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FULL PAPER

Stock Assessment of *Arius maculatus* (Thurnberg, 1792) (*Ariidae, Siluriformes*) in Panguil Bay, Northwestern Mindanao

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ABSTRACT

Arius maculatus, commonly known as spotted catfish and locally known as *Tambangongo*, has a great potential as an aquaculture species, but there is very limited information known for the stocks in Panguil Bay. This study aimed to assess the wild stocks of *A.maculatus*, and make an inventory of the fishing boat and gears in two stations in Panguil Bay, namely: Tangub, Misamis Occidental and Baroy, Lanao del Norte. Length frequencies were analyzed to provide estimates of growth, mortality, exploitation ratio, and recruitment pulse of *A. maculatus* in the bay. A total of 589 boats (324 motorized boats and 265 non-motorized boats) were recorded from the sites. There were 473 units of 15 types of fishing gear used in the sites and 6 types of these were only used in catching *A. maculatus*. A total of 3,259 specimens were collected for 12 months from the sites. The aquatic habitat of *A. maculatus* from the two sites was characterized by a pH range of 7.9-8.1, temperature of 28.5-29.1°C, salinity of 13.31-15.9 ppt, dissolved oxygen levels of 4.0-5.41 ppm, and total suspended solid values of 0.1-0.6 g/L. Reproductive biology analysis indicates that eggs start to mature from October to December, then spawning starts from January to March, and the fish fry recruitment starts in April and May. *A. maculatus* can grow up to 98.95 cm with an asymptotic length of 98.86 cm (K value = 0.35) equivalent to asymptotic weigth of 8,750 g. Mortality Z = 0.99, with natural mortality M = 0.67 and fishing mortality F = 0.33. This study revealed that *A. maculatus* in Panguil Bay is not over-exploited since the exploitation rate (E = 0.33) is minimal and large individuals can still be collected from the field.

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1. INTRODUCTION

A tropical Asian ancient species, the Spotted Sea Catfish (Chu et al. 2011), *Arius maculatus* (Thunberg 1792), is an economically important fish in the country. The species, together with eight others, are members of the Family Ariidae (Carpenter and Niem 1999) and are collectively known as *kanduli* in the Philippines. *A. maculatus* has a great global potential as an aquaculture species and apart from serving as food, sea catfish may provide pharmaceutical and nutraceutical benefits such as for faster wound healing (Al-Bow et al. 1997) and source of high essential polyunsaturated fatty acids (EPA and DHA) (Osman et al. 2007).

An earlier study reported that spotted catfish only breeds once a year with a prolonged spawning season between January and April off the Bombay coast and during the period of September and October (Jeyaseelan 1998). The spawning pattern was periodic, although the individual fish of the species breeds only once a year; a different population of the species in India seems to breed almost all year round. The spawning pattern was cyclic, and fish breeds only once a year. *A. maculatus* reproduction is dioecism; fertilization occurrs externally and the males incubate the eggs in the oral cavity and start starvation to swallow one or two eggs to regulate basal metabolism. The newly hatched embryos feed on inhaled particles of the females (Balon 1990).

Chu et al. (2011) reported the following growth parameters of *A. maculatus* estimated by length-frequency analysis: asymptotic fork length (L = 34.4 cm), growth constant (k = 0.28 $year^{-1}$), and age at length 0(t_0 = -0.57 $year^{-1}$). The total mortality, natural mortality, fishing mortality and the exploitation ratio were 1.29, 0.86, 0.43 $year^{-1}$, and 0.24, respectively. According to the monthly length distribution, the smallest fish (median = 2 cm) appeared in July 2009, which implies that the spawning season of spotted catfish is in June or July.

It was reported in the 1930s that abundance of *Arius* species in Luzon was declining (Villadolid 1934), but the commercially important and premium food species *A. maculatus*, or *Tambangongo* in Panguil Bay, is rarely studied. *A. maculatus* is a euryhaline, benthic species in tropical and subtropical waters, inhabiting the bottom of estuaries, rivers, and coasts (Mazlan et al. 2008). At present, there are no research studies focusing on the potential of *A. maculatus* to become a priority species for aquaculture, thus this study aimed to determine the status of fishery *A. maculatus* in Panguil Bay.

This study was conducted to determine the status of *A. maculatus* in Panguil Bay prior to the selection of a potential broodstock for its hatchery program. Specifically, it aimed to (1) make an inventory of fisherfolk, fishing boat and gears used for *A. maculatus* fishery, 2) determine the catch species composition associated with the *A. maculatus* fishery, 3) provide estimates on the growth, mortality and exploitation rates of *A. maculatus*, and 5) determine the reproductive biology of *A. maculatus* in Panguil Bay.

2. MATERIALS AND METHODS

2.1 Inventory of fisherfolk, fishing boat and gears involved with A. maculatus fishery

The sampling stations were established in the two coastal municipalities of Panguil Bay, namely, Baroy, Lanao del Norte, and Tangub City, Misamis Occidental (Figure 1). Data on the number of fisherfolk, fishing boat and gears were collected and recorded by the enumerators from the fisherfolk

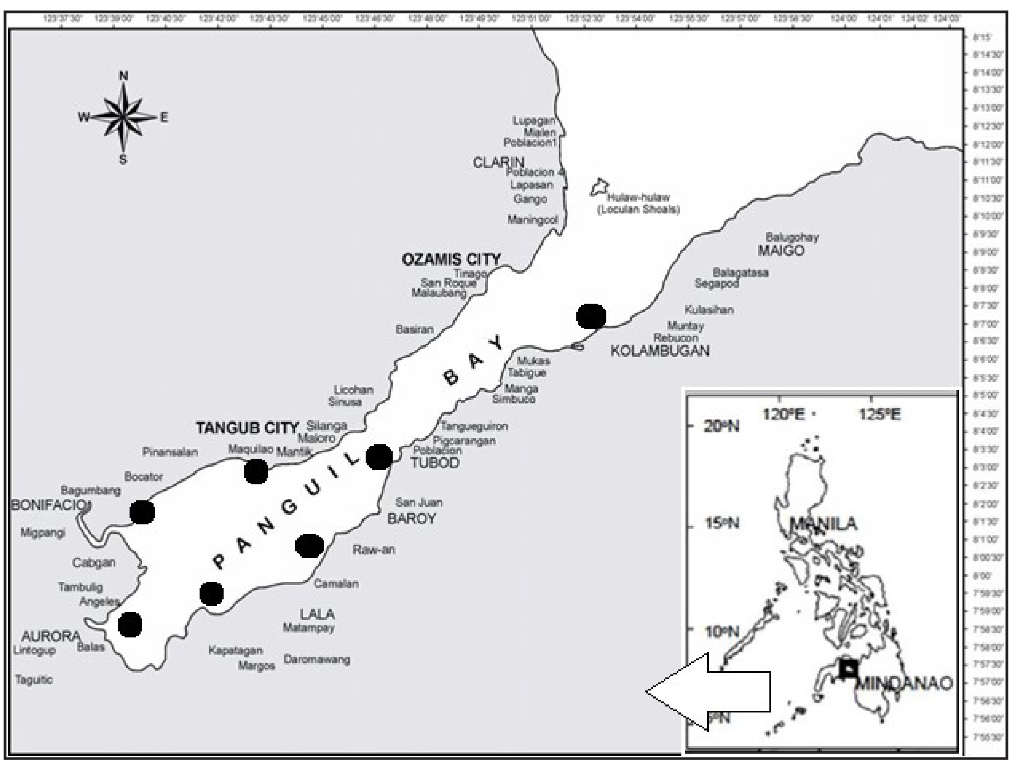

Figure 1. Map showing the sampling sites of fish stock assessment, data collection sites, and physico-chemical sampling points in inner Panguil Bay.

registry of the Office of the Municipal Agriculturist (MAO). The actual enumeration was also done to validate the records.

Fish landed catch survey was conducted by trained fisherfolk enumerators using a standard survey form on catch and effort. The survey was done in 2 days' interval for a total of 20 days in a month including Saturdays, Sundays, and holidays. The survey form included the following data gathered: landing site, fishing ground, volume of catch per species, type and number of gears and boat used, number of hours fishing operation. All survey forms were submitted monthly for collation and processing.

2.2 Catch species composition associated with the *A.maculatus* fishery

The species composition caught by all gears in the bay were listed and identified up to species level. The fishery resources were categorized into fish, invertebrates, and other organisms. Total catch of each species by gear for the year was computed and ranked from highest to lowest. Percentage composition of the major species from the total fish production was determined.

2.2.1 Production estimates

Fish production estimates was estimated by extrapolation. Total catch for the day in kilograms (TCD) was computed by multiplying the total catch for the day (C) to a raising factor (RF) equivalent to the number of sampled landing sites over total landing for the day. Monthly and annual productions were computed by raising the total catch for the day. The following were the computations made:

(1) Total catch for the day (TCD) = Catch for the day (C) x raising factor (RF)
where: RF = number of total landing/sampled landings

(2) Total catch for the month (TCM) = TCD x RF
where: RF = number of days in a month/sampled days

(3) Total catch for the year (TCY) = TCM x RF
where: RF = number of months in a year/sampled months

2.2.2 Catch per unit effort

The different fishing gears used in the bay were identified, and catch composition by each gear was determined. The catch per unit effort (CPUE) of each gear was determined using a standardized unit of effort such as kilogram per day (kg/day). The CPUE was computed by taking the average catch for the day per gear. The annual mean CPUE was obtained by the summation of the monthly fish harvest over the summation of the number of fishing days in a month/year.

2.3 Estimates on the growth, mortality parameters, and exploitation rates

The analysis of length-frequency data of *A. maculatus* was done. The total length (TL) of fish specimens per month were measured to record length-frequency data. The data were measured using the FAO-ICLARM Stock Assessment Toll or FiSAT II version 1.2.2 software (Gayanilo et al. 1997). Growth parameters were determined first by estimating the initial asymptotic length (L_∞), and the ratio of the total mortality to growth coefficient (Z/K) using Power-Wetherall method based on the equation of Beverton and Holt (1956) as cited by Gayanilo and Pauly (1997). The initial seed value of L_∞ was further analyzed in ELEFAN I (Electronic Length Frequency Analysis), where the constant (k) was estimated from k-scan routine finding the best appropriate growth curve. The estimated values of L_∞ and k were visually assessed for progression of modes in the growth curve utilizing the von Bertalanffy Growth Function or VBGF (Pauly 1983). The mortality parameters (*Z, M,* and *F*) and Exploration Rate (E) were estimated via the Length Converted Catch Curve method (Pauly 1984) and using the mean annual habitat temperature 30°C. The instantaneous Total Mortality (Z) was estimated using the following the formula:

$$Z = M + F$$

Where: M = natural mortality and F = mortality caused by fishing.
Expanding the equation for mortality would lead to the estimation of Exploitation Rate (E) via the following equation:

$$E = \frac{Z}{F}$$

2.4 Reproductive biology of *A.maculatus* in Panguil Bay

A total of 332 specimens were collected from actual sampling for one year (from March 2017 to

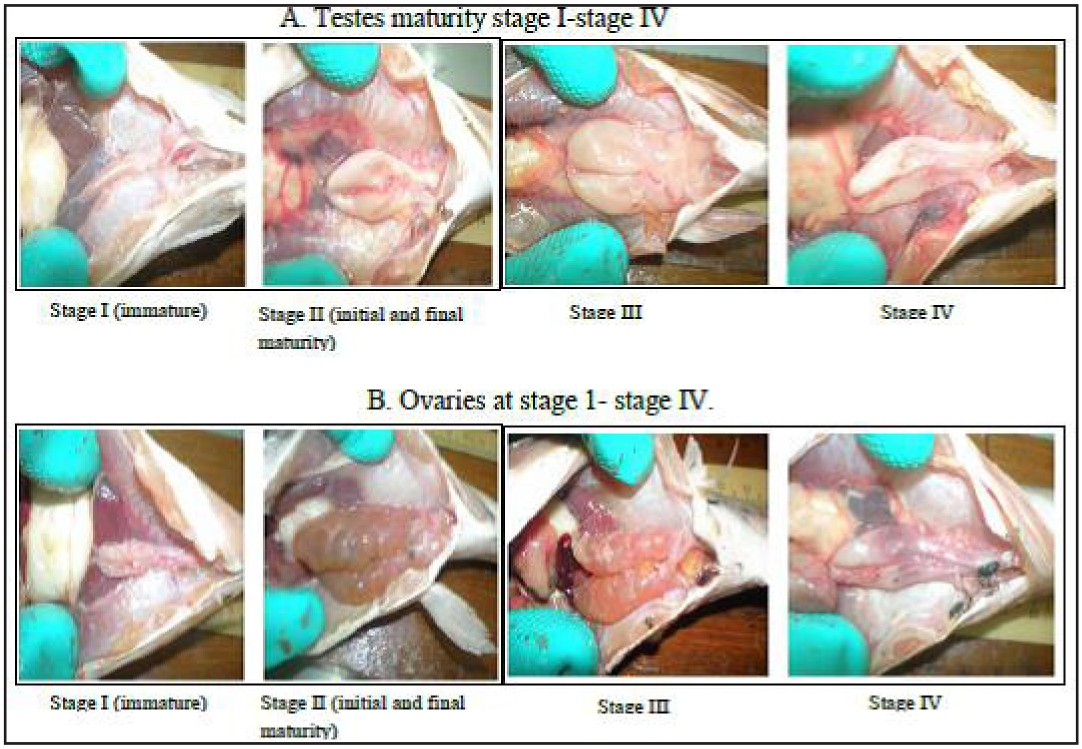

Figure 2. Gonad maturity stages of *A. maculatus* (Gomes and Araújo 2004).

March 2018) from four sampling areas for reproductive biology analyses. The collected fish sub-samples from fish corral were divided according to their minimum and maximum size ranges. Before dissection, the fork length (cm) and weight (g) of the fish were taken first. Dissection was done by opening the abdominal cavity to determine the sex and degree of gonad maturity through visual examination (Gomes and Araújo 2004) of the gonad in fresh individuals (Figure 2).

2.4.1 Gonadosomatic index

Gonadosomatic index (GSI) gives an indication of the percentage of the fish weight used in egg production. The gonads were removed and weighed to the nearest 0.01 g using digital electric weighing scale. Only female gonads in stage III were used in the analysis to verify strength of spawning during the biological months. The GSI was computed as follows:

$$GSI = \frac{Gonad\ Weight}{Body\ Weight} x100$$

2.4.2 Gonadal maturity determination and spawning season

The degree of gonad maturity was determined by visual examination of male and female gonads seen in Figure 2 based on the four-point gonad maturity scale and were assigned as immature (stage I), initial and final maturity (stage II), ripe (stage III), and spent (stage IV), according to the vascular irrigation intensity, color, and percent volume of abdominal cavity occupied by gonads (Gomes and Araújo 2004). Seasonal distribution of gonads by maturity stages were determined monthly, and the overall percentage frequencies observed were used to indicate the seasonal distribution of the gonad maturity stages. The average duration for the spawning season was identified as the time when at least 50% of the adult population has reached maturity.

2.5 Physico-chemical parameters

Physico-chemical parameters were determined once a month per sampling area in this study. Temperature (°C), salinity (ppt), pH, and dissolved oxygen (mg/L) were measured using a mercury thermometer, ATAGO refractometer, Hanna pHep+, and YSI Pro Multi-parameter meter, respectively. Water samples were collected underwater about 1 m from the surface. Determination of total suspended solids was done by gravimetric method.

3. RESULTS

3.1 Fisherfolk, fishing boat, and gear inventory

There are 11 towns and 78 coastal barangays surrounding Panguil Bay. The number of fisherfolk recorded in 2005 was 453 individuals (Jimenez et al. 2009). In this study, at Tangub, Misamis Occidental and Baroy, Lanao del Norte, 578 fisherfolk were recorded, which represents an increase of about 12% from the value recorded in 2005. Of the 578 fisherfolks, around 14% (91 individuals) were engaged in fishing of *A. maculatus* (Table 1 and Figure 3). The reported numbers of fishing boats in 2005 was 1,202 units; 602 of these were motorized and 600 were non-motorized (Jimenez et al. 2009). The number of fishing boats recorded in this study was only 589 units (324 motorized and 265 were non-motorized), representing a decrease of about 34% from the value recorded in 2005 (Table 2).

There was an increasing number of gears recorded in 1991, 1995-1996, and 2005 (Jimenez et al. 2009). The fishing gear inventory in 2017 recorded a total of 473 units of 15 types of fishing gears used in the bay (Table 3). These included fish corral, bottom set gill net, bottom set long line, multiple hook and line, drift gill net, push net, beach seine, bakho-bakho, crab pot, fish pot, single hook and line, bag net, salom, surface gill net, cast net, scoop net, buy-anan, balayan, and ligid. Among the 15 gears identified, 6 gears were used for catching *A. maculatus*, namely: fish corral, bottom set gill net, bottom set long line, multiple hook and line, fish pot, and surface gill net. The gear that was mostly used for catching *A. maculatus* is fish corral with 178 units or 37.6% of the total number of gears used in the bay (Table 3 and Figure 4). In addition, among the 15 gears identified, 2 were prohibited active gears: the beach seine and push net. Although prohibited in the bay, these gears were observed to have fish catch landings in the bay.

Table 1. Number of fisherfolk in sampling areas in Panguil Bay, 2017.

Town	No. of Coastal Barangays	Number of Fisherfolk	
		Fishes & Crustaceans	*A. maculatus*
Baroy	4	296	34
Tangub City	15	282	57
TOTAL	**19**	**578**	**91**

3.2 Catch species composition associated with the *A. maculatus* fishery

A total of 25 species were caught from the two

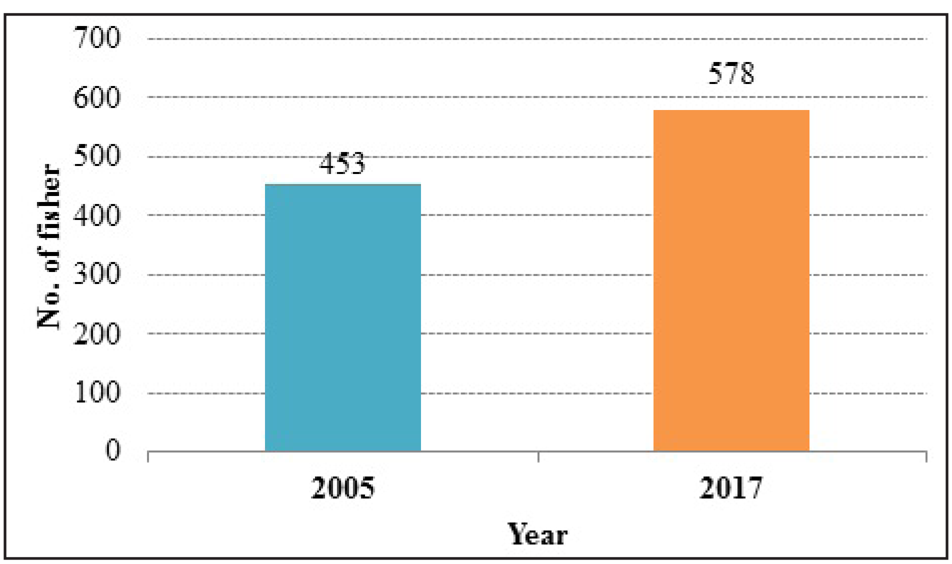

Figure 3. Number of fisherfolk in Panguil Bay recorded in 2005 (Jimenez et al. 2009) and 2017 (this study).

Table 2. Number of fishing boats in sampling area in Panguil Bay, recorded in 2005 (Jimenez et al. 2009) and 2017 (this study).

Number of Fishing Boat				
	2005		**2017**	
Coastal Municipality	**Motorized Boat**	**Non-Motorized Boat**	**Motorized Boat**	**Non-Motorized Boat**
Baroy	129	243	130	154
Tangub City	473	357	194	51
Total	**602**	**600**	**324**	**265**
Grand Total	**1202**		**589**	

Table 3. Number of fishing gears in sampling areas in Panguil Bay, data recorded in 1991, 1995-1996, and 2005 (from Jimenez et al. 2009) and 2017 (this study).

Number of Gear				
Gear	**1991**	**1995-1996**	**2005**	**2017**
1. Fish corral (baklad)	1	3	96	178
2. Bottom set gill net (panti)	2	3	89	128
3. Bottom set long line (palangre)	-	-	-	21
4. Multiple hook and line (bira-bira)	1	2	6	46
5. Drift Gill net (panting paanod)	-	15	24	44
6. Push net (sud-sud)	-	3	6	22
7. Beach seine (baling)	-	-	-	1
8. Bakho-bakho (modified)	-	-	-	
9. Crab pot (sugong)	-	-	65	
10. Fish pot (bubo)	-	-	-	4
11. Single hook and line (pasol)	-	-	11	29
12. Spear gun (pana)	-	-	-	
13. Buy-anan (modified)	-	-	-	
14. Balayan (modified)	-	-	-	
15. Ligid (modified)	-	-	-	
	4	**26**	**297**	**473**

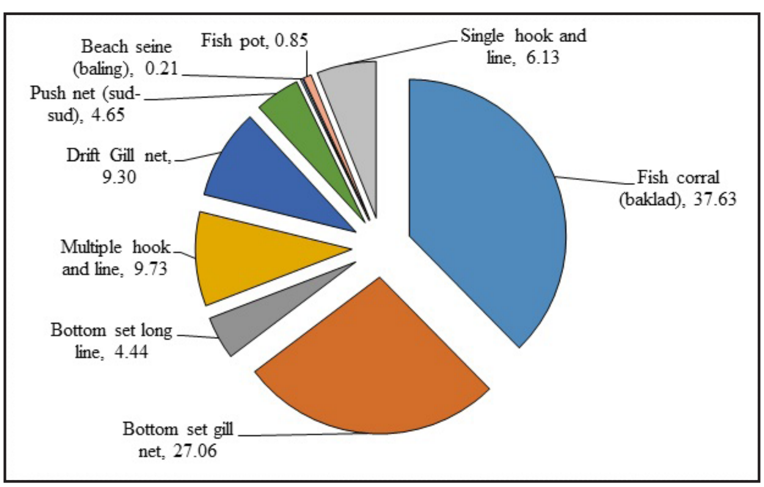

Figure 4. Percent composition of major fishing gears in the bay recorded from 2017 to 2018.

coastal municipalities in the Panguil Bay from 2017 to 2018. The species composition included finfishes, crustaceans, and mollusks belonging to families Ariidae, Leiognathidae, Clupeidae, Ambasssidae, Mugilidae, Sillaginidae, Siganidae, Teraponidae, Engraulidae, Mugilidae, Lutjanidae, Penaeidae, Portunidae, Loliginidae, Veneridae, Donacidae, and Mytilidae (Table 4).

Crustaceans and molluscs associated with *A. maculatus* catch were also present in the landed catch survey. The species of crustaceans (*Penaeus merguiensis, Scylla tranquebarica, Penaeus monodon, Metapenaeus ensis, Penaeus indicus, Scylla serrata and Scylla olivacea*) and species of molluscs such as squid, Asian hard clam, Wedge clam, Brown mussel and Surf clam (Table 4) were found. Among them, *S. tranquebarica* was recorded to have a large quantity of catches.

3.2.1 *A. maculatus* harvest estimates

Figure 5 shows the estimated total fish harvest of Panguil Bay. There was an increasing fish harvest from 177.8 MT to 763.8 MT in 1991 to 1996, however,

Table 4. Species composition caught in Panguil Bay recorded from 2017 to 2018.

No.	Scientific name	Family	English name	Local name
	FINFISHES			
1	*Arius maculatus* (Thunberg 1792)	Ariidae	Spotted catfish	Ito
2	*Leiognathus equulus* (Gunther 1874)	Leiognathidae	Common ponyfish	Sap-sap
3	*Sardinella lemuru* (Bleeker, 1853)	Clupeidae	Sardines	Tamban
4	*Ambassis* sp. (Lacepede, 1802)	Ambasssidae	Asiatic glass fish	Ibis
5	*Valamugil cunnesius* (Valenciennes, 1836)	Mugilidae	Mullet	Agwas
6	*Sillago sihama* (Forsskal, 1775)	Sillaginidae	Silver sillago	Aso-os
7	*Siganus* sp. (Park, 1797)	Siganidae	Rabbit fish	Danggit
8	*Terapon jarbua* (Forsskal 1775)	Teraponidae	Tiger Perch	Buga-ong
9	*Stolephorus* sp. (Lacepede, 1803)	Engraulidae	Anchovy	Bolinaw
10	*Mugil cephalus* (Linnaeus, 1758)	Mugilidae	Flathead grey mullet	Gisaw
11	*Siganus guttatus* (Bloch 1787)	Siganidae	Goldenlined spinefoot	Kitong
12	*Lutjanus* sp. (Cuvier, 1828)	Lutjanidae	Snapper	Maya-maya
	Others *Crustacean*			
13	*Penaeus merguiensis* (De Man, 1888)	Penaeidae	Banana shrimp	Bagalan
14	*Scylla tranquebarica* (Fabricius, 1798)	Portunidae	Purple mud crab	Lawodnon
15	*Penaeus monodon* (Fabricius, 1798)	Penaeidae	Jumbo tiger shrimp	Pansat
16	*Metapenaeus ensis* (De Haan, 1844)	Penaeidae	Greasy back shrimp	Putian
17	*Penaeus indicus* (H. Milne Edwards, 1837)	Penaeidae	White shrimp	Pasayan
18	*Scylla serrata* (Forskal, 1775)	Portunidae	Giant mud crab	Bulik
19	*Scylla olivacea* (Herbst, 1796)	Portunidae	Orange mud crab	Pula
	Mollusk			
21	*Architeuthis* sp.	Loliginidae	Squid	Nocus
22	*Meretrix meretrix* (Linnaeus, 1758)	Veneridae	Asian hard clam	Burnay
23	*Donax* sp. (Linnaeus, 1758)	Donacidae	Wedge clam	Agihis
24	*Modiolus metcalfei* (Hanley, 1843)	Mytilidae	Brown mussel	Amahong
25	*Katylesia hiantina* (Lamark, 1818)	Verenidae	Surf clam	Punaw

fish harvest declined to 535.6 MT in 2005, (Jimenez et al. 2009). The survey in 2017-2018 recorded a total catch of 4.2 MT of fish and 0.3 metric tons of invertebrates associated with *A. maculatus* catch. The estimated total harvest of *A. maculatus* in Panguil Bay is more or less 1.5 MT/year or 26% of the estimated total fish harvest from March 2017 to March 2018.

3.2.2 Dominant species

The 10 major species caught in the bay were *A. maculatus, Sardinella melanura, gulama, Lutjanus* spp., *Valamugil cunnesius, Muraenesox* spp., *Stolephorus commersonii, Siganus* spp., and *Leiognathus equulus* (Figure 6). The figure shows that *A. maculatus* is a dominant fish catch which consist of 34% of the total fish harvest in the bay.

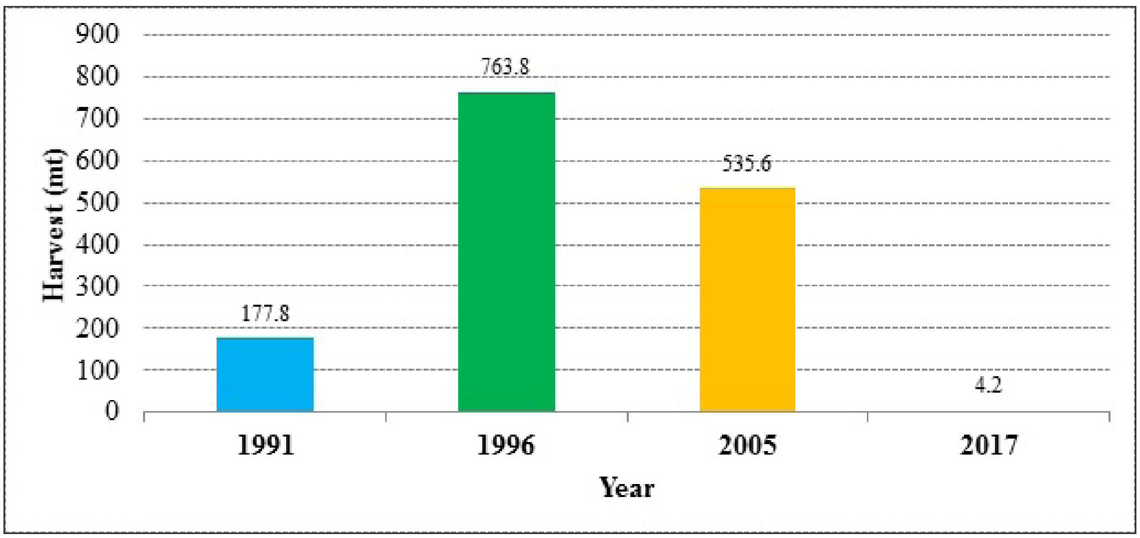

Figure 5. Fish harvest trend of Panguil Bay recorded in 1991, 1995-1996, 2005 (Jimenez et al. 2009) and 2017 (this study).

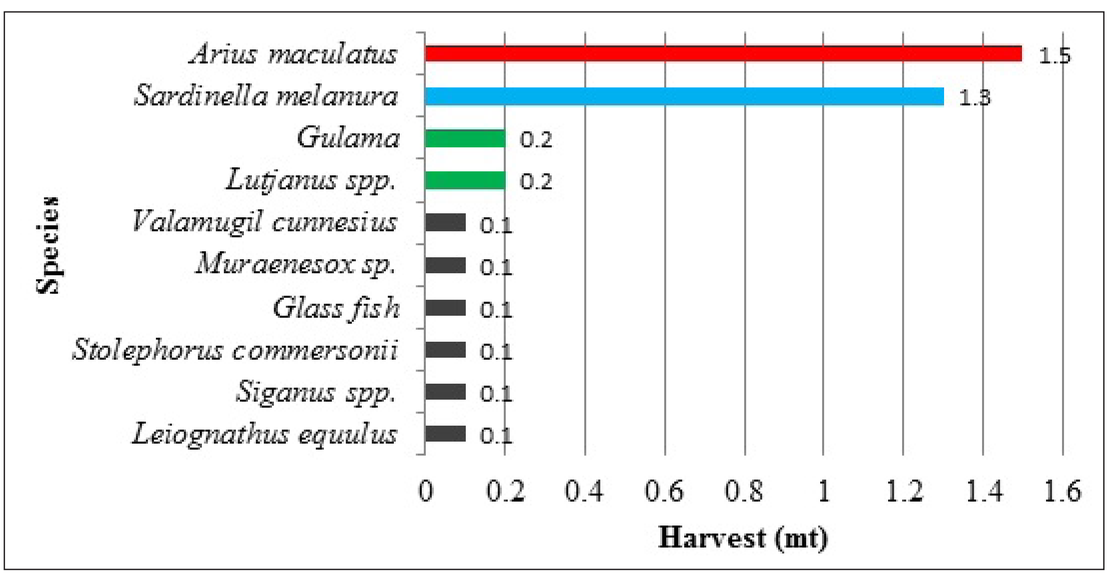

Figure 6. Relative abundance of major species caught in sampling areas in Panguil Bay from 2017 to 2018.

3.2.3 Catch per unit effort

The catch per unit effort (CPUE) of the major fishing gears in the bay shows that fish corral had an annual catch of 204.2 kg; bottom set long line, 74.9 kg; bottom set gill net, 49.0 kg; and multiple hook and line 3.5 kg (Table 5). Among the 4 major fishing gears, fish corral had the highest annual catch in the month of September. However, bottom set long line observed to have a year round catch among the gears. In addition, the annual catch per unit effort was decreasing from 70.1 kg in September 2017 to 2.0 kg in January-March 2018 combining all the gears associated in fishing of *A. maculatus* (Fig. 7).

3.3 Estimates on the growth, mortality parameters and exploitation rates

The L_∞ is the mean length of the fish in the population that will be reached if they grow indefinitely. In a previous study, the L_∞ of A.maculatus was L_∞ = 34.4 cm with the growth constant k= 0.28, total mortality, natural mortality, fishing mortality and the exploitation ratio were 1.29, 0.86, 0.43, and 0.24 respectively (Chu et al.2011). This past study was conducted in Yunlin, Southwestern Taiwan, and the data (*A. maculatus*) that the authors analyzed were from fish that were caught using bottom trawling only. In contrast, the length-frequency data of *A. maculatus* caught by combined bottom set gill net, bottom set long-line, multiple hook and line, and fish corral from 2017 to 2018 in Panguil Bay yielded an estimated range of L_∞ 98.86 with the growth constant k=0.35. The total mortality (*Z*) obtained 0.99, natural mortality (*M*) is 0.67, and fishing mortality (*F*) is 0.33. The exploitation rate (*E*) was estimated at 0.33. The estimated exploitation rate (i.e., <0.5) imply that fishing is still within sustainable levels. (Figure 8).

Table 5. Catch per unit effort (kg/mo) in sampling areas by major fishing gear associated in fishing *A. maculatus*, recorded in 2017 to 2018.

Mean CPUE (kg/month) in sampling areas														
Fishing Gear	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	∑	Mean
Fish corral	3.0	0.1	18.0	44.4	9.4	48.8	59.2	9.2	6.1	39.5	0.0	0.0	2.5	240.2	18.5
Bottom set gill net	1.3	2.7	1.5	4.3	3.3	6.8	6.2	10.1	6.1	2.0	2.0	1.4	1.3	49.0	3.8
Bottom set long line	5.5	5.7	8.1	5.4	5.9	4.2	4.7	10.4	7.2	11.8	0.0	3.4	2.6	74.9	5.8
Multiple hook and line		1.9		0.6	1.0									3.5	0.3

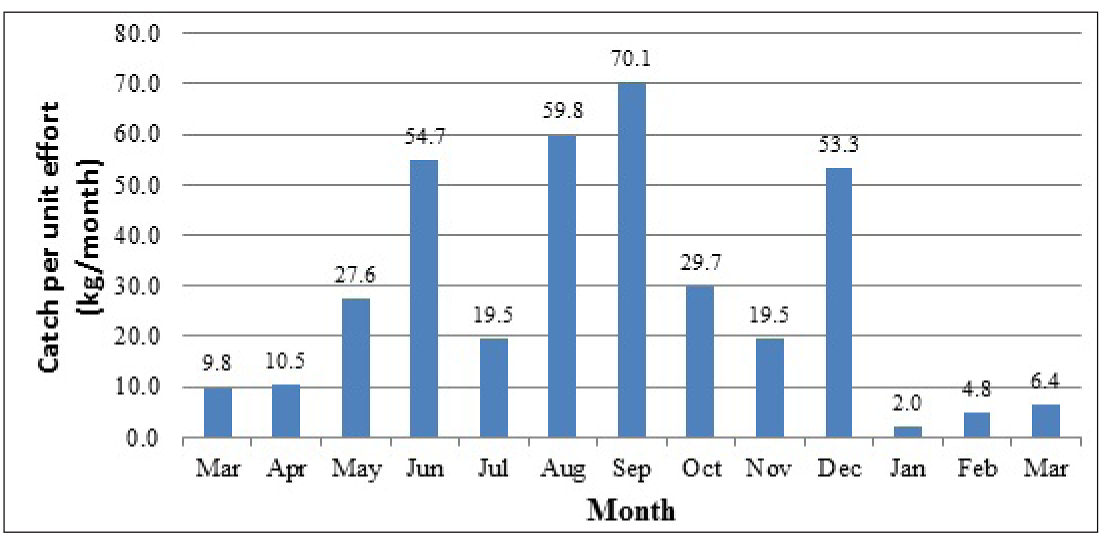

Figure 7. Catch per unit effort (combined for all gears) in sampling areas recorded from 2017 to 2018.

3.4 Reproductive biology

3.4.1 Sex ratio

In this study, males usually outnumbered females of *A. maculatus* collected in Panguil Bay (actual fishing/sampling, once a month). A total of 219 specimens were caught which consisted of 44 females and 175 males. The size of male *A. maculatus* ranged from 6.1 to 68 cm while females ranged from 11 to 98.77 cm. The sex ratio of male to female for the entire year was 3.98:1 (Table 6). The results indicate that in the months of December and January, the sex ratio (1.06:1 and 1:1.5) of *A. maculatus* is generally equal.

3.4.2 Gonado-somatic index

The monthly mean gonadosomatic index (GSI) values of female *A. maculatus* ranged from 10.00 to 14.02, with the lowest GSI value recorded in January and April, and the highest in March; 12.41 to 16.57. Only one male specimen of *A. maculatus* had a GSI value of 9.98. The specimens were mostly immature starting April and the peak month is in January. As a result, the data collected from actual sampling GSI showed correlation with maturation of gonad (Figure 9).

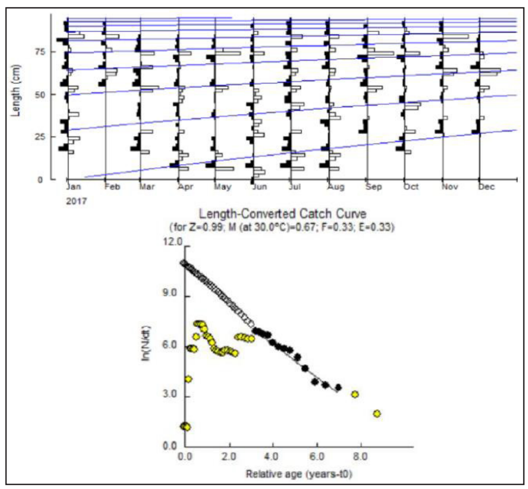

Figure 8. Length-frequency and length-converted catch curved (Gayanilo et al. 1997) (Gayanilo and Pauly 1997) of *A. maculatus* in Panguil Bay.

Table 6. Monthly variation in sex ratio of *A. maculatus* in Panguil Bay Philippines (collective data from 2017 to 2018).

Months	Male	Female	Total	F:M
March	3	1	4	3:1
April	11	1	12	11:1
May	44	1	45	44:1
June	21	0	21	21:0
July	16	0	16	16:0
August	9	0	9	9:0
September	44	10	54	4.4:1
October	0	0	0	0:0
November	7	3	10	2.3:1
December	18	17	35	1.06:1
January	2	3	5	1:1.5
February	0	8	8	0:8
March	0	0	0	0:0
Total	175	44	219	3.98:1

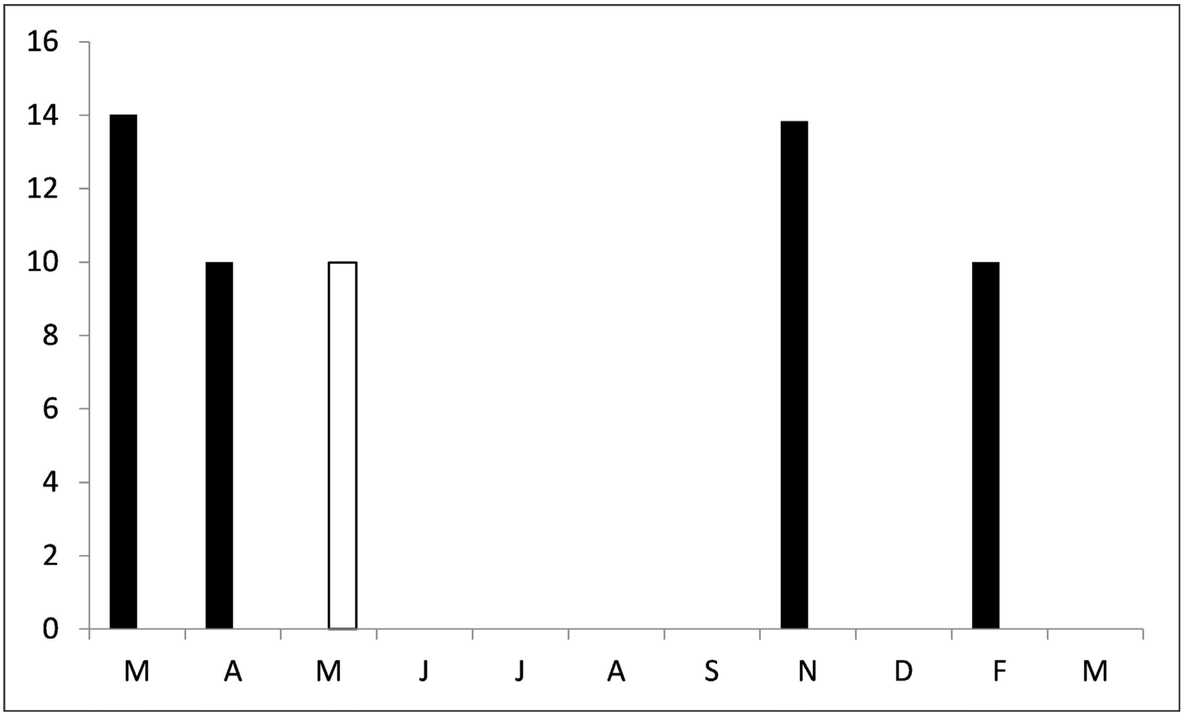

Figure 9. Monthly gonadosomatic index (GSI) of female (solid bar) and male (open bar) specimens of A.maculatus.

3.4.3 Gonadal maturity determination and spawning season

Monthly observation of the gonad maturity stages of the male and female gonads from 2017-2018 shows that immature or stage I *A. maculatus* can be seen throughout the year (Figure 10a and 10b). Mature/spawning male and female (Stage III) *A. maculatus* were recorded in January. Results revealed that the spawning starts from January to March, consistent with our FiSAT length-frequency analysis output (Figure 8).

3.5 Physico-chemical Parameters

Physico-chemical parameters recorded from the two sampling sites in Panguil Bay showed that the ranges of water quality parameters at the sampling sites were 7.95-8.17 for pH, 28.5°C-29.1°C for temperature, 13.31-15.9 ppt for salinity, and 4.0-5.41 ppm for dissolved oxygen. During sampling months from March 2017 to May 2017 the YSI Pro20 oxygen meter was not working, so there were no dissolved oxygen data on the said months (Table 7).

4. DISCUSSION

The total sample size and the sampling period affect the results of the length-frequency analysis (Hoenig et al. 1987). It is, therefore, suggested that the total sample size should include at least 1,500 specimens to get an accurate estimation of the growth parameters by using the length-frequency analysis. In this study, the total sample size was 3,259 specimens, thus this dataset is believed to be more than enough for length-frequency analysis. A comparison on the previous study conducted by Chu et al. (2011) showed that the L_∞ (34.4 cm) they obtained is lower than in the present study (L_∞ 98.86 cm). In addition, the exploitation rate (E = 0.33) in this study did not exceed the desired exploitation value of 0.5 (Chu et al. 2011). With regard to the spawning period, this study found that eggs start to mature from October to December, which signifies that the spawning period will be from January to March, and fish fry recruitment will be in April and May. An earlier study reported that spotted catfish only breeds once a year with a prolonged spawning season between January and April off the Bombay coast and during the periods of September and October off the Karnataka coast in India (Jeyaseelan 1998). The spawning mode of *A. maculatus* was periodic, although the individual fish of the

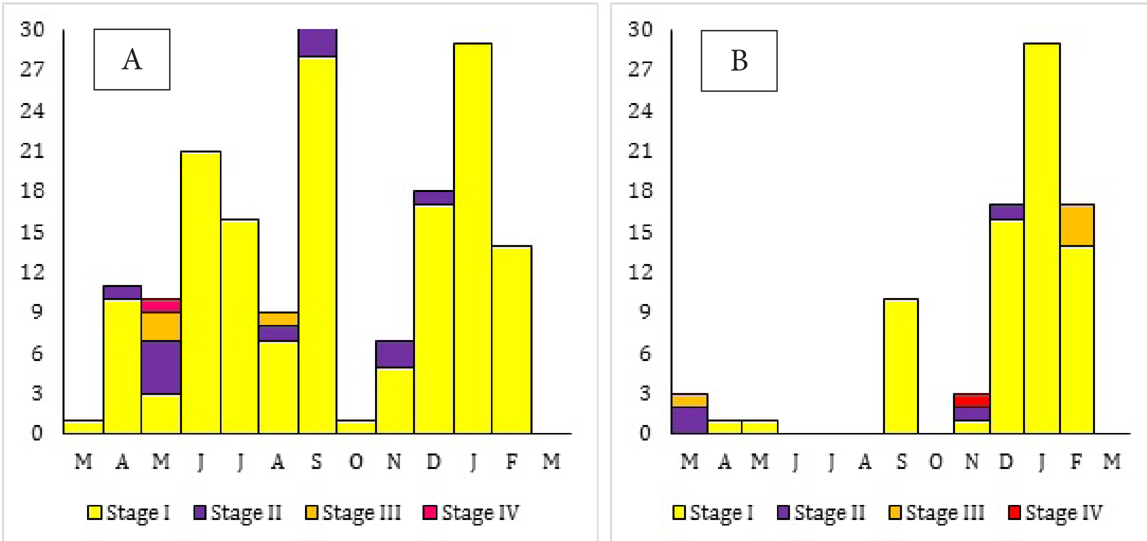

Figure 10. Monthly variation of gonad maturity stages of male (A) and female (B) *A. maculatus* collected from 2017 to 2018.

Table 7. Physico-chemical parameters recorded in 2017-2018 from the sampling sites of *A. maculatus* in Panguil Bay

Station	Month	Dissolved Oxygen (ppm)	Salinity (ppt)	pH	Temperature (oC)
	Mar /17	0	21	7.6	29.5
	Apr	0	21	7.6	30.1
	May	0	10	6.6	30
	Jun	0	19	8	28
	Jul	8.78	15	7.9	29
	Aug	6.1	9	8.3	28.6
Baroy, Lanao Norte	Sept	5.89	19	8.4	30
	Oct	8.74	15	7.9	29
	Nov	8.1	14	7.7	29
	Dec	7.31	16	8.3	29.9
	Jan	6.39	15	8.3	28.2
	Feb	7.1	18	8.4	28.6
	Mar/18	7	15	8.3	28.6
	Mar/2017	0	21	8	28.8
	Apr	0	21	8.2	29
	May	0	13	7.7	30
	Jun	0	18	8	29
	Jul	7.8	5.5	7.6	29.8
	Aug	5.6	10	8.3	28.7
Tangub City	Sept	6.15	20	8.2	30
	Oct	7.15	17	8.3	28.3
	Nov	7.09	18	8.3	27.9
	Dec	8.1	14	7.7	29.3
	Jan	7.6	12	8.3	29
	Feb	5.3	7	8.2	28.8
	Mar/18	4.9	5	8.2	28.2

species breeds only once a year; a different population of the species seems to breed almost all year round. Therefore, the inference of a spawning season that appears in this study is reasonable. The results of this study provide detailed life history parameters such as growth parameters, total mortality, natural mortality, fishing mortality, and reproductive biology for the spotted catfish in Panguil Bay. Moreover, this study provide physico-chemical parameters of the Panguil Bay such as pH, D.O., temperature, and salinity, which are very important factors to determine the growth of Spotted catfish.

A. maculatus is not a commercial species in Philippines, however, the fishing mortality is slightly high (F = 0.33 per year). In this study, this fish is a predominating species: it makes up 39.5% of the total catch composition, which means that *A. maculatus* is a major bycatch species in the bay.

5. CONCLUSION

The assessment revealed that *A. maculatus* in Panguil Bay has relatively low fishing pressure and appeared not to be overexploited given the estimated exploitation rate of 0.33, and large individuals can still be collected from the study sites. *A. maculatus* in Panguil Bay can grow up to 98.95 cm, maximum observed length with an asymptotic length of 98.86 cm with an equivalent asymptotic weight of 8,750 g. We propose that other aging methods, such as ring counting of hard tissue, should also be conducted to further validate the growth parameters of this species in the future. In addition, the increasing number of fish corral in the bay can be assessed given its potential effect on the fisheries resources in the study area in the future.

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