IMPACT OF FISHING AND HABITAT DEGRADATION ON THE DENSITY OF BANGGAI CARDINAL FISH (*Pterapogon kauderni*, Koumans 1933) IN BANGGAI ARCHIPELAGO, INDONESIA

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ABSTRACT

Banggai cardinal fish (*Pterapogonkauderni*, Koumans 1933) is uncommon example of a marine fish with distributed in small range area while being in highly exploited. This fish is in high demand as an ornamental fish. However, the information on the number of density is limited. An underwater visual fish census survey was conducted in June to July 2010 at 18 fishing sites around Banggai archipelago to estimate the density of the stock and assess the impact of fishing and habitat on density. The areas are divided into three main islands, namely Banggai Island, Peleng Island, Toropot-Tumbak-Labobo Island. The lowest density index of the *P. kauderni* recorded at Kindandal village on Peleng Island, 0.014 fish/m^{2}while the highest abundance index of 3.0 fish/m^2 found at Toropot village at Toropot Island. In three survey sites (Bonebaru and Toropot villages) where the fishing activities are still ongoing, the density has declined compared to the survey conducted in 2004. Majority of the villages in Peleng Island have lower density compared with the other islands probably due to the degradation of microhabitat of *P. kauderni*. In many cases, microhabitat degradation might be as a result of collection of sea urchins and sea anemone for consumption by local community.

Keywords: impact of fishing, habitat degradation, density, banggai cardinal fish

INTRODUCTION

The endemic Banggai Cardinalfish (*Pterapogonkauderni*) in habits a small area in the Banggai-Sula platform Archipelago, Eastern Indonesia. It is mainly found in shallow sheltered bays and in harbours, on silty reef flats with sandy bottoms and sea grass beds (Allen, 2000). Depth distribution generally ranges between 0.5 and 6 m, but the species is most commonly found between 1.5 and 2.5 m (Vagelli, 2005). First described from specimens collected in the Banggai Islands of Sulawesi in 1920 by Koumans (1933), it was forgotten by the Western scientific community until 1991 when a Bali tour operator chanced upon the species and brought it to the attention of a taxonomist (Lunn & Moreau 2004). Since its rediscovery, *P. kauderni* became heavily exploited as it is highly-prized in the aquarium trade (Lunn & Moreau, 2004).

Fishing pressure may result a negative impact on *P. kauderni* population, such as affecting the density, group size and the density of its preferred associate fauna (sea urchins and sea anemones). Vagelli & Erdmann (2002) reported that in Bangkulu Island, approximately 10.000 individuals of Banggai Cardinalfish per month were caught and between 50.000-60.000 *P. kauderni* were received for export each month at North Sulawesi buyer alone. The study carried out by Vagelli & Erdmann (2002) also reported that density in three different sites (Bokan, Limbo, and Masoni) islands was "cropped" due to heavy fishies pressure, namely 0.029, 0.031, and 0.027 individual fish/m^2 respectively. Moore & Ndobe (2005) also reported that density of *P. kauderni*had varied from 0.31 to 11.99 individual/m^2 at several sites in Banggai Island, Peleng and Toropot Island.

The aims of this study are to analyse the underwater visual fish census survey data conducted in 2010 and compare the findings to a previous survey conducted in 2004 (Moore& Ndobe, 2005). The analysis will then focus on the effects of fishing and habitat on the observed densities of *P. kauderni* at 18 sites.

MATERIALS AND METHODS

Underwater Visual Fish Census Survey

The underwater visual fish census surveys were conducted from June to July 2010 in 18 sitesin the Banggai Archipelago area, identified as habitat of

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Table 1: Sites surveyed for Banggai Cardinalfish density from June to July 2010 on the Banggai Archipelago, Indonesia. Longitude and Latitude are on a decimal form. X means that the availability of density estimated from 2004

No.	Island (survey site)	Longitude (in decimal)	Latitude (in decimal)	Density estimates available from 2004 (Ndobe& Moore 2005)	Fishing activity
	Banggai Island				
1	Matanga	123.579	-1.7168889	X	2001-2006
2a	Bone Baru	123.494	-1.5320278	X	2001-present
2b	Bone Baru	123.493	-1.5320278	X	2001-present
3	Monsongan	123.483	-1.6375278	X	2001-2006
4	TinakinLaut	123.492	-1.6027222	X	2001-2006
	Peleng Island				
5	Bajo	123.239	-1.548369		2001-2006
6	Boyomoute	123.251	-1.496031		2001-2006
7	Apal	123.259	-1.467544		2001-2006
8	Popidolon	123.231	-1.60165		2001-2006
9	Tolulos	123.139	-1.5524722		2001-2006
10	Kindandal	123.151	-1.6233889		2001-2006
11	Bobu	123.381	-1.503066		2001-2006
12	Boniton	123.444	-1.5083611		2001-2006
13	Lobuton	123.472	-1.4747222		2001-2006
	Toropot-Tumbak-Labobo Islands				
14	Minanga	123.708	-1.9238333		2001-2006
15	Kombongan	123.691	-1.9073333		2001-2006
16	Toropot	123.636	-1.9366944	X	2001-present
17	Tumbak	123.489	-1.9818333		2001-2006
18	Bontosi	123.269	-1.7844167		2001-2006

Banggai Cardinal Fish. This wasbased on information obtained from local fishers. Four survey sites were located at BanggaiIsland, nine sites were located at Peleng Island, three sites atToropot Island, one site at Tumbak Island, and one site at Labobo Island (Fig. 1). Table 1 gives an overview of the survey sites and the exploitation history of the sites.

At each site, transect was set in shallow water close to shore at a depth between 30 cm to 150 cm. In areas where the habitat iswide (shallow area stretching far from the coast line), transect was started at a maximum of 200 m distance frombeach line. This was mainly done to avoid having transects going through villages which are built into the water. All transects were 50 meters long (Figure 2) and it is assumed that the diver can observe fish up to 10 meters along the transect (5 meters to each side) (Labrosse *et al*., 2002). The location of transect at each site was set in the main fishing areas as identified by local fishers.

At each transect the following data were recorded:

1. The number of fish observed.
2. The habitat type along transect was estimated as percentage of the total surveyed area. The habitat types identified were
   a. Coral reef
   b. Sea grass bed
   c. Mangrove
   d. Sea urchin
   e. Anemone
3. After the transect had been surveyed specimens for biological sampling were caught at the transect using a small scoop net with a

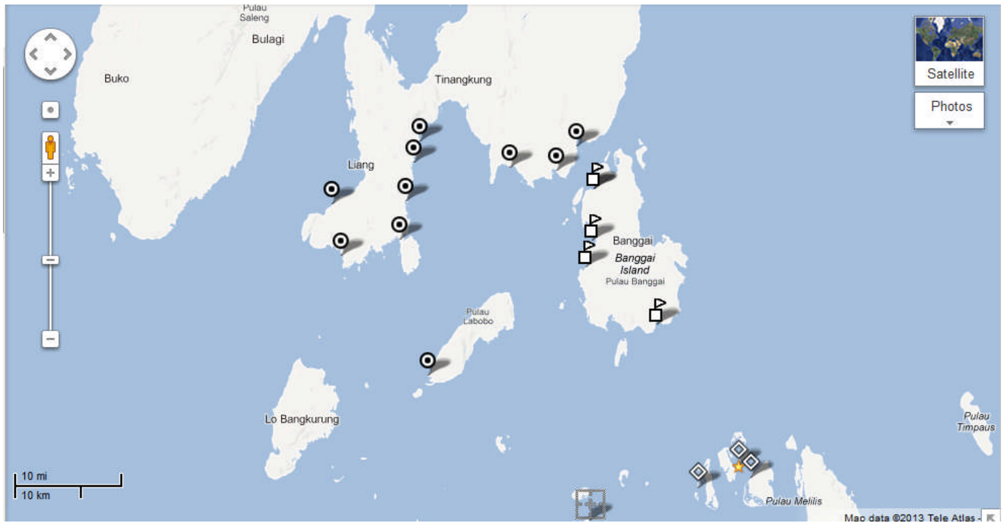

Figure 1: Sampling points of underwater visual fish census survey.

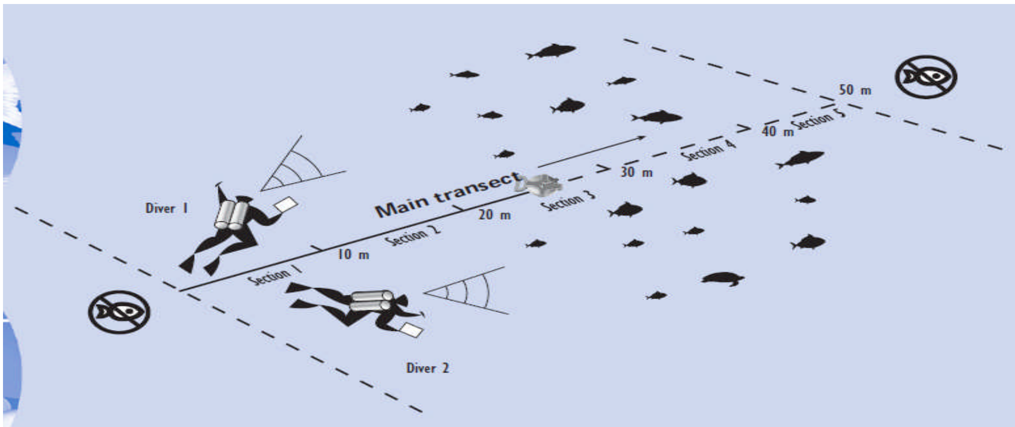

Figure 2: A schematic drawing of the underwater visual census survey design.

mesh size of 4-5 mm and the length of net used was 60-80 cm. The material of the net is nylon monofilament. The material sampled was then analysed at the laboratory (See next section).

4. The following environmental parameters were measured at each transect: temperature, salinity, dissolved oxygen, pH, and depth. The depth was measured by depth sounder, while temperature, salinity, pH, and dissolved oxygen were measured by Lutron Digital Oxygen Meter with a polarographic type probe.
5. Fish density for each transect was calculated according to the formula: $D = n/w$, where D is density (individuals per m^2), n is the number of fish counted at a transect and w is the size of the transect area in m^2.

RESULTS AND DISCUSSION

RESULTS

Density Estimates from the Underwater Visual Fish Census Survey

Density varied among the 18 different sitesfrom 0.014 fish/m^2 to 3 fish/m^2. The lowest density was found in Kindandal village at Peleng Island while the highest density recorded was in the Toropot village at Toropot Island. In the two villages where fishing is still ongoing, the average density decreased from 1.96 fish/$m^2$to 1.49 fish/m^2 at Bonebaru village, and 11.99 fish/$m^2$to 3 fish/m^2 at the Toropot village in Toropot Island (Table 2).

Table 2: Results of the 2010 survey with density estimates and for comparison the estimates from the 2004 survey. Abundance is the density multiplied with the size of the area as estimated in table 2. The aesthetic (*) means survey data conducted by Moore & Ndobe (2005)

Island	Fishing history	Density (ind/ m^2) 2004*	Number of fish counted in the transect	Density (ind/ m^2) 2010
Banggai				
Matanga	2001-2006	1.86	334	0.67
Bone Baru A + B	2001-present	1.96	1,492	1.492
Monsongan	2001-2006	0.48	1,316	2.63
TinakinLaut	2001-2006	0.31	1,205	2.41
Peleng				
Bajo	2001-2006		102	0.204
Boyomoute	2001-2006		63	0.126
Apal	2001-2006		113	0.226
Popidolon	2001-2006		157	0.314
Tolulos	2001-2006		58	0.116
Kindandal	2001-2006		7	0.014
Bobu	2001-2006		249	0.498
Boniton	2001-2006		53	0.106
Lobuton	2001-2006		162	0.324
Toropot-Tumbak-Labobo				
Minanga	2001-2006		174	0.348
Kombongan	2001-2006		219	0.438
Toropot	2001-present	11.99	1,500	3
Tumbak	2001-2006		174	0.348
Bontosi	2001-2006		736	1.472

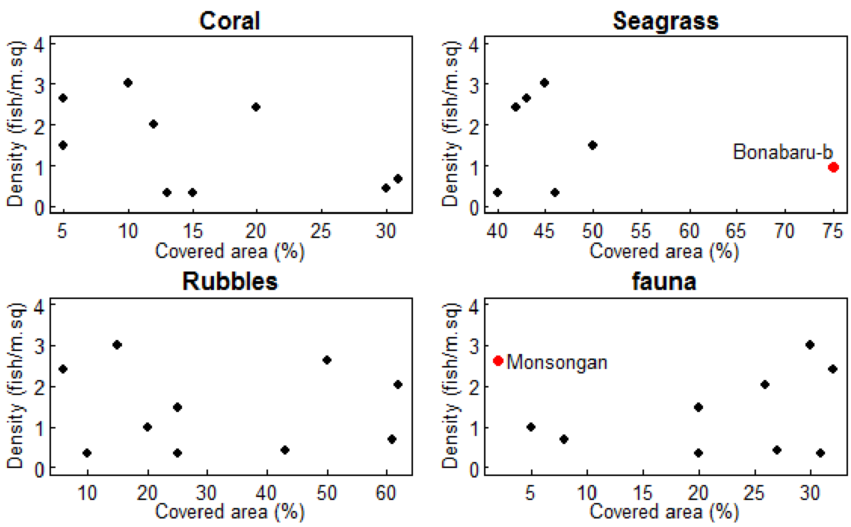

Figure 3: The correlation plot of habitat areas to the index density of *P. kauderni* in 500 m^2 transect (Monsongan and Bonebaru-b were excluded in sea grass and fauna habitat type).

Table 3: Estimates of habitat types at transect sites in the 2010 *P. kauderni* survey and the associated density estimate

Island	Type of Habitat					Density (ind/ m^2) 2010
	Fishing activity	Seagrass (%)	Coral (%)	Coral rubbles or sands (%)	Other fauna (Sea urchin or anemones) (%)	
Banggai						
Matanga	2001-2006	-	31	61	8	0.67
Bone Baru A	2001-present	-	12	62	26	2.01
Bone Baru B	2001-present	75	-	20	5	0.97
Monsongan	2001-2006	43	5	50	2	2.63
TinakinLaut	2001-2006	42	20	6	32	2.41
Peleng						
Bajo	2001-2006	yes	na	Na	yes	0.204
Boyomoute	2001-2006	yes	yes	Yes	yes	0.126
Apal	2001-2006	yes	na	Na	yes	0.226
Popidolon	2001-2006	yes	yes	Yes	yes	0.314
Tolulos	2001-2006	yes	yes	Yes	yes	0.116
Kindandal	2001-2006	yes	na	Na	yes	0.014
Bobu	2001-2006	yes	yes	Yes	yes	0.498
Boniton	2001-2006	yes	na	Na	yes	0.106
Lobuton	2001-2006	yes	na	Na	yes	0.324
Toropot-Tumbak-Labobo						
Minanga	2001-2006	46	13	10	31	0.348
Kombongan	2001-2006	-	30	43	27	0.438
Toropot	2001-present	45	10	15	30	3
Tumbak	2001-2006	40	15	25	20	0.348
Bontosi	2001-2006	50	5	25	20	1.472

Table 4: Value of pearson's correlation (*r*) and probability value (*p-value*) obtained from linear model analysis

Dependent Variable	Dependent Factor	Pearson's Correlation (r)	P-value	Remarks
Density index	seagrass	0.01	0.6525	weak positive correlation
Density index	Fauna(sea anemones & sea urchins)	0.39	0.672	Fairly positive correlation
Density index	Coral rubbles	-0.05	0.8907	Negative correlation
Density index	Coral	-0.37	0.2915	Negative correlation

At two sites (Monsongan and Tinakinlaut) where fishing stopped in 2006, the density increased from 0.48 fish/ m^2 to 2.63 fish/ m^2 at Monsongan village but from 0.31 fish/ m^2 in 2004 to 2.41 fish/ m^2 in the 2010 survey at the Tinakinlaut site. This means that density increased from 5 to 8 fold after harvesting stopped (Table 2).

Likewise to Monsongan and Tinakinlaut the density in Matanga village were fishing also stopped in 2006, has still decreased. The density was 64% lower than estimated in the 2004 survey. Most of the survey sites in Peleng Island have low density estimates compared to the other islands. The lowest density estimate of 0.014 fish/ m^2 is from the Kindandal village while the highest density of 0.498 fish/ m^2 was from the Bobu village as shown in Table 2.

Habitat types in relation to the density index of *P. kauderni*

Table 3 presents lists the relative vegetation and substrate coverage along transects at the 2010 survey sites. In Figure 3 the relationship between the percentage of habitat type and density is plotted. There is significant between the percentage covered by a given habitat type and density. The results from a correlation test are summarised in Table 4, in all cases the tests do not show significant correlation between density and the coverage of a given habitat type.

DISCUSSION

Fishing Activity and Habitat Type and its Impact to the Density Index of *P. kauderni*

In the two villages (Bonebaru and Toropot village) where fishing activities were still ongoing at the time of survey (2010), average density index decreased from 1.96 fish/m^2 in 2004 to 1.49 fish/m^2in 2010 in Bonebaru and from 11.99 fish/m^2 to 3 fish/m^2 in Toropot. Fishing activity probably caused the decrease in the density of *P. kauderni* over the period.

Ndobe & Moore (2009) reported a significant coral reef degradation at five sites around Banggai archipelago including at Bonebaru from survey/ monitoring data collected in 2004 to 2006 compared to the latest survey conducted in 2011 by Ndobe & Moore (2012). According to this data, area covered by coral had reduced from 25% to 11%. The latest survey conducted by Wijaya (2010) who reported that the densities of *P. kauderni* at Bonebaru were 0.65 fish/m^2, Mbato bato 0.42 fish/m^2, Tolokibit 0.31 ind/ m^2, and Bandang Island 0.87 fish/m^2, respectively. The survey results reported by Wijaya (2010) were similar with these of current work. The correlation tests showedweak positive correlation between density of *P. kauderni* with the size area covered by other fauna such sea urchins and sea anemones. However the tests were not significant. Sea urchins and sea anemones are known as microhabitat of *P. kauderni* (Lilley, 2008). Ndobe *et al*. (2008) reported that massive extraction of sea anemones was first observed in a survey in 2007. This resulted in a drastic decline of *P. kauderni* after the sea anemones, that were numerous in 2004 and 2006, had all disappeared. Moore & Ndobe (2012) also stated that all recruits groups of *P. kauderni* of more than 3 individuals were associated with sea anemones, often also inhabited by clownfish. Sea anemone seems to be a particularly important microhabitat for newly released *P. kauderni* recruits and small juveniles.

In two sites (Monsongan and Tinak from laut) where fishing stopped in 2006, the density has increased from 0.48 fish/ m^2 to 2.63 fish/ m^2 in Monsongan village while 0.31 fish/ $m^2$to 2.41 fish/ m^2 in Tinakinlaut site. It means thatdensityincreased 5 to 8 fold since fishing stopped in 2006. It also implies that the population of *P. kauderni* has recovered to some extent in the four years after fishing stopped in 2006.

Most of the survey sites in Peleng Island likely have lower density compared to the other islands. In Peleng Island, the lowest density of 0.014 fish/ m^2 was recorded in Kindandal village while the highest density of 0.498 fish/ $m^2$was observed at Bobu village. Unfortunately, no survey data were available for comparison from 2004. Fishers and local resident in Peleng Island collect sea urchins for consumption, as bait for *bubu* (trap), or as feed for Napoleon fish. The fishers catch Napoleon fish and rear the fish temporarily in a small pond before they sell it to the buyer. The fish is fed on sea urchins collected by the fishers. Sea urchin (*Deademasetosum*) and sea anemone are the main shelter of *P. kauderni* and as one of important habitat in their lifecycle stage. Study related to the importance of microhabitat was conducted by Ndobe & Moore(2012) stated that over 80% of new *P.kauderni* recruits were assosiated with sea anemones and sea urchin. This may explain the low density of *P. kauderni* at Peleng Island.

CONCLUSION

P. kaudernii density increases when fishing activity no longer conducted. Similarly at sites where fishing is on-going density is lower in 2010 than was recorded in 2004. Majority of the villages in Peleng Island have lower density compared to other islands due to the degradation of microhabitat of *P.kauderni* as a result of collection of sea urchins and sea anemone for consumption by local community. The habitat types appeared to be not significant to influence the density of fish according to the data presented here since the existing data have been very limited in scope compared to the total habitable area of the population. The results suggest a better monitoring of the fishery for *P. kauderni* would be essential in the future including log-books of daily record of catches by village and biological sampling (length measurements, maturity data, etc).

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