Wild lobster (Panulirus ornatus) fry fishery in Balete bay, Davao Oriental: Catch trends and implications to fisheries management

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Abstract

The coastal ecosystem of the Philippines is one of the richest and most diverse on earth. Lobsters are one of the commercially exploited species targeted by small-scale fishers for their livelihood and income. This study aims to determine the catch, and catching pattern of the wild lobster fry fishery, quantify the catch per unit effort (CPUE) and identify issues and challenges present in the lobster fry fishery for improved conservation and management. A combination of semi-structured interviews (n=90), focus group discussion (n=35) and actual catch monitoring for three months of lobster fry fishers (n=20) were conducted to elicit information on lobster catch, composition, fishing practices and issues and challenges. Results from the interview and focus groups showed that majority of fishers catch the fries of *Panulirus ornatus*, *Parribacus antarcticus* and *Panulirus versicolor.* They catch most of the lobster fries using bamboo traps and beach seine. The analysis of the CPUE also revealed significant results ($P \leq 0.05$) with the good catch having the highest CPUE value (0.30 g) followed by the normal catch (0.16 g) and worst catch of (0.02 g). In terms of weekly field monitoring of the catches of 20 fishers, temporal variation in terms of weeks was highly significant ($P=0.000$; $R^2=22$). Some management issues mentioned by fishers include effluents from shrimp farming, illegal fishing, chemical residues from mango farms and improper waste disposal. The lack of a management plan, as well as a system to control who has access to the fishing ground of lobster fries, can negatively affect the long-term sustainability of the lobster fry fishery.

Keywords: Davao Oriental, fisheries, fisher's knowledge, fry, growth overfishing, lobster fry, Mati City, puerulus

1.0 INTRODUCTION

The marine ecosystem faces various threats from human exploitation, habitat destruction, marine pollution, coastal degradation, and climate change problems that lead to a decline in biodiversity and ecosystem goods and services (Abreo et al., 2015; Guerrero, 1999; Lugo, 2018; Macusi et al., 2015a; Macusi et al., 2011). The open access nature of the fisheries in many coastal areas of the country contributes to species extinction (Lavides et al., 2010; Turner et al., 2007). In addition, inadequate information on their fishing effort and lack of coherent management plan in the different coastal embayments can lead to minimal impact of conservation efforts (Abernethy et al., 2007; Tsehaye et al., 2007; Turner et al., 2014). The lobster fisheries include collection of both adults and fries that are just part of the ubiquitous pelagic and reef fisheries present all over the Philippines (Cabral et al., 2015; Gonzales and Taniguchi, 1995). The adult lobster fishery is considered to be highly valuable and in high demand (Dao, 2016). The commonly caught species include, *Panulirus ornatus*, *Panulirus versicolor*, and *Panulirus longipes longipes* (Gonzales and Taniguchi, 1995). In 2017, the lobster production of the Philippines was 12 tons, mainly coming from the CARAGA region, which includes Surigao del Norte and Surigao del Sur; meanwhile the country's total production for 22 years was just 622 tons (PSA, 2018). Due to a high demand and high price for lobsters, many small-scale fishers are eager to catch lobsters for economic reasons. Lobsters are a fixture in seafood restaurants providing a good protein source and enjoyment during a fine dining experience (Fabinyi and Liu 2014). Lobster fishing is highly export led, as fishers harvest lobsters coming from various coastal provinces such as Davao Oriental, Palawan, Surigao, and Zamboanga. This commercial exploitation results to a declining catch of both the adult and the fry stages (Gonzales and Taniguchi, 1995; Hart, 2009). In addition, the global supply of wild caught spiny lobsters are usually in short supply and declining. Because of this, there is intense commercial interest to collect wild lobster fries in enclosed and sheltered bays

in the country. The fries are collected in the wild using rock aggregators that are hanged on bamboo poles or on bamboo rafts anchored to a shallow seabed near the coast. Fishers usually use old nettings, sargassum leaves or old dried banana leaves to lure the lobster pueruli to the hanging aggregators. With the use of sea cages or ponds, the collected fries are grown until adult and ready for export or for the local seafood restaurants. Often, because of lack of stable supply of wild caught fries, the suppliers and operators of lobsters from CARAGA region have ventured to other nearby provinces such as Davao Oriental for their lobster fry collection. For this reason, lobster fries commanded a hefty price, ranging from two to five dollars during the peak season of collection (April and May). As such, aquaculture production of lobsters has become an important proposition worldwide to increase its market sustainability but only a few countries can supply the fry needed for such aquaculture ventures (Radhakrisnan, 2013). Moreover, a cost-effective hatchery technology on lobsters is largely lacking, causing lobster aquaculture to depend heavily on wild-caught fries. The lobster farming in Vietnam and China, are dependent on natural availability of live lobster fries which are sourced from Indonesia, the Philippines and other countries (Pereira and Josupeit, 2017). This reliance on wild live seeds for aquaculture may lead to natural collapse of the species due to growth overfishing (Jeffs, 2010). Growth overfishing happens when there is over collection of natural seed fries in the wild such that there is less fish stocks reaching their full biological and economic potential. This is different from recruitment overfishing where the reproducing part of the fish stocks are removed so that there are far fewer recruitment that can occur in the future (Diekert, 2012; King, 2007). This practice might lead to heavy exploitation of the natural stocks of lobsters, which until now the country does not have much data. To address the lack of data, local ecological knowledge (LEK) can be useful in understanding the fisheries and in determining the behavior of the species as well as their present distribution patterns (Macusi et al., 2017a). This will be done through personal interview of individual fishers as this can elicit large amount

of information pertaining to past and present existence of the lobster fisheries (Johannes et al., 2000; Neis et al., 1999).

This study contributes to the understanding of catch patterns, fishing practices, catch monitoring of lobster fries and its present management status in Balete bay, Davao Oriental. To our knowledge, the biology and ecology of crustaceans particularly lobsters is scarce in the Philippines which precludes the conservation of this species. The results of this study will be useful in developing future policies for the lobster fisheries management.

2.0 MATERIALS AND METHODS

2.1 Description of study area

The study was conducted in Balete bay, Davao Oriental located in southeastern coast of Mindanao. This bay is biologically diverse and a haven of both reef fisheries and lobster fishing in Mati City because of its cove-like formation and protected embayment that hosts abundant mangrove forests, seagrass beds and diverse reef fisheries. The study was conducted in the area because of the present assessment of marine fisheries resources found in Mati City and the fact that buyers from Surigao del Norte and Surigao del Sur are coming in droves to buy lobster fries starting from February until June due to scarcity of supply in the two Surigao provinces.

Balete bay is part of the Pujada bay protected landscape and seascape area, a declared NIPAS area through Presidential Proclamation 431 of 1994. The NIPAS or the National Integrated Protection Act System (Republic Act 7586) of the Philippines is a presidential declaration that an area declared will be administered and managed primarily by the Department of Environment and Natural Resources (DENR). The access to the resource is strictly controlled by the DENR. It lies between 6 52’ to 6 55’ N latitude and 126 09’ longitude (Figure 1). It has an area of 77 ha which is smaller than Pujada Bay. It is characterized by hilly and mountainous landmasses. The Balete bay mouth faces Pujada Bay waters as it is located at the western

portion of the bay. During low tides, wide sand or sandy muddy and coralline flats are exposed particularly in the northeastern part of the bay. Part of the reason that the bay remains shallow is due to many fallen logs that were dump by loggers in the past. The area is important and known as a nursery and breeding ground for various reef fish species as well as for lobsters.

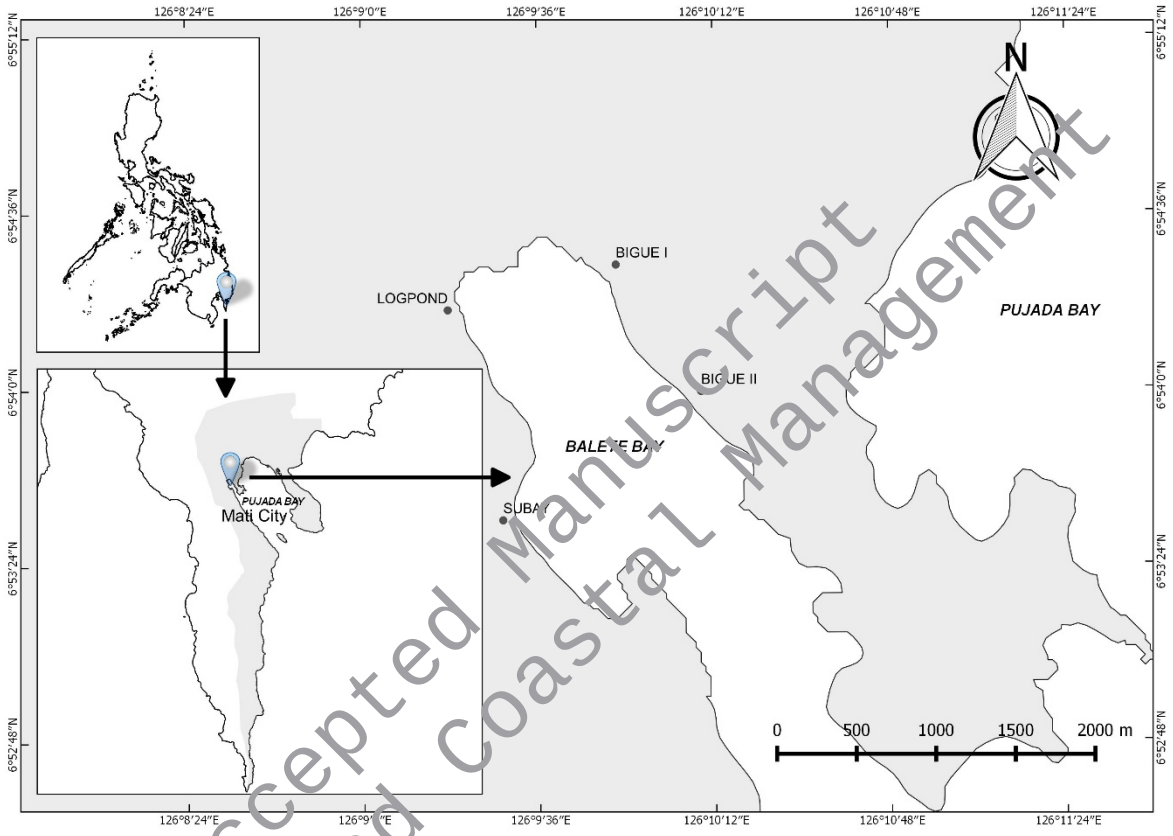

Figure 1. The study sites are located in Balete bay, Mati City, Davao Oriental.

2.2 Fishing location and floating rafts

A grid map below shows the location of the 140 bamboo rafts established by the 90 fishers within Balete bay that was surveyed. The fishing ground is muddy and shallow, with a depth of 1-6 m. Large lobsters are usually found in deeper areas (11-20 m) and in crevices and near the coral reefs. More than 50% of the traps are located near sitio Logpond, in an area referred to by fishers as "Louk" and known to be the spawning ground of various fishes and lobsters.

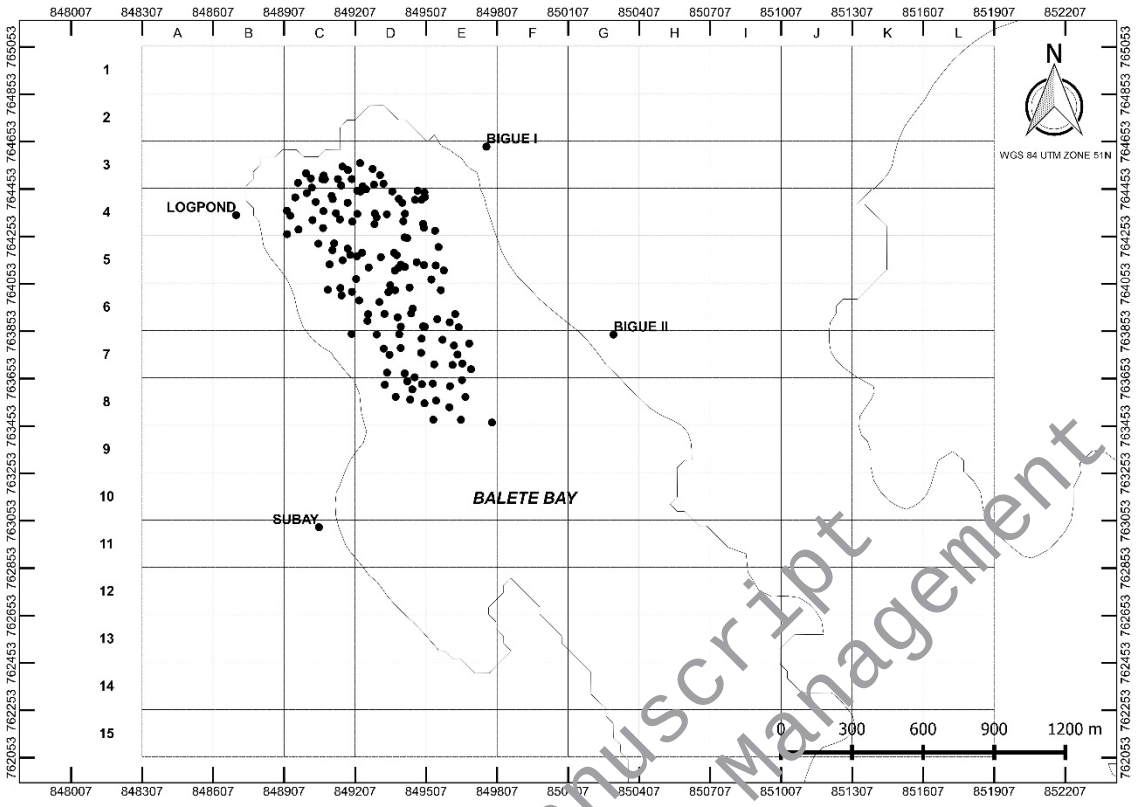

Figure 2. Grid map of the location of bamboo rafts of lobster fry fishers in Balete bay, Davao Oriental.

2.3 Data collection

A) Semi-structured interview

The data was gathered through a combination of semi-structured interview, focus groups and actual catch monitoring. During the interview, fishers referred others who are also catching lobster fries in the area since there was a lack of database of fishers that specifically target lobster fries for commercial use. Pilot test of the interview was conducted on October 21- 22, 2017 at the villages of Bigue I and Bigue II with only 10 respondents each, to test the validity and the length of time needed for the respondents to answer the question (Macusi et al., 2017). A semi-structured questionnaire was used to obtain data such as the socio-demographic profile of lobster fishers, the occurrence of lobsters, catch trends, various catching methods, and the usual problems encountered by the fishery (n=90). Table 1 below shows the number of

152 respondents found in the different survey sites in Balete bay. In addition, the researchers also
153 conducted a grid mapping of the fishing location of the lobster fry fishers by including a map
154 at the back of the semi-structured questionnaire (see Figure 2). The respondents pointed to the
155 map where they established their traps to catch lobsters. This provides an understanding of the
156 level of fishing intensity found in the area. After conducting the semi-structured interview,
157 actual sampling followed by enrolling 20 lobster fry fishers who were willing to be monitored
158 for their weekly catch of fries for three months (February to April 2018).

159

Table 1. Number of respondents interviewed by study site.

Site	Respondents (n)
Bigue I	28
Bigue II	47
Logpond	4
Subay	8
Camansi	3
Total	90

160

161 **B) Focus group discussion (FGD)**

162 Three focus group discussions (FGD) were conducted from February 24 to 25 at the villages
163 of Bigue I and Bigue II (n=35), in order to validate the data taken from the semi-structured
164 interview. The participants were sub-samples of the interviewed fishers. The participants
165 provided additional information on species composition, catching methods, and seasonality of
166 the catch. During the FGD, the discussion started by giving a short lecture on the life cycle of
167 the lobster and related factors that influence the motivation of fishers to catch lobsters and on
168 the season of lobster fishing. The second author also participated in catching operation of
169 lobsters for two days to validate the information provided by fishers. This was to observe how

fishers' conduct different methods of catching lobsters and to validate the habitat information taken from the respondents. For the identification of various lobster species, the field guide of Motoh (1980) on the edible crustacean in the Philippines and, Gonzales and Taniguchi (1995) and Hart (2009) was used to identify the lobsters. Furthermore, the researchers used other morphological information such as the size, fishing ground, and the color of individual lobsters to identify the lobsters.

2.3 Data analyses

A) Catch per unit effort (CPUE)

The catch per unit effort (CPUE) in its basic form can be defined as the total fishing effort in a given period (Van Hoof et al., 2001), since the available data based on the semi-structured interview of fishers was based on the number of pieces caught per week the following formula was modified to calculate the CPUE of individual lobster fishers.

Formula:

$$U=\frac{C}{f}$$

Where:

U- Catch per unit effort

C- Weight of the species caught

f- Time spend in fishing

The modification consist of taking the weight (g) of three post/ nektonic-larvae lobsters and using the average weight as a multiplier for the normal, good and worst catches. This produced the normal, good, and worst catches in grams and then divided by the haul time of

fishers to get the CPUE. This haul time was based on the average of the haul times mentioned by the respondents during the semi-structured interviews.

Modified formula

Average weight of three nektonic/post puerulus x number of nektonic/ post puerulus in normal, good, worst catch in a week = grams per fishers on its normal, good and worst catch.

$$U = \frac{grams\ per\ fishers\ (weekly)}{Haul\ time\ (weekly)}$$

B) Statistical analysis

The normal, good and worst catches in grams as well as the CPUE were tested for normality test using Ryan-Joiner tests as well as homogeneity of variance using Levene's test and evaluating their graphs using a QQ and PP plots before ANOVA was used. (The normal, good and worst catches represent the usual, maximum and minimum catches of fishers in their daily experience. Getting this data is essential when you want to be confident about the range of the daily catch of fishers). When the data was not normally distributed, this was $\log_{10}$ transformed and then tested again for normality and homogeneity of variance. After which, a one-way ANOVA was used to check differences in catch and cpue between normal, good and worst catches from the interview data. To investigate the relationship between normal, good catches and factors that influences these catches, we tested their relationship with haul time, months operation, depth of fishing ground, number of traps deployed, age of fisher, number of years, experience of fisher and the following interaction terms haul time*months operating, haul time*traps, months operating*traps, haul time*months operating*traps. The $\log_{10}$ transformed values of catches were used since these were the response values while the factors were untransformed in the regression analysis. The ANOVA table of the regression was checked for its significance at $P<0.05$ value and the fitted line at R^2 and P values of factors

were checked including their VIF (Variance inflation factors, where the smaller value is more significant) values. In the case of actual field data taken from the notebooks given to 20 fishers, the catch data were also $\log_{10}$ transformed after first multiplying with the average weight of the lobster fry. All statistical analyses were done using the software Minitab version 17, Minitab Inc., State College, Pennsylvania, USA.

3.0 RESULTS

Sociodemographic profile

The interview included socio-demographic profile of the respondents, which included their age, years of residency, years of fishing, number of household members, and alternative sources of income that may motivate the eagerness of individuals to catch lobster fries. The youngest respondent interviewed was 19 years of age while the oldest respondent was 74 years and the mean age was 44. In terms of education, most of the fishers had basic elementary education (6 years), some were high school (10 years), and college graduates (14 years). The mean number of years of schooling was 8 years and the most frequent number of years was 6 years of basic education (N=48), followed by high school (N=36) and then college (N=6). In terms of fishing experience, the longest and most experienced fisher was 57 years while the shortest fishing experience was 2 years; the mean number of years of fishing experience was 21.

Motivations of fishers for lobster fry fishing

To catch lobsters, there are also some costs involved but because of the higher demand and the availability of natural lobster fry in the area, fishers are motivated to catch this marine resource in their area. A major motivation mentioned by fishers (n=35) during the FGD include daily allowance (26%) and payment for school fees (22%) followed by motivation to help build their houses (19%) and to pay for their credits (17%) and to buy grocery supplies

239 (16%). These are all intrinsic motivations for survival, food (daily allowance and grocery),
240 shelter and education.

241 **Catching methods**

242 Majority of the fishers used bamboo raft (72%) as an associated gear similar to a payao or fish
243 aggregating device in the tuna fisheries. Some of the fishers used beach seine to catch lobster
244 puerulus (7%), while the rest used both beach seine and bamboo floaters with traps (21%). The
245 standing or anchored bamboo rafts were established in the shallow areas (1-5 m), while the
246 floating bamboo rafts were deployed in the deeper portion of the bay (6-10 m) (see Figure 3).
247 Lobster fishers mostly operate the beach seine in a shallow area at a depth of 1-1.5 m as they
248 walk in the sediments; fishers used the beach seine during the peak season (March, April and
249 May) of nektonic puerulus as well as on their regular catch of fishes. Moreover, instead of meat
250 for bait in the traps, fishers used any black or brown colored materials for luring the fries such
251 as nets, dried leaves of banana and the thalli of the brown seaweed *Sargassum*. These are
252 materials usually used by the post nektonic puerulus for camouflage to avoid predators. Rocks
253 with various holes aided with dry banana leaves are used to lure nektonic puerulus to shelter in
254 the collecting rock.

Figure 3. Accessory gears used to catch lobster fries: floating bamboo rafts (A); fisherman tying nylon ropes to a rock that is used to aggregate lobster peurulus (B); bamboo poles (C) and stakes where rock aggregators are left and hung-ed (D) in Balete bay, Davao Oriental.

255

256 As for the average worst, normal, and good catches of the various fishing gears used to collect
257 lobster fries, traps can collect 2, 12, and 23 pieces of fries per week. While the use of beach
258 seine yields an average of 2, 20, and 28 pieces of fries per week. Whereas the combination of
259 both traps and beach seine can yield an average of 2, 25 and 43 lobster fries per week (Table
260 3).

261

Table 3. Mean catches of the different types of gears used to catch lobster fries in Balete bay, Davao Oriental

Gears	Worst	Normal	Good
Traps (n=65)	2	12	23
Beach Seine (n=6)	2	20	28
Traps and Beach seine (n=19)	2	25	43

262

263 In the FGD fishers have also mentioned that the number of lobster fries caught per month varies
264 depending on the phases of the moon. They could catch more pueruli when it is new moon as

265 the larvae congregate into their traps under the lighted floating rafts. According to the fishers,
266 there are also more lobsters captured in the night from 19:00 to 24:00 H (33%) as well as during
267 daytime from 07:00 to 12:00 H (31%) compared to catching them at other times of the day.

268 **Common species of lobsters caught**

269 The three most common species caught are *Panulirus ornatus* (the fries are called 'wak-wak'
270 and 'tiger-tiger'; 82%), *Parribacus antarcticus* (locally called 'kupa'; 12%) and *Panulirus*
271 *versicolor* (locally called 'bamboo'; 6%) species. Based on the results of the survey and the
272 FGD, the adults of these are caught year round as a fish by-catch but the fries are caught mostly
273 during March, April, and May (see Figures 4 and 5).

274 **Catch pattern, operation and CPUE**

275 The fishers catch the larval stage of the lobster throughout the year starting from February
276 until November (Figure 4). The most abundant catches of lobster fries occur during the
277 months of March (2,430), April (7,958) and May (4,292). The value of lobster fries
278 dramatically increases during these months from the base price of $1.81 ($1.00=Php 55.00)
279 to as high as $4.54 per piece. In the months of March, April, and May, the income of fishers
280 also increased from the stated total catch above, having a value of $8,659.64 followed by
281 $28,359.42 and $15,295.13 or an average of $167.00, $366.00, and $223.00 per individual
282 fishers in the months of March, April and May.

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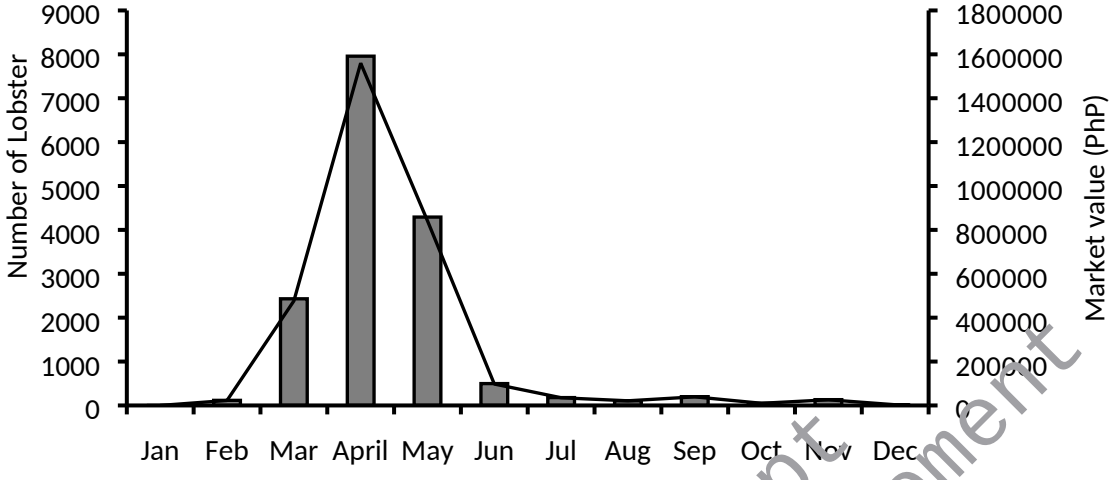

Figure 4. Number of lobster fries caught every month for one year and its catch value based on semi-structured interview of fishers from Balete bay, Davao Oriental (N=90).

284

285 In terms of the length of time of fishing operation in a year, these fishers operate mostly for

286 three months (N=32), two months (N=23) and four months (N=14) (Figure 5A). The longest

287 period of operation lasted from 8 to 10 months (N=1).

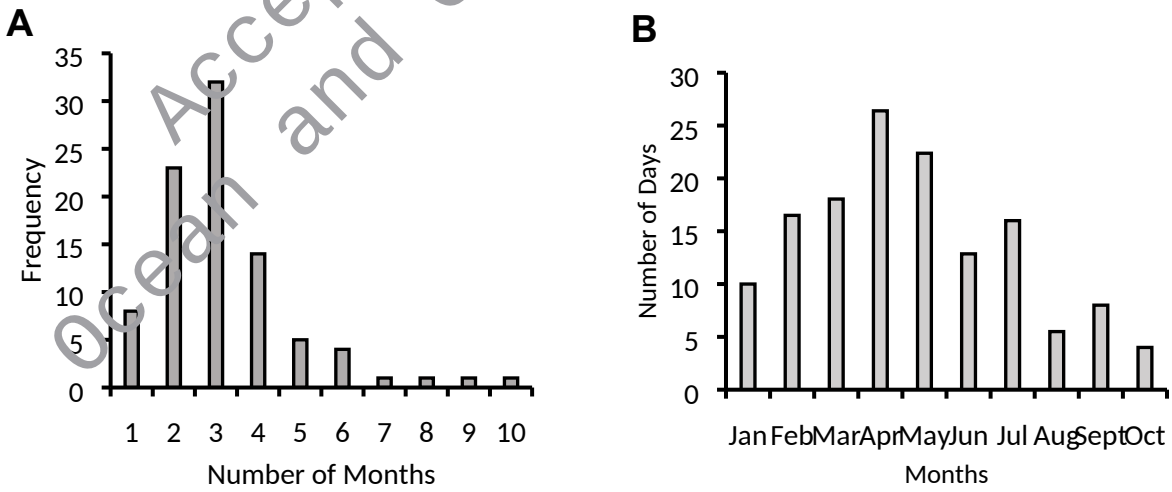

Figure 5. Number of months that fishers operate per year (N=90; Survey) (A); Mean number of days of operation and months that lobsters are caught (N=35; FGD) (B).

288

289 Results of the FGD have shown that operation on floating rafts starts around January and
290 increases by February and March. The number of hours that fishers operated have two peaks
291 during April and then during May which also mirrors the result of the survey where there
292 were higher peaks found in April and May for most number of lobsters caught in Figure 4.
293 The number of days of operation per fisher also increased during these months of March (18
294 days), April (26 days) and May (22 days) (Figure 5B). There was no mention about having a
295 fishing operation around November and December. Based on the interviews, the weekly
296 catch of lobster fries ranged from 0.9g (worst catch) to 10.42g (good catch). The normal
297 catch reported by fishers was 5.25g. The result of the ANOVA comparing the reported
298 weekly catches per week showed highly significant differences between good, normal, and
299 worst catches (7.92g > 4.08g > 0.63g; Df=2, MS=23.11, F=246.21, P=0.000; Figure 6).
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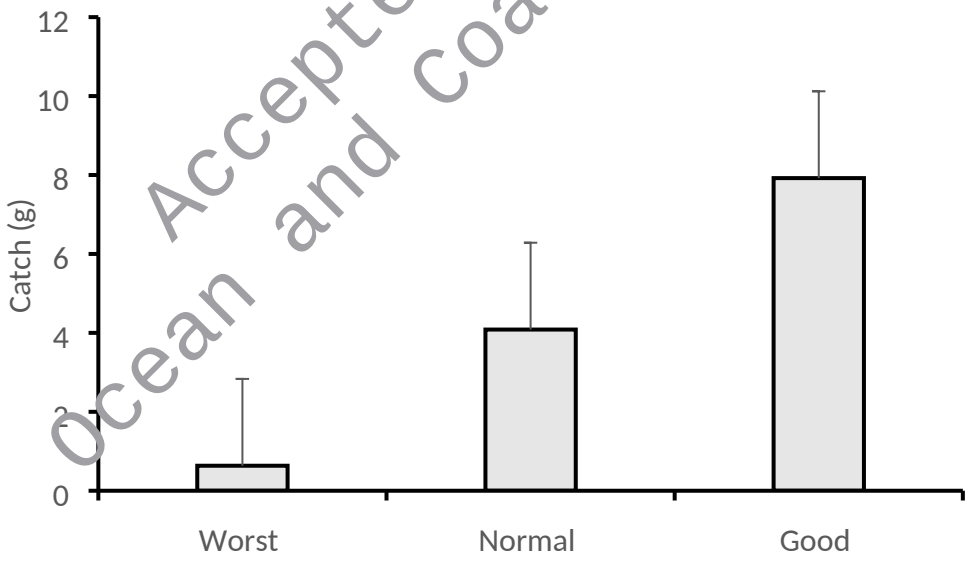

Figure 6. The worst, normal and good catches reported by lobster fry fishers from Balete Bay, Davao Oriental which are significantly different from each other (N=90; error bars are pooled stdev).

301

The analysis of the CPUE also revealed highly significant results between the three types of CPUE based on the catches. The highest mean CPUE value was (0.30 g/hr) followed by the normal CPUE (0.16/hr g) and worst CPUE (0.02 g/hr) (Df=2, MS=29.11, *F*=228.99, *P*=0.000). Meanwhile, the result of the regression involving the different factors of haul time, months operation, depths, number of traps, age, and experience, showed highly significant results for the normal (*P=0.003*) and good catches (*P=0.000*). For the normal catch, the significant factor predicting a normal catch was haul time *(R^2=15.54; P=0.011*; Table 4) while for the good catch the significant factor that could influence a good catch was months of operation *(R^2=19.71; P=0.057;* Table 4).

Table 4. Regression analysis to determine which factors influence normal and good catches

Source	Df	MS	*F*	*P*	Source	Df	MS	*F*	*P*
Regression	3	0.48	4.97	0.003	Regression	3	0.58	6.63	0.000
Haultime	1	0.66	6.81	0.01	Haultime	1	0.13	1.5	0.22
Depth	1	0.15	1.56	0.22	Months Oper	1	0.33	3.74	0.057
Months Oper	1	0.21	2.13	0.14	Haultime*Mo s Oper	1	0.001	0.02	0.88
Error	81	0.097			Error	81	0.08		
Total	84				Total	84			

These shows that haul time and months of operation influences the amount of normal and good catches. This also means that haul time, which predicts normal catches, shows that normal catches are taken within 0-24 hours. While in the case of good catches, what was more important is the months of operation, which shows that more catches are taken within the months where there was higher operation e.g. March, April and May.

The result of the actual catch monitoring of 20 fishers for three months (starting from February to April) showed two peaks during weeks 7 and 11. During the first peak, the mean weekly catch was 41 pieces with a minimum of 2 and maximum of 259 in the third week of March while in the second peak, the mean weekly catch was 52 pieces while the minimum was 24 and the maximum was 93. A monthly comparison of the catches for three months using

322 ANOVA showed no significant differences (P=0.073), the same was true for a comparison of
323 catches using the location of the two different villages (Bigue I vs Bigue II; P=0.419). But
324 comparison of catches in a week for all the 13 weeks showed highly significant differences
325 (Df=12, MS=0.767, F=4.47, P=0.000; R^2=22%). It also showed that week 11 has the highest
326 mean (1.38 g) followed by weeks 12 (1.056 g), 13 (0.780 g), and 10 (0.603 g) while the lowest
327 means were week 4 (0.306 g), week 9 (0.277 g), and week 3 (0.252 g).

328 **Challenges affecting the sustainable management of the lobster fry fishery**

329 Among the surveyed fishers, about fifty-eight percent (58%) did not belong to any fishing
330 organization and there was a general impression among fishers that both formal and informal
331 organizations did not offer them any benefit. Results based on the discussion with the
332 respondents identified the most common problems that fishers have encountered: chemical
333 residues from shrimp farming (36%); unmanaged floating marine debris and plastic garbage
334 (28%); presence of illegal fishing (compressor fishing and beach seine; 27%) and others
335 (residues from pesticides of mango farms, and inadequate livelihood; 9%; see Figure 7).
336 These are the key challenges that are affecting the lobster fry fishery in Balete bay.

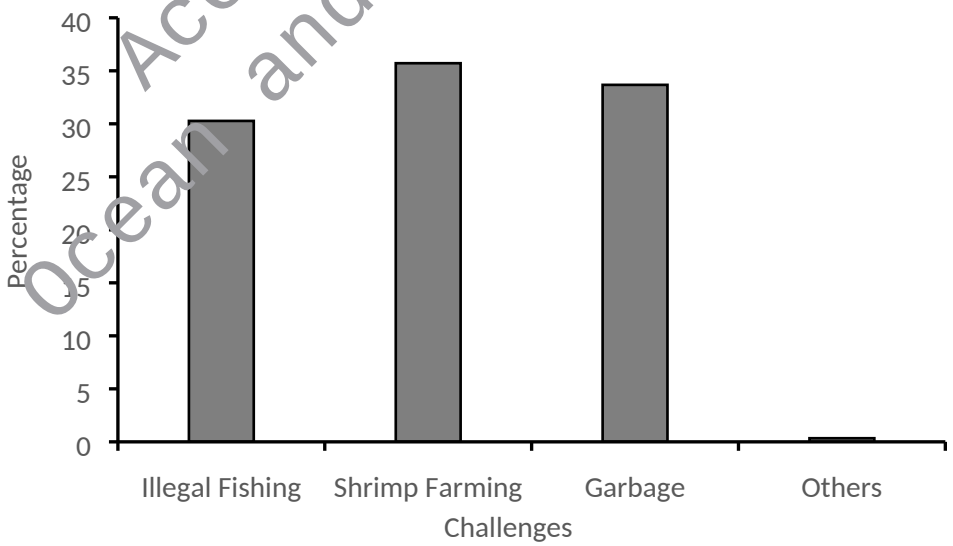

Figure 7. Challenges that are affecting the sustainable management of the lobster fry fishery in Balete Bay, Davao Oriental (N=35; FGD).

337

4.0 DISCUSSION

Motivations to fish

Most of the lobster fishers are engaged in fishing activities primarily to satisfy the needs of their families. As Abraham Maslow (1943) mentioned in his theory of human motivation, until the primary needs of human beings are provided, their self-actualization are not a priority but their daily survival. Fishers are marginally poor, live with less dignity and often less empowered in many development programs because of their economic conditions and social status in the society. Their condition could be the result of lack of formal education, formal training, failed government policies and lack of empowerment such as capital for alternative livelihoods away from the fisheries (Macusi et al., 2017b; Macusi et al., 2011). The lack of empowerment is obvious in the area where there are no cooperatives or active fisherfolk association that would be marketing their products.

In Belize, the fisher cooperatives that are formed help in the proper distribution of benefits that would derived from the lobster production in their city (Huitric, 2005). The same can be said about the tuna fishers of General Santos City who have various active fisher cooperatives and organizations that can lobby for their rights and interests to fish in certain areas in the Pacific (Macusi et al., 2015b). The seasonality of the lobster fry fishery in Balete bay necessitates that the fishers in the area have to find an alternative livelihood to supplement their incomes, especially during the lean months (July to December). This is a characteristic common to some of the small-scale fisheries in the Philippines (Garces et al., 2010; Macusi et al., 2011; Pomeroy et al., 2007). In addition, the decline of productivity in the fisheries through the years have led to lesser income for fishers and compelled them to find other alternative livelihood (Muallil et al., 2011; Muallil et al., 2014). This low productivity in the fisheries have been associated to the effects of chronic overfishing. It is therefore not surprising that most small-scale fishers in Southeast Asia are impoverished, faces the threat

of overexploitation, habitat loss and declining productivity since coastal resources in the region have been considered overfished (Cabanban et al., 2014; Chuenpagdee and Pauly, 2004; Pomeroy et al., 2007; Pomeroy, 2012). In Balete bay, most of the lobster fry fishers are also engaged in other farming activities such as coconut plantations as an alternative livelihood. To the fishers, farming is a productive alternative activity especially during bad weather conditions and during times when their target catch are seasonally, usually from July to December. Fishers who are engaged in other income generating activities are better able to meet the needs of their families.

Fishing location and practices

Several factors can influence the decision of fishers on where to deploy their fishing efforts (Abernethy et al., 2007). Previous experiences on fishing could significantly affect the decision of fishers on where to fish, and one factor that fishers consider in site selection is the profitability of the fishing site to offset their fishing cost (Daw, 2008; Macusi et al., 2015b). The current distribution pattern of floating bamboo rafts and stakes with hanging traps and other fishing materials utilized in the lobster fry collection can reflect the abundance and distribution of lobster fry in the area. Fishing in areas where there is aggregation of target species also increases the CPUE (Daw, 2008; Rijnsdorp et al., 1998). The common practice of fishers in bringing more than one gear to fish could mean to secure an alternative target species or to maximize the opportunity to catch a fish. Although the majority of the fishers utilize traps only in the case of the lobster fry fishers. Nevertheless, the fact that fishers will also use nettings and rocks with holes or sargassum leaves as lures show their keen knowledge about the behavior of their target species.

Catch composition, seasonal patterns and CPUE

The most common species caught by the lobster fishers include the fries of *Panulirus ornatus* and sometimes the adult forms of *Panulirus ornatus*, *Parribacus antarcticus* and *Panulirus*

388 *versicolor*. These are all tropical species with wide distribution in the Philippines (Gonzales
389 and Taniguchi, 1995). Caraga region has the highest and most consistent lobster production
390 among all the regions. However, the production never increased beyond 53 tons and because
391 of inadequate supply of fries, fishers and suppliers of the seafood business ventured to
392 neighboring Davao Oriental for their needed supply of wild sourced fries.
393 The peak of lobster fry production in Balete bay coincided with the inter-monsoonal period in
394 the Philippines but generally during the Amihan period (northeast monsoon from November
395 to end of June). Seasonality in marine fisheries production is often observed which coincides
396 with the reproductive timing of marine species (Erisman et al., 2012; Villanoy et al., 2011).
397 However, other factors (e.g. temperature, food availability) may influence the reproductive
398 timing of marine species, therefore affecting seasonality of fishery production (Jones, 2010;
399 Ratunil, 2017; Villanoy et al., 2011). In previous studies, the abundance and distribution of
400 lobster fries and juveniles were shown to be affected by wind patterns, and current circulation
401 (Villanoy, 2004). Other species of lobster (e.g. *Jasus edwardsii*) have been shown to have
402 puerulus settlement peaks around July and August and less prominent settlement peaks in
403 February and March while in Samar, Philippines, the peak lobster season is from May to
404 August (Junio, 1986). Meanwhile, lobster fishery in Mindanao, Philippines was recorded to
405 have two peak seasons: (1) October to March in western Mindanao and (2) March to August
406 in Southern Mindanao (Juinio-Menez and Gotanco, 2004). The present study corroborates the
407 findings of Juinio-Menez and Gotanco (2004), with peak in lobster fry harvest from March to
408 May, with highest production stated around April. Reports on CPUE for adult lobster fishery
409 showed that the highest daily catches per fisher per day is 50 kg in different areas of the
410 Philippines (Juinio-Menez and Gotanco, 2004). However, no data is currently available on
411 CPUE of lobster fry in the country, which make this valuable fishery susceptible to illegal,

412 unreported and unregulated (IUU) fishing. According to Petrossian et al., (2015), several
413 species of crustaceans, including crabs and lobsters, are prone to IUU fishing.

414 **Present challenges and sustainable management**

415 Unregulated and unmonitored fishery ends up in overexploitation of marine resources and
416 destruction of habitats that often leads to negative socioeconomic impacts (Lavides et al., 2016;
417 Tsehaye et al., 2007). Having a proper understanding and monitoring of both the resource and
418 its ecosystem dynamics is a prerequisite for better response and conservation efforts to the
419 resource (Berkes and Folke, 1998). Unmonitored fisheries often lead to collapse and extirpation
420 due to unregulated extraction of marine resources (Lavides et al., 2016; Lavides et al., 2010).
421 Balete bay is part of the larger protected area of Pujada Bay, which is under the NIPAS act as
422 a protected landscape and seascape by virtue of Republic Act 7586. However, implementation
423 of the law in the area is lacking. As a NIPAS area, the government, particularly the DENR
424 should protect the area from incursions and its biodiversity from commercial extraction. In the
425 case of Balete bay, this means implementation of yearly registration of fishers, to record their
426 names, boats, gears and to monitor what fish they catch and how much they catch in the area
427 to avoid over-exploitation of the marine resources in the area. The NIPAS act recognized the
428 role of biodiversity in providing ecological services to the communities adjacent to the
429 protected sites and initially there were 290 protected areas included in the NIPAS act (Lasco
430 et al., 2008). Most of the protection accorded to these areas were merely on paper due to lack
431 of resources and externalities. These externalities include patterns of resource use, societal
432 values, political patronage, poverty, and insurgency (Van Der Ploeg and Mesipiqueña, 2005).
433 Due to the lucrative nature of the lobster fry fishery, more fishers have been attracted in recent
434 years to collect lobster fries and to fish in Balete bay. A number of these fishers however do
435 not understand the benefits of fishing regulations especially in controlling their number and
436 access to the area. A common example is the use of illegal fishing gears such as compressor

fishing and beach seines with tiny mesh sizes. Most of the fishers interviewed believe that they have the freedom to operate as long as they want and they point instead to the wrongdoings of some law enforcers who were corrupt. For instance, the local fisheries council under the village level called BFARMC (short for Barangay Fisheries Aquatic Resources Management Council), has the tasked to prevent illegal fishing but seldom prevents or deters the users of compressor in fishing.

Illegal fishing

The gears used such as compressor, beach seine and triple gillnets are three illegal fishing methods that were identified by the respondents. Beach seine and triple gillnets can catch smaller sized fish in which some fishers throw it back into the sea already injured or weakened by the struggle. Whereas the use of compressors for diving together with cyanide are used to catch big fishes, open the traps of other fishers or to stun them. Illegal fishing is a recurrent problem in the Philippines from dynamite fishing in the past to the use of small mesh sizes for various net gears (Alcala, 1988; Macusi et al., 2017b; Muallil et al., 2013). Currently, illegal, unreported and unregulated fishery production is unknown and catch reconstructions are being done to augment our understanding on this unknown production (Cabanban et al., 2014; Zeller et al., 2006). In Balete bay, several fishers admitted that they engage in the use of fine mesh beach seine to collect lobster peurulus as this is more efficient. However, the indiscriminate nature of the fine mesh size beach seine also collects both target and non-target species. The fishery by-catch resulting from indiscriminate fishing is a threat to sustainable management of the fishery and have ecological repercussions (Forget et al., 2015; Gilman et al., 2005).

461 **Marine Pollution**

462 Fishers perceived that the effluents from shrimp farms and fruit farms surrounding the bay
463 was becoming a major problem for the lobster fry fishery. They have observed that chemicals
464 dumped into the bay, resulted to lower fry catch, affecting their income. In the past, large
465 mangrove areas in the country have been converted to shrimp farms, mainly extensive
466 aquaculture and then later into intensive farming of the tiger shrimp (*Penaeus monodon*)
467 (Primavera, 1995, 1997). In the process water pollution from farm effluents lead to increased
468 incidence of diseases becoming a serious problem that lead to the eventual collapse of the
469 shrimp farming industry (Dierberg and Kiattisimkul, 1996). Environmental pollutants, such
470 as heavy metals, pesticides and other chemicals used in farms are known to affect marine
471 organisms physiologically (Abreo et al., 2015). Effluents from fish farms are detrimental to
472 marine organisms (Holmer et al., 2002; San Diego-McGlone et al., 2008). These effects
473 perhaps warrant the observation of the lobster fry fishers. Fishers are worried that if this will
474 continue, it will also lessen the number of fishes that they are catching, affecting almost all of
475 the stakeholders who rely on marine resources.

476 Another source of pollution identified by the lobster fry fishers is the presence of
477 anthropogenic marine debris (AMD). They have identified fishing related materials, such as
478 discarded nets and nylon strings as common anthropogenic marine debris in the area where
479 they collect lobster fries. The fishers have also identified household wastes such as plastic
480 packaging materials, food wrappers, and cellophane as components of floating marine debris
481 within Balete bay. These findings reflect the fact that there are two input sources of AMD in
482 the area, the fishing activities of the community and the households surrounding the bay.
483 Land-based input of anthropogenic debris, on the other hand, is said to contribute most AMD
484 in the Philippines since Filipinos are fond of using single-dose sachets (e.g., shampoo sachet,
485 toothpaste sachet) and excessive packing of goods from local sari-sari stores (Abreo, 2016;

Abreo et al., 2018). Although there is a law prohibiting dumping such as RA 9003 or the solid waste management act 2000, the barangays surrounding the bay did not implement the law religiously. A recent study in the area have found out that there were more green wastes or floating coconut husks, detached mangrove leaves and twigs, seagrass leaves, and seaweeds in the area than plastic packaging materials (Mapaa, 2018). Although this is the case, the plastics, would have come from the domestic solid wastes carried away by rains before getting into the bay. There were no actual sightings and reports of entanglement of wildlife during this study and in the study of Mapaa (2018) on the perceived biological impacts of floating marine debris in the area.

Implications of lobster fry fishery in Balete bay

The lobster fry fishery in Balete bay is a lucrative activity for the fishing communities in the villages surrounding the bay. Fishing for lobster fry is a great supplemental livelihood as lobster fries command high prices in the market during the peak season from March, April, and May. Although there is minimal information available on the current status of other fisheries present in Balete bay and the adult lobster fishery, the conflict between fishers using different fishing gears points to a high fishing pressure in the area. Given that the area is small at 77 ha, the distribution of fishing rafts for lobsters as well as bamboo stakes in the shallow portions of the bay implies overcrowding because of the open-access nature of the fishery at present. This is a recipe for over-exploitation and this might lead to overcapacity of fishers in the area. Moreover, since the conflict arose from the overlap of fishing areas between fishers with different fishing gears, this points to a high number of tenants utilizing the same area. The lack of management regime leads to a “race for fish”, increasing fishing power that would also lead to overcapacity (Mora et al., 2009). Since there is no clear regulation in the area, such as the lack of lobster management plan, fishers have taken for granted that they are not registered. Consequently, there is eagerness among the fishers to use

beach seine in the collection of lobster fries, which will pose a problem on the biodiversity of Balete bay. Beach seine is a fishing gear that harvests fish larva, various fish species as well as the pueruli of lobsters. Moreover, beach seining in such area can disturb the breeding activities of marine species in the area and lead frequently to the capture of juveniles affecting the stock abundance. Considering that it takes years for a lobster to be fecund and dependent on the size of the geographic area as well as the temperature for it to spawn, conservation efforts to protect the juveniles will be essential for its sustainability. Since the area is not clearly managed, a declaration of the 77 ha area to be included as a marine protected area (MPA) with managed access together with the local government and the communities surrounding the bay should be part of the sustainability management plan of the bay. The establishment of an MPA, although it is not a cure-all for the poverty of fishers would in the long-term help in preventing stock collapses. Although this goal will be challenging to both scientists, resource users, and decision makers, their consensus could lead to a well-managed ecosystem where their livelihood will persist without endangering the stocks present in the bay (Sanyo et al., 2008). Restrictions or zoning of the different areas of the bay should be a consensual decision among the local government, the resource users, and the community as a whole leading to longterm co-management of the bay. Fishers will be more conscious on their role, particularly in conserving the fish species and the lobsters found in the area so that their attitudes will change and the stock abundance are not depleted. Financial and food insecurity may remain but a partnership together with the local government will be an avenue towards providing a better livelihood for the fishers. During the FGD and the survey, there was a repeated mention about the lack of organization among the fishers of Balete bay and their wrong perception on the law enforcers in the area, which hinders their cooperation with authorities. By organizing a bonafide fisherfolk association in the area, the registered fishers would become recipients to various donors and organizations

that are into conservation of lobsters and reef fishes. Through organizing the fisherfolk association they could broker collective arrangement with the buyer, develop market outlet and increase their capacity building through offered helps and dole-outs (Jimenez-Badillo, 2008). Two factors could benefit fishers with an organized fisherfolk association: 1) since they have specific target species and small in number, they can be more organized; and 2) they could gain attention and support from government agencies as they could deal with them as an entity instead of individuals. Predominantly, the fishers of Balete bay have an attitude of working hard for their families and do not wait for government dole-outs. Nevertheless, they are more than willing to cooperate in fisheries resource management if their livelihood would be improved. The essential idea in fisheries co-management is the sharing of decision-making, management among stakeholders, resource users and the local government. Co-management have various aspects, which would include the integration of the local government and national management strategies of the national government agencies like BFAR and DENR (Pomeroy, 2012). In order to win back the confidence of fishers in the authorities, projects should have workshop components that addresses the role of fishers, authorities, local government, and scientists, which will make the management inclusive in its stewardship (Rice, 2011). Moreover, fishers, or resource users, together with the local government and the national government agencies should be able to come up with a management plan, specifying zones where they can fish and their fishing gears for such zones. The closure of areas should also have a consultation with the local government as well as the resource users in the area to avoid resource user conflicts and lastly, they should be involved in the protection of their own resource in the area (Pomeroy et al., 2007).

Conclusion

This study have found out about the catch, catching methods, seasonality, fishing practices and the lack of proper management of the lobster fry fishery in Balete bay. The high

value of lobster fry encouraged the fishers to engage in catching lobsters to gain higher income other than their current livelihoods in coconut plantations. This also drove some fishers to use an illegal fishing gear such as a beach seine to collect great number of fries at a lesser time compared to using other gears such as traps and rock collectors of lobster pueruli. The use of this gear, which catches juveniles of fish other than lobster fries, can cost the future stock and biodiversity of Balete bay. The lack of lobster management plan for the fisheries resources of the bay can be addressed through developing a marine protected area or a fish sanctuary in the area that will be co-managed by the community and the local government with regular monitoring from BFAR and DENR. This would help address its long-term productivity and sustainability. In the past, most of the government projects and dole-outs ignore fishers' participation, co-management allows resource users together with the local government, authorities and other stakeholders the freedom to influence and make decisions together. Together, the authorities and the resource users could develop ordinances, and management plans that will enhance the living conditions of fishers.

ACKNOWLEDGEMENT

This paper would not have been possible without the help of the following people during the conduct of the field sampling and the writing of the manuscript, Dr. Lea A. Jimenez, France Guillian B. Rapiz and Ms. Chella Sison. The maps were made possible through the efforts of Mr. Remie Aurelio Jr. of UP Mindanao.

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