Evaluation of traditional traps: towards ecosystem-based fisheries management

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In Maluku, Indonesia, trap fishing is one of the traditional fisheries that plays an important role in supplying reef fish to sea food restaurants and to the trade of live fish. To support the implementation of ecosystem-based fishery management, it is important to analyse the catch of trap through a multi-species approach rather than a single-species (selectivity) approach. In this study, multi-species catch analyses estimated species diversity, trophic levels and spatial distribution based on catch data, and sustainability of catch based on biological and ecological information. Traps were fished from February 2018 to January 2019 in waters 5 to 40m deep in Ambon Bay, Waai Bay and at Babar Island. The most abundant fishes caught were the family Mullidae, Parupeneus barberinus (n = 102) and P. indicus (n = 126). Spatial distribution of species analysed with Multivariate Principle Component Analysis showed each trap has significant co-varying species. The mean trophic level of the traps was 3.37 (SE: 0.175), indicating that the trap catches were dominated by low to moderate levels of carnivorous secondary consumers. From 42 species captured by traps, the least likely to be sustainable was Heniochus cuminatus and the most likely to be sustainable were, Selar boops. It is proposed that traditional trapping is a suitable practice in coral reef areas, with low impacts on the community of reef fish that eventually supporting balance fishery.

Keywords: Fish traps, Trophic level, Species diversity, Balance Fishery, Sustainable.

Introduction

It has been recently popularly discussed that ecosystem-based fisheries management (EBFM) has more beneficial in managing the fishery through implementing balance fishery. In EBFM, degradation of ecosystem will be avoided and irreversible change to natural assemblages of species and ecosystem process will be minimised while long-term socioeconomic benefit is being maintained (Pikitch et al 2004). Because EBFM is defined as an integrated approach to management that considers the entire ecosystem, including humans, sustainability of fishery is possibly achieved. Maintain the production of target species of fisheries is the main goal of EBFM but it must be managed in the context of the overall state of the system, habitat, protected species, and nontarget species. Therefore, single species approach is still important but need to be modified accordingly.

In single-species approach, discarding is an integral part of the most fishing operation (Belido et al 2011) and avoid discarding by putting device or modification on the gear is consider as a wise method of increasing the valuable of target species (Broadhurst et al 2007). Increase selectivity is generally favoured by fishers not just to minimise less valuable catch but also reducing sorting difficulties. Zhou et al (2004) were being critical on 6S of selectivity including selectivity in species, space, size, sex, season and stock. A major criticism on selectivity approach is that they cannot predict change in community structure (Trtis et al 1998). Selectivity of species ignored interaction between species (Rochet et al 2009). Selectivity of size may trigger evolutionary change in a harvested population (Law 2000). Selective stock contributes to collapsing some important stock such as in European waters (Marteindottir and Pardoe 2009). Selective sex, especially on larger sizes which represent a particular sex may leads to collapse of the population (Orenzans et al 1998). Selectivity of season may lead to intensive fishing at open seasons which effect greatly on species, stocks or...
individuals that behaviourally active during the open season (Jokikokko and Jutila 2005). Selectivity of space due a particular species may consequently generate high impact on other species that are not particularly associated with the closure area (Hiddink et al 2006). Therefore, the implementation of single-species approach so far least consider the habitat and nontarget species (Mace 2001) and the philosophy of selective fishing needs to be changed (Zhou et al 2004).

Based on single species approach, trapping is a multi-species fishing technique and it has more serious impacts on some species than other fishing gears (Hawkins et al 2007). Trap caught small sizes of fish in big portion propose a threat to juveniles, reduced productivity through growth over-fishing (Robichaud et al 1999) by removal premature fish. Trap produces much unwanted bycatch which is commercially wasteful (Dayton et al., 1995; Boehlert, 1996). Some studies showed the increase of traps selectivity by changing the mesh size and adding escape gaps. Mesh size limit, employed in Jamaica by Sary et al (1997) showed increase of fishery yields when small meshes were replaced with larger mesh, allowing juvenile fish to escape (Mahon and Hunte 1994). Escape gaps also help provide an opportunity for juvenile to escape (Stewart and Ferrel 2002). Nevertheless, if trap is maintained to be less selective, captures more varies of species and sizes, can changing in community structure of reef fishes be detected? Furthermore, it was claimed by Sary et al (1997) and Hawkins et al (2007) that traps caused serious impacts on reef fish species in Jamaican reefs could not be proven as traps were not the only one gear used. In addition, the situation become more complex as the use of small mesh size by traditional fishermen continued as with the implementation of large mesh size regulation (Sary et al 2003). Based on the above arguments, we like to address some questions:

a. If traps caught multi-species and multi-sizes, how can we consider traps as non-selective fishing gears?
b. How can be measure that traps may restrict the sustainable of reef fish community?

Purpose of this study is to investigate the effect of traps which harvesting various ranges of size and species may contribute towards balance fishery on reef fish.

Material and methods

Study sites and sampling

This study was undertaken from February to September 2019 at 3 separate coral reefs in Maluku. Two reefs were located in South-West Maluku Regency, Luang Island and Babar Island. The other reef was in the regency of Central Maluku which was Waai waters.

Samples were collected using traditional traps constructed of bamboo and net materials. These traps consist of various shapes as arrowhead, rectangular and cylindrical with 0.5 and 2inches in mesh sizes. The entrance funnel was designed downward and its aperture was ellipsoid and square. Traps were hauled in variable soaking time between 3, 5 and 7 days. In overall, 7 traps were used in this study and numerical order for the trap was aply in order to just identify their application in each sampling location. Traps of arrowhead and cylindrical shape that were deployed in Waay Bay (Central Maluku District) were given number 1 and 2. In Babar island was however, three cylindrical traps were numbered as 3, 4 and 5 respectively. Meanwhile, in Ambon bay, arrowhead and rectangle traps were identified as no 6 and 7. It is considered that this practice is limited in technical standardization of fishing operation, but the differences are considered to have no impact on the assessment of the catch. Catches from all traps were identified to species (Randall et al, 1990), counted and their total length measured to the nearest centimetre.
Figure 1. Map of Maluku archipelago province. Red circles are the study sites.

Data analysis

Abundance, species richness and Diversity (D, Simpson’s index) are presented per trap per sites. Trophic level estimated for each family are based on diet composition data compiled in fishbase.org (Froese and Pauly 2000). The mean trophic level was calculated following Pauly et al (2001).

Biological and ecological information was collated from literature for each species. This information was used to rank the species along two axes that describe the historical characteristic that would determine the sustainability of the species caught, axis 1 indicating the capacity of species to recover after the population is depleted (Recovery) and axis 2 the susceptibility of a species to capture (Susceptibility). The criteria used to rank susceptibility and recovery capacity of species trapped is an application from the sustainability analysis for bycatch mortality due to trawling (Stobutzki et al 2001).

Result and Discussion

Catch characteristic

The catch of 7 different type of traps from 3 different coral reefs comprised 46 species representing 27 families. Of the 601 total fish caught during the experiment, the catches were dominated by only a few species which occurred almost in all sites. Of the 6 most abundant species, two accounted for about 38% of the total catch from all types of traps, namely the Indian goatfish, *Parupeneus indicus* (Shaw) (N = 126), the dash-and-dot goatfish, *P. barberinus* (Lacepede) (N = 102). Two species of goatfish were mostly caught at Ambon island (arrowhead 1, cylinder 1, arrowhead 2 and net trap) while from deeper sites at Babar island (cylinder 2, 3 and 4) was only 13 individuals. Four other abundant species represented 27% of the total catch were *Plotosus sp*, *Lethrinus amboinensis*, *Siganus canaliculatus* and *Plotosus sp*. *Plotosus sp*, a marine catfish, was trapped in large quantities (N = 81) only by one trap, arrowhead 2, in single trip at Rumah Tiga waters, maximised the mean catch/trip of the trap (Figure 2). The emperor, *Lethrinus amboinensis*, was captured by all types trap at Waai Bay and Babar Island but none from Ambon Bay. *Siganus canaliculatus* was the only species that was trapped by all types of traps but found in large quantities in Ambon Bay. The last abundance species was a non-economical species, *Heniochus cuminatus*, mostly caught by net trap with very small mesh size. The remaining species were variable in each traps.
Based on the species catch-per-type of traps, diversity index (D) of each traps ranged from 0.73 to 0.86. Cylinder traps 3 had the highest species diversity to their catches (D = 0.86) followed by net trap (D = 0.85), cylinder 1 (D = 0.83) and the lowest arrowhead 1 (Figure 2). The least species richness captured are by trap types cylinder 2 and 4 from Babar island. The catch represented 6 economical species and dominated by sweetlips, *Lethrinus amboinensis*. Each of the traps had a high mean trophic level (3.1 to 3.4) because of the low to moderate level of carnivores were trapped (Figure 2). Five trophic guilds represented the total catch were 16.5% of herbivores, 21.6% of planktivores, 31.8% of omnivores, 24% of piscivores and 6.1% of top predator.

The overall length-frequency distribution of fish belonging to Babar island and Waaia bay (N = 352) is unimodal with a mode of 23cm, mean of 22.6cm and standard deviation of 8.7cm. Size spectra of this unimodal shape is -1.39, means the abundance of fish caught tended to decrease with size, larger predator was high. The size distribution for each species caught seen in Figure 3 showed that the length of fish ranged from 5cm to 55cm depending to the available resource. Surgeonfish (*Acanthuridae*) is the largest sized range of size caught (5 - 55cm) followed by grouper, *Serranidae* (15-55cm), parrotfish, *Scaridae* (15-45cm) and goatfish, *Mullidae* (10-35cm).

Fish trapped in this study had a large range of size (5 to 55 cm) and dominated by 20cm fish. Since selective fishing tend to harvest large body fishes, these traps are not a practical of selective fishing but the length distribution figured out the natural fish community’s size structure. The size composition in communities can be described by size spectra. Size spectra give relationships between abundance and body-size (Graham *et al*, 2005) and indicate community change due to fishing activities (Rochet and Trenkel, 2003; Trenkel and Rochet, 2003) through the changes of the slope and peak (intercept) of the size-spectrum (Rice, 2000; Graham *et al*, 2005; Macpherson *et al*, 2002). Our result showed -1.39 of size spectra’s slope. This steeper slope, slightly less than -1 (balance condition) indicated that abundance of large-body fish have reduced. Since large-body fishes tend to have higher fecundity, slow-growth and late maturity compared to small-body fishes (Reynolds *et al*, 2001), and the rate of population growth is relatively lower (Denney *et al*, 2002), the community structure of reef fish should be concerned. Reef fisheries are not dominated by a particular gear but by various fishing operation such as spear fishing, gillnet, longlines and handlines. If selective fishing practices is high, as a consequence, large species are more vulnerable to exploitation than smaller species as their capacity to replace the numbers removed by exploitation is lower (Reynolds *et al*, 2001). As large bodied fishes may apply top down control upon other community members, through predation on smaller bodied prey, changes in size-structure of communities also reflect changes in trophic functioning (Karpouzi and Stergiou, 2003). Therefore, balance harvesting should be considered in the fishing management rather than selectively targeting on large species.

Reef fish communities and their coralline habitat are thought to be structured by feedback process through predation, grazing and habitat construction, and selective fishing may affect this fish functional groups. Carnivorous and omnivorous fish dominated the trophic guild of fish captured. Taking higher trophic level should be concerned because predators may account for up to 50% of the biomass in some reef communities (Mitchell *et al*, 2011). Larger predators on reefs influence the community structure of smaller species (Alamany and Webster, 2004), and may play an important role in maintaining high local diversity by preventing dominance by particular species (Power *et al*, 1996). This result is slightly different than trap catch in Kenya and PNG which tend to catch herbivores (McClanahan *et al*, 2008). Herbivorous fishes only represented 6.1% of the total catch. Herbivorous fish have a key function in maintaining coral habitats by preventing the growth of macroalgae (Hughes *et al*, 2007). Parrotfishes or surgeonfishes are the most abundant herbivores on reefs, decreased macrophytes up to 7%, increased corallines and coral growth also prevent coral mortality (Hay, 2011 pers.com). Sweetlips, *Lethrinus amboinensis* dominated the 6 economical species caught. Family Lethrinidae together with humphead wrasse, *Cheilinus undulatus*, protect the corals by feeding on the
junior of crown-of-thorn seastars (*Acanthaster planci*), a corallivore, individuals of which can consume up to 6 square meter of living coral reef polyps per year (Randall *et al.*, 1978). It is not likely that traps caught a high proportion of species highly susceptible to coral mortality and critical to coral reef resilience through their top-down control. From this point, traditional trap should be concerned as environmental friendly fishery.

![Figure 2](image)

Figure 2. Plots of the (a) catch per trip (b) diversity (Simpson’s index) and (c) trophic level for each of the traps. Bars are standard errors.
Figure 3. Size structure of 46 species captured in two location, compiled by family. Slope is obtained from the correlation between body size and fish abundance.

**Sustainable analysis**

By separating target and non-target species, two non-target species were in the condition of least resilience and most resilience which were *Heniochus cuminatus* and *Selar boops*, respectively. Target species in condition of moderate to high resilience were herbivores including *Acanthurus xanthonopterus*, *Siganus canaliculatus*, and *Siganus fuscescens*. Other herbivores species from the family of Scaridae was in condition of low to moderate resilience. Carnivore species such as *Cephalopolis sp.*, *Diagramma pictum*, *Epinephelus sp.*, *Lethrinus amboinensis*, *Lutjanus fulviflamma*, *Variola louti*, and the family Mullidae were less resilience.

Sustainable analysis showed that no particular species is susceptible to any type of trap. In overall trapping, some species had relatively high recovery ranks but they also had high susceptibility, so were less likely to be resilience. This group were *Cephalopolis sp.*, *Diagramma pictum*, *Epinephelus sp.*, *Lethrinus amboinensis*, *Lutjanus fulviflamma*, *Variola louti*, the family Mullidae and Scaridae. This result should assist researchers and managers to focus on these species and use as precautionary approach. Single species approach may be useful for these species by applying alternative and modification gears.
Conclusion

As a non-selective fishing method, traditional trap fishing in Maluku supports a balance fishery. Traps represented a fishing pattern where fishery exploits all trophic level in proportion to the natural production. Although traps produce bycatch, it is in resilience condition.

Acknowledgement

We greatly thankful Paul van Zwieten for advising in data analysis, also Nonny, Selly and Femsy for data collecting. Funding support from Indonesian Directorate General of High Education through the research scheme of International Collaboration for presenting and publishing this article is honourable.

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