can be detected in changing catch rates and catch composition (Welcomme, 1999). The management of a fishery requires a reliable prediction of the consequences of exploitation strategies (Sainsbury, 1982). A single-species fisheries management approach that avoids by-catch and other selectivity measures is an important tool to protect non-target and vulnerable species (Pikitch et al., 2004). However, improved selectivity may also lead to greater contrast in biomass among components of the trophic level. One common consequence of changes in trophic structures has been the depletion of apex predators (Polovina et al., 2009), intermediate consumers (Bundy et al., 2009) and predator fish (Hjermann et al., 2004). In this regard, management based on selective fishing tends to ignore the impact on the overall ecosystem (Garcia et al., 2012) and may not usefully support the end-goal of fishery management, which is to maintain the structure and function of the ecosystem (Zhou, 2008) as defined in the EAF (Garcia and Cochrane, 2005). A balanced fishery, which catches a selection of the natural population proportional to the productivity of its various size components (which is linked to trophic level) represents a model that may sustain fish production.

In this article, we aim to assess the condition of reef fisheries and of the reef fish community structure in a particular location based on our ongoing study of a balanced fishery in Kotania Bay. Kotania Bay hosts a type of traditional reef fishery common to Maluku and to Indonesia in general. Our study will address how traditional fishers utilize the fish resources in the bay, the effect of fisheries and how an ecosystem approach can be implemented to support regional food security in order to sustain the island community's future.

Methods

Study sites

The ecosystems of Kotania Bay and the adjacent area of Pelita Jaya Bay are structured by mangroves, sea grass and corals (Fig. 1). Detailed studies undertaken in 1994 indicated that mangroves occupied 1250 ha, sea grass inhabited 115 ha and the coral that can be found along the bays covered 820 ha (Wouthuyzen & Sapulete, 1994) and there does not currently appear to be any significant variations. Fringing and atoll reefs are also scattered around the bay.

Fishing history

Due to a lack of detailed reef fisheries data from Kotania Bay, fisheries information was reconstructed from interviews with the fishers who live and catch reef fish around the bay (Neis et al., 1999). Fishers from six villages were interviewed to determine current and historic catch records (species and yields) and the types of fishing gear and methods that were used. Fishers were selected for interview in order to draw on