BIODIVERSITAS
Volume 17, Number 2, October 2016
Pages: 679-686

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d170242

Biological characteristics on three demersal fish landed in Tegal, north coast of Central Java, Indonesia

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Manuscript received: 20 April 2016. Revision accepted: 26 August 2016.

Abstract. *Nugroho D, Patria MP, Supriatna J, Andrianto L. 2016. Biological characteristics on three demersal fish landed in Tegal, north coast of Central Java, Indonesia. Biodiversitas 17: 679-686.* Java Sea has a potential marine biodiversity that has been harvested since years. Demersal fish resources is one of the targeted species by Danish seine fisheries operated in North coast of Java. To support on developing conservation and management measures, an observation on species composition, length frequencies and maturity stages were carried out during August 2014 to July 2015. Sampling took place in landing place of Tegalsari fishing port central Java. A total 129 fish species identified, among them 91 species were targeted as edible fish. Sampling on three dominant species i.e., Purple-spotted bigeye *Priacanthus tayenus* (Richardson, 1846), Lattice monocle bream *Scolopsis taenioptera* (Cuvier, 1830) and goatfish *Upeneus sulphureus* (Cuvier, 1829) were measured regarding length, weight and their maturity stages. The results shows that length-weight relationship for each species were *P. tayenus* $W = 0.0324 L^{2.7321}$, *S. taenioptera* $W = 0.0366 L^{2.7262}$ and *U. sulphureus* $W = 0.038 L^{2.7312}$. Monthly average GSI of *P. tayenus* and *S. taenioptera* indicated that the highest index occurred during SE monsoon while *U. sulphureus* on NW monsoon. Maturity stage analysis indicated that estimated of length at first maturity (L_m) were at 12.9 cmFL (*U. sulphureus*), 16.8 cmFL (*S. taenioptera*) and 19.4 cmFL (*P. tayenus*). Size frequency distribution shows that most of the fish were caught at immature cohorts. The diversity or evenness indices of ichtyofauna is also described as descriptors of community structure and be complemented with information on biological characteristics of those dominant species.

Keywords: Demersal fish, dominant species, biological characteristics, north coast, Java

INTRODUCTION

Knowledge on nature and function on marine fish diversity including its biological characteristics could help to provide baseline information for long-term suitable ecosystem base for fisheries management. Utilization of marine biodiversity is the oldest impact on the ocean environment by humans. Widespread developments of fisheries become the major issues on ecological impact to marine biodiversity. Java Sea is one of vast shallow water (<100 m) that significantly contributed on demersal fish production among fisheries management areas in Indonesia. Broad range of pelagic, demersal and benthic fish community existed in the area. Three dominant demersal of fish species i.e. of purple-spotted bigeye *Priacanthus tayenus* (Richardson, 1846), lattice monocle bream *Scolopsis taenioptera* (Cuvier, 1830) and goatfish *Upeneus sulphureus* (Cuvier, 1829) play a significant role in demersal fish landing in north coast of Java. Those are the common species caught by demersal Danish seine fishery for years. The aim of this study is to describe the diversity index and the biological characteristics of three dominant species. Regular observation was conducted during August 2014 to July 2015 in Tegalsari fishing port, Tegal City, Central Java, Indonesia. The result showed that the catches consisted of 76 families, 101 genus and 129 species in landing place. Among them, 91 species were categorized as edible fish and others were indirectly served as fishmeals. Data on length, weight, stage of maturity of each species were measured on monthly bases. Other measurements on catch composition were also observed to provide a good understanding of ecosystem functioning. Three combine species contributed at around 55-60% of the total demersal fishes. Understanding diversity index and the reproductive biology of major species that under fishing pressures are the critical aspect of providing sound scientific advice for fisheries management. Knowledge on reproductive biology will largely determine the productivity of a stock and its resilience to exploitation.

MATERIALS AND METHODS

Sampling site

The sampling site was in Tegalsari fishing port with a geographical reference of 6°50'58.01" S-109° 7'43.74" E. It located in Tegal City, western part of north coast of Central Java, Indonesia (Figure 1). Regular sampling from commercial drag wooden demersal Danish seiner (trawl like fishing gear) was collected during August 2014 to July 2015. The fleet size ranged from 10-30 GT, completed with fish net of 18-27 m length of head rope and cod end of ¾ inch mesh size. The gear operated at the bottom of the shallow water of the Java Sea. Sample were collected from selected fleets that landing during the date of observation. Selected samples were taken into the mini field laboratory in polyethylene bags containing ice blocks to prevent deterioration. A total of 2038 fish specimens (688 *P. tayenus*, 587 *S. taenioptera* and 763 *U. sulphureus*) belong to 3 families of (Priacanthidae, Nemipteridae and Mullidae) were systematically observed.

Procedures

Species were identified by using FAO Species catalog (Carpenter and Niem 1999). Sampling protocol was adopted from Sparre and Venema (1998) and Sparre (2000). Measurements were carried out based on one box (25-30 kg) sample of each group of species then subsample in weight around 5 kg or in number of 100 specimens. Individual specimens processed in temporary field laboratory and the following measurements made for fork length (cmFL), body weight (g), gonad weight (g) and sexual determination. Catches from 10 commercial fishing boats (< 6 m LOA) representing fishing activities in near shore fishing areas (< 12 nmi or around 20 m depth) and other 10 boats with > 6 m LOA representing off shore fishing (>12 nmi) were recorded. Catch composition were obtained based on the landing volumes. The catch was first standardized by trip, then dividing the total weight of fish species caught by the total weight of all species. Diversity index were measured through proportion of its catch composition. The species grouped at genera level then sub-sampled into species. Fork length (cm) of each fish was measured from the tip of the mouth (mouth closed) to the middle of caudal fin using a standard measuring paper. Body weight was measured to the nearest gram using top model digital balance. Accuracy of 0.01 g and measured to 0.1 cm were applied. Maturity stages were macroscopically observed.

Maturation and spawning characteristics were observed by conventional methods. Different color levels and percent of abdominal cavity occupied by gonads were used to identify their stage of maturity. The stages were marked as resting, developing, ripe, spawning and spent according generic scale of maturity stages by King (1995). The stages were identified into immature (stage 1, II) and mature (stage III, IV, V) as presented in Table 1.

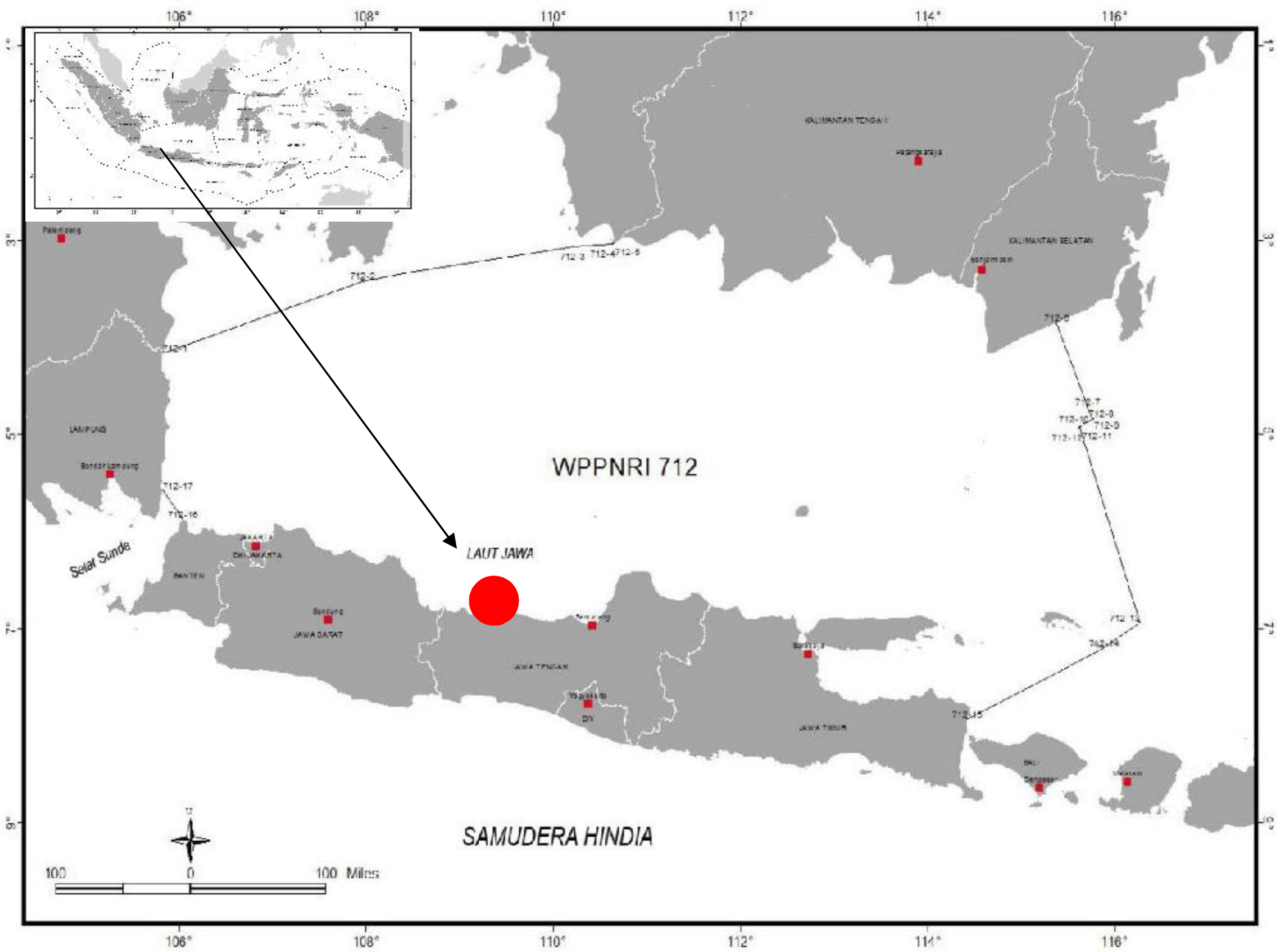


Figure 1. Tegal, north coast of Central Java, Indonesia (6°50'58.01" S-109° 7'43.74" E). Note: ● site location

Table 1. classification on ovary development stage

Stage	Description	Ovary	Eggs
I	Resting	Undeveloped, small, translucent	None visible to naked eye
II	Developing	Opaque, orange color	Visible and opaque
III	Ripe	Fills body cavity	Translucent, large and round
IV	Spawning	Release eggs when pressed	Large, translucent, some free ovary
V	Spent	Shrinking/slack	Some residual eggs

Data analysis

Diversity of fish were estimated based on catch data by group of species. Data standardized into kg per each haul. The presence of taxa in each tow was used to derive species richness (S) that defined as the cumulative number of taxa found in a given number of tows. Species evenness was expressed by Pielou's index (Heath and Speirs 2012) as follows:

$$J = \frac{H'}{\ln(S)} J = \frac{H'}{\ln(S)} \quad \text{..........................} (1)$$

Where, H' is the Shannon-Wiener diversity index:

$$H' = \sum_{i=1}^{s} p_i \ln(p_i) H' = \sum_{i=1}^{s} p_i \ln(p_i) \quad \text{...........} (2)$$

and

$$p_i = \frac{B_i}{\sum_{i=1}^{s} B_i} \; p_i = \frac{B_i}{\sum_{i=1}^{s} B_i} \quad \text{....................} (3)$$

Where, B_i is relative biomass of each genera. The indices expressed in terms of biomass (weight) and not in terms of number of individuals.

Data on length and weight by species were graphically plotted in scattered diagram while the relationship (LWR) was estimated using the equation of Ricker (1975).

$$W = aL^3 \quad \text{.......................} (4)$$

Where, length (L) in cm and weight (W) in gram. The data were converted into linear equation by using logarithmic expression of Ln W = Ln a + b Ln L. Parameters a and b were calculated by least square regression. The b value for each species is close to 3 in isometric growth and tested by t-test to verify if significantly different from 3 and a is a constant determined empirically.

Fulton condition factors (K) is also the parameters used in fisheries research and closely related to LWR. The value of K is calculated as follows (Froese 2006):

$$K = W/L^3 * 100 \quad \text{.......................} (5)$$

Gonado-somatic index (GSI) is often used to follow the reproductive cycle of species over the year. The index, which assumes that an ovary proportionally increases in size and development stages compares the mass of gonad (Wg) with total mass of fish (W) were determined by following equation (King 1995) of:

$$GSI = 100 * (Wg/W) \quad \text{.......................} (6)$$

The percentages of each stage were shown in histogram. Stages of reproductive development indicated the appearance of ovary and eggs. Empirical equations were applied to length at sexual maturity of those three interested species. The proportion of length of first maturity was derived following equation (King 1995) of:

$$P = \frac{1}{(1 + \exp(-r(L - L_m)))}$$

$$P = \frac{1}{(1 + \exp(-r(L - L_m)))} \quad \text{.......................} (7)$$

Where, P is proportion of sexual mature individual by length (L), r is the slope of the curve; Lm is the mean length at first sexual maturity.

RESULTS AND DISCUSSION

General condition

Observation during August 2014 to July 2015 showed that the species composition landed by demersal Danish seine predominantly by group of small size species. The fleets operated in wide range of depth. Fishing were done during the daylight with 6 to 8 hauls per day. Active fishing day at about 14 to 30 days per trip. In general, the proportion of large fish species was relatively low in number and weight. The landing of group of species with an average weight of more than 200 gram per individual (Losse and Dwiponggo 1977; Beck and Sudradjat 1978) were less than 5%. A group of small size species belong to genera *Priacanthus* spp., *Nemipterus* spp. and *Upeneus* spp. were the major contribution of each daily landing. Among them, purple-spotted bigeye *P. tayenus*, lattice monocle bream *S. taenioptera* and goatfish *U. sulphureus* were the major (55-60% by biomass) species landed in Tegalsari fishing port.

Species diversity

The species caught in different scale of distance from the shore. A simple count of species was applied for measuring diversity to yield species richness value for assemblage in area of interest. Diversity were particularly analyze to the ichtyofauna landed by the demersal Danish seine net. Other group of elasmobranch and cephalopods were also contribute in their harvesting as an unintended species but commercially accepted. The relationship between species landings and its diversity by monthly landing were determined by applying equations of species evenness and its diversity indexes. The result is presented in Table 2.

Table 2. Biodiversity index of demersal fish landed in Tegalsari fishing port (August 2014-July 2015)

Period of observations	2014					2015						
	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Inshore												
Species richness (S)	17	18	17	21	19	21	16	22	17	15	16	17
S index of diversity (H)	2.13	1.98	2.11	1.54	2.44	2.13	1.86	2.45	1.97	2.17	1.99	2.21
Species eveness (H'/ln (S))	0.75	0.68	0.74	0.51	0.83	0.70	0.67	0.79	0.70	0.80	0.72	0.78
Offshore												
Species richness (S)	30	37	33	34	31	35	34	32	29	27	31	31
S index of diversity (H)	2.39	2.33	2.48	2.50	2.40	2.59	2.55	2.49	2.21	2.39	2.44	2.43
Species eveness (H'/ln (S))	0.70	0.64	0.71	0.71	0.70	0.73	0.72	0.72	0.66	0.72	0.71	0.71

Note: S = Shannon-Wiener index

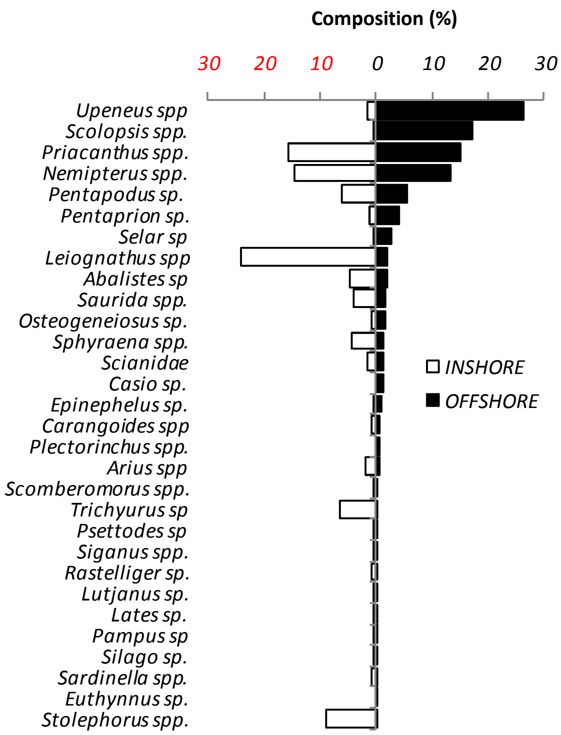


Figure 2. Catch composition of demersal by area inshore (*left*) and offshore (*right*)

The lower species richness (S) and its index of diversity (H) in the inshore waters were presumably due to the significance of fishing mortality in the area. The National capture fisheries data (DGCF 2015) indicated that the estimate fishing mortality were high represented by huge number of trawl and trawl like (demersal Danish seine) fishing boats of around 10,000 units in which 80% of them are harvesting in inshore waters of < 12 nmi or approximately at 20 m isobaths along the coast of north of Java. This results shows that all harvesting activities not only caused a direct impact on target species and species may related to ecological characteristics as stated by Cochrane (2002) but it could also affected the whole marine ecosystem including population structure, habitats, biodiversity and its productivity (Bas 2005).

Catch composition

Fishing affects the demersal fish communities through selective removal of target species, unintended species and habitat modification, resulting overall biomass in species composition and size structures (Bianchi et al. 2000). The catch composition in inshore waters was predominantly composed of small size Leiognathidae, i.e. *Secutor ruconius*, *S. insidiator*, *Leiognathus bindus*, *L. elongatus* and *Gazza minuta* at around 10.4% followed by larger *Leiognathus* spp. such as *L. splendens* and *L. equulus* (8.3%), *Priacanthus* spp. (particularly *P. tayenus*) and *Nemipterus* spp. (*Nemipterus japonicus*) 5%. The offshore waters were dominated by *Upeneus* spp. (particularly *U. sulphureus* at about 21%, *S. taenioptera* 14.7% and *P. tayenus* 12.2% (Figure 2). In relation to spatial distribution of the species, Ibrahim et al. (2003) found that *P. tayenus* and *S. taenioptera* in coastal waters of east Malaysia peninsula were distributed at depth of > 20m, while Silvestre and Pauly (1997) suggested that the three interested species distributed at > 10 m depth at coastal waters of Bangladesh. Uiblein and Heemstra (2010) in coastal waters of western Indian Ocean found that *U. sulphureus* inhabited the water of 20 to 60 m depth.

Size composition

The fish landed by this demersal fishery varied according to species. As many as 12969 specimens were measured for length frequency distribution during August 2014-July 2015 and 2038 specimens of those were observed for bio-reproduction data. Cumulative length frequency distribution during the observation indicated that *U. sulphureus* ranged at 5.5 to 16 cmFL, *S. taenioptera* at 9 to 26 cmFL, and *P. tayenus* at 7 to 30 cmFL with mean length of each subsequent species approximately at 11.2, 18.9 and 17.1 cmFL. These data indicated broad range of size occurred at juvenile to adult stages. Adopting the estimate length at first maturity of each species (see Figure 7), the size composition of catch are a sign of immature cohort except for *S. taenioptera*. The graph (Figure 3) indicates that 68% size distribution of *P. tayenus* and 79% of *U. sulphureus* were belong to immature cohort while for *S, taenioptera* at about 24.7%.

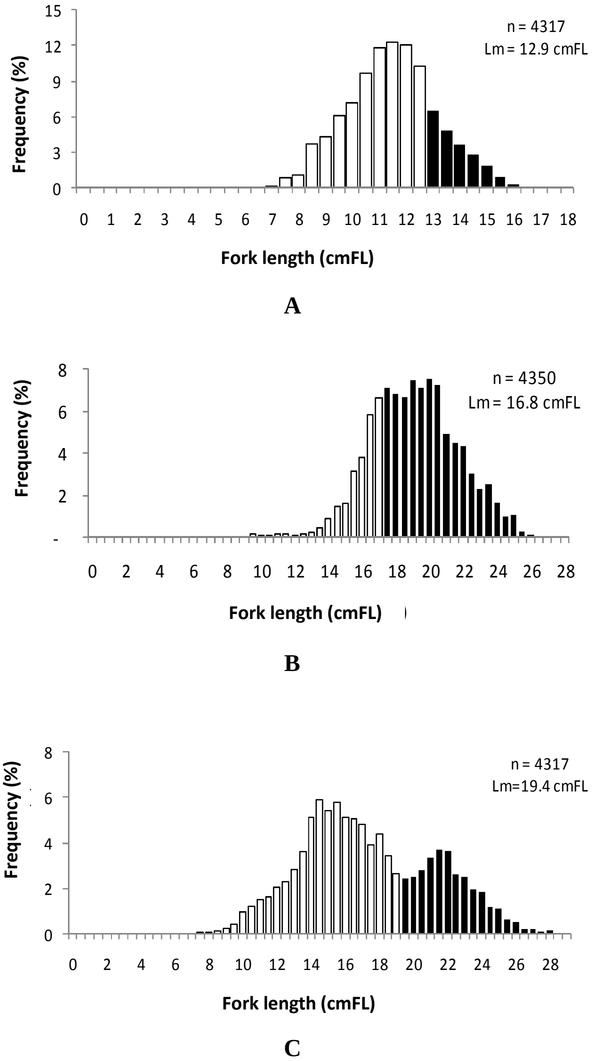


Figure 3. Length frequency distribution of A. *U. sulphureus*; B. *S. taenioptera*; C. *P. tayenus.* Note: Blank bar represented distribution under size of Lm and black bar is larger than Lm. Lm = estimated length at first maturity

Length-weight relationship

Length weight relationship (LWR) is of great importance in fishery assessment (Haimovici and Velasco 2000). Length and weight measurements, in conjunction with age, could contribute information on catch composition, age at maturity, life span, mortality, growth and reproduction (Diaz et al. 2000). A total number of 688 specimens of *P. tayenus, S. taenioptera* and *U. sulphureus* were observed during August 2014 to July 2015. Three dominant species revealed significant portion on the exploitation. Fish body size and weight were measured on monthly bases. The fish size was relatively small as 5.5 cm FL (5.0 g) of *U. sulphureus* and as larger size of 29.8 cm FL of *P. tayenus*. All three species exhibited allometric negative ($b<3$) and the student t-test showed growth coefficient b (ranged of 2.671-2. 884; sb = 0.022-0.073; t-test t = 0.043-0.144; $p<0.05$) was significantly lower than the theoretical value of 3. This indicates negative allometric growth. Other study on length weight relationship on *P. tayenus* in Malaysian waters shows that $W = 0.0068\ L^{3.3525}$ (Awong et al. 2011), this difference probably due to different environment and its unequal fishing pressures as mentioned by selectivity at high rates of exploitation can radically alter the age/size structure and breeding structure of exploited populations. Overall growth parameters were positive and highly correlated (>0.90). Summary of length-weight relationship is presented in Table 3.

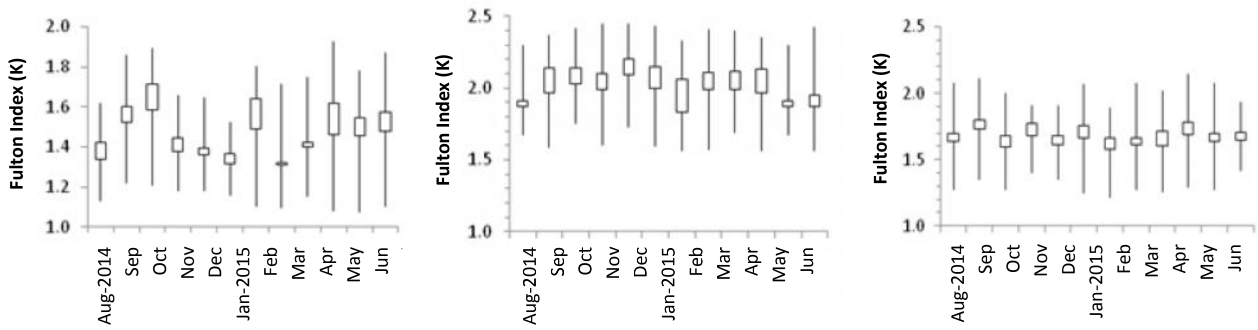
The Fulton condition factors (K)

The condition factor of fish (K) is part of its biological characteristics and it represents a quantitative healthiness parameter of fish in its habitat. It is based on the hypothesis that the heavier fish in a given length would represent the better physiological condition (Froese 2006). Figure 4 illustrates the distribution monthly values of K of each species. The lowest average monthly condition factors (1.3-2.1) were *U. sulphureus*, followed *P. tayenus* and the highest is *S. taenioptera*. Prihatiningsih et al. (2013) indicated that K value of *P. tayenus* in Banten Bay north

Tabel 3. Length and weight relationship for three species of *P. tayenus*, *S. taenioptera* and *U. sulphureus*

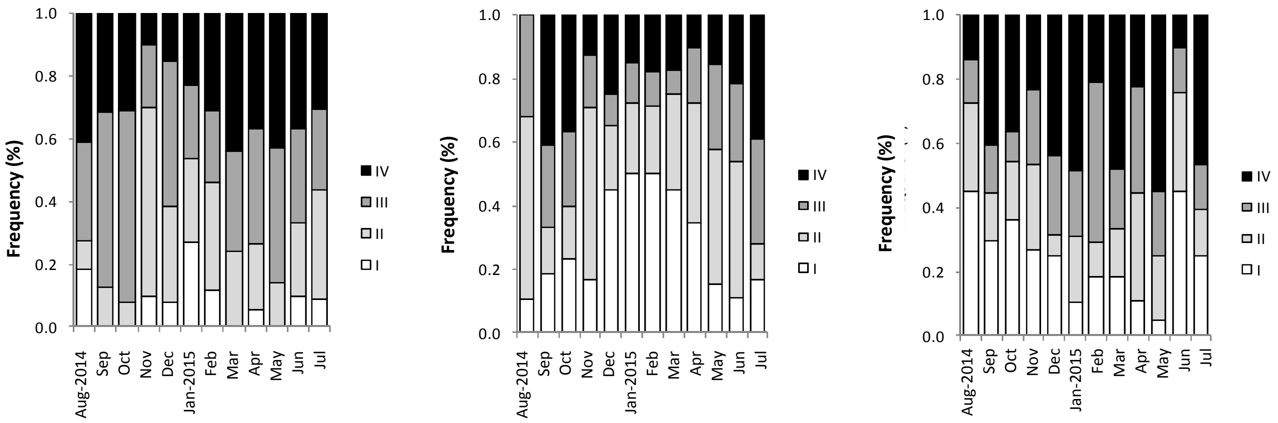
Family Species	Sex	n	Length (cmFL) Min	Max	Mean± SD	Body weight (g) Min	Max	Mean± SD	Growth coefficient a	b	r^2	sb	t-test	A/I
Priacanthidae	M	318	13.2	30.1	21.7±3.36	43	369	152.9±69.2	0.0270	2.788	0.93	0.044	0.086	A
P. tayenus	F	370	13.2	30.1	21.5±3.57	46	366	153.3±76.6	0.0259	2.808	0.94	0.038	0.074	A
	All	688	13.2	30.1	21.6±3.48	43	366	151.6±73.4	0.0201	2.884	0.93	0.029	0.056	A
Nemipteridae	M	157	14.7	25.4	20.3±2.50	52	263	141.5±47.7	0.0401	2.688	0.95	0.050	0.097	A
S. taeniopterus	F	428	11.5	25.5	18.5±2.42	35	255	108.1±42.1	0.0346	2.735	0.92	0.039	0.077	A
	All	585	9.1	25.5	19.0±2.60	21	263	117.2±46.1	0.0354	2.738	0.94	0.022	0.043	A
Mullidae	M	154	8.2	15.5	12.1±1.54	13	68	36.4±13.3	0.0390	2.722	0.91	0.073	0.144	A
U. sulphureus	F	471	8.2	15.9	12.4±1.47	12	72	37.9±12.1	0.0510	2.617	0.91	0.043	0.084	A
	All	763	5.5	15.9	11.9±1.80	5	72	34.5±13.8	0.0380	2.731	0.94	0.027	0.052	A

Note: M = Male; F = Female; A = allometric; I = isometric



A B C

Figure 4. Monthly average of Fulton condition factor index by species. A. *P. tayenus*, B. *S. taenioptera*, C. *U. sulphureus*



A B C

Figure 5. Monthly maturity stages of: A. *P. tayenus*, B. *S. taenioptera*, C. *U. sulphureus*

coast of west java at around 1.26, which is lower than this present observation. The K value is also used as a parameter to estimate fish body structures. In this study, the mean K values of those species varied on monthly basis. Le Cren (1951) and Gilliersa et al. (2006) suggested ecological condition of the habitat or variation in physiology of the animal or both are responsible for growth rate variation in the same species in different month.

Maturity stages

Monthly variation of its maturity indicated that highest proportion of immature specimens (I, II) of *P. tayenus* found in November to May while for *S. taenioptera* on occurred from December to April and for *U. sulphureus* occurred during June to August (Figure 5). The highest proportion of mature stage (III, IV, V) for *P. tayenus* occurred during March to October where as November-January intensity of reproduction is lower. For *S. taenioptera*, July-October is marked out by large number of fish ready for spawning (stage IV), and *U. sulphureus* occurred on December to March and May. These may indicate that the pattern of maturity stages for those species were almost in the same for *P. tayenus* and *S. taenioptera* and opposite pattern for *U. sulphureus.* In general all species have two peaks season for their spawning period (Figure 5). These might be related to typical spawning of tropical fish that regularly batch with peak season in certain period. Observation in east coast of Malaysia peninsula that *P tayenus* spawned throughout the year (Ambak 1987), while in Hongkong, only on a relatively short period from June to July (Lester and Watson 1985). Several general studies on fish maturation indicates that largely depends on a combination of age and length, long-term environmental changes including fisheries activities that alter the environment and population structures (Hunter et al. 2015).

Gonado-somatic index (GSI)

The monthly average GSI showed that two dominant species of *P. tayenus* and *S. taenioptera* relatively have similar trend with fluctuation in between, while *U. sulphureus* has an opposite trend that February to April tend to increase (Figure 6). The highest average GSI of *P. tayenus* found May to October, *S. taenioptera* on May to October and November to April for *U. sulphureus,* Highest index just prior to spawning period and it is relatively similar trends on the occurrence of macroscopic maturity stages (Figure 5).

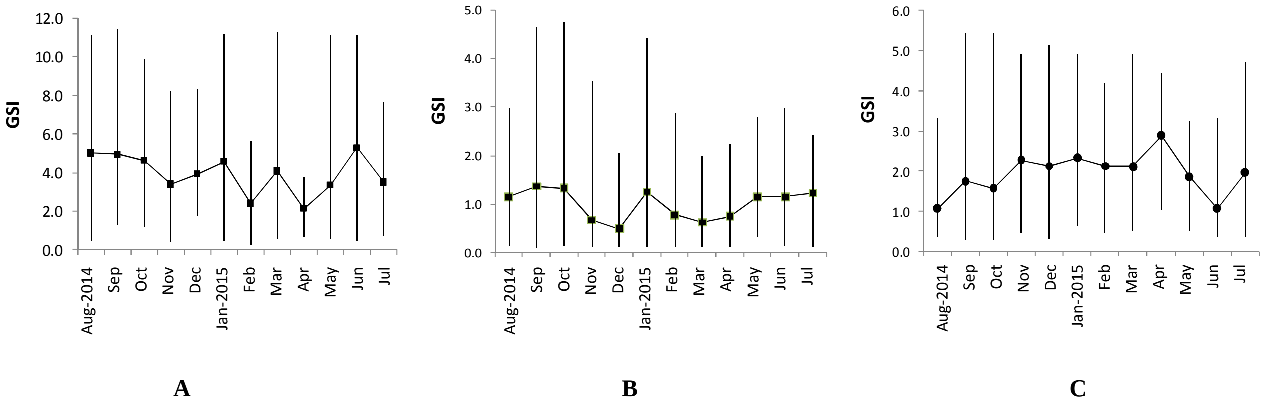


Figure 6. Monthly average GSI of three dominant species. A. *P. tayenus*, B. *S. taenioptera*; C. *U. sulphureus*

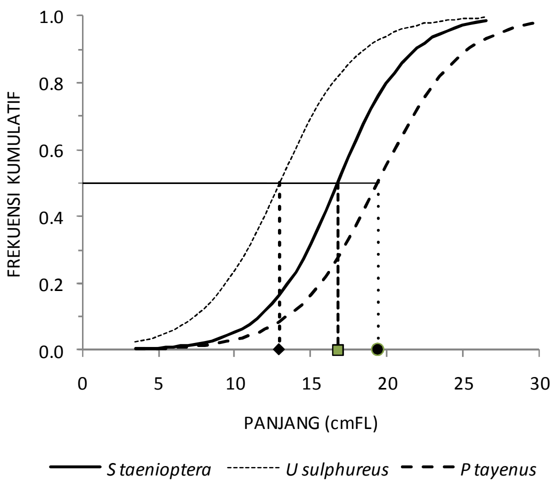


Figure 7. Estimated length at first mature of three species

Due to unclear threshold to distinguish between reproductive and non-reproductive season, there are some probabilities that intensive spawning period of *P. tayenus* occurred in May to October, *S. taenioptera* in May to October and longer period of November to April for *U. sulphureus*, while low-season of spawning occurred in February to April for *P. tayenus*, November to December for *S. taenioptera* and June to August for *U. sulphureus.*

Length at first mature

The percentage distribution of mature ovaries (stages III and above) in relation to length was plotted. This depicted the minimum length during sexual maturity for *U. sulphureus, S. taenioptera* and *P. tayenus* was at 12.9, 16.8 and 19.4cmFL (Figure 7). It is interesting that most of the size from these dominant species occurred in size of less than their length of first maturity. Observation on the average size of length combined with the estimated length at first mature indicated that most of the catches were on a stage before their regenerating age. Fishes always have a definite course of life history that often starts from hatching of eggs or life births in some few groups to larva stages, juveniles and the adults stages (Mustapha 2014). Following long historical harvesting on demersal fish in the area, yield of this marine fish species tend to be at high pressures. Nugroho and Atmaja (2014) explain that serial landing data on demersal Danish seine fishery harvesting near overfishing might occurred in the area. Lack of response on regular catch documentation scheme caused some difficulties on establishing the biodiversity impact of this existing harvesting strategy. A fundamental goal on sustaining biodiversity as part of conservation biology is to ensure the long-time survival of species (Meffe and Carol 1997; Primack 2006). However, these indicated that to sustain the long-term utilization of the diversity of the demersal fish, introducing an appropriate harvest strategy by using selective fishing gear should be implemented through government regulation.

Historically, the benefit for human wellbeing of harvesting marine biodiversity recorded since 1970s. Broad range of pelagic demersal and sedentary fish species existed in northern coastal waters of Java. The target species were shifted from large size demersal to small size group of species. These indicated that multispecies harvesting marine biodiversity occurred in the north coast of Java. Landing dominated by small size of fish and low trophic level fisheries. Size compositions were at broad range of juvenile to adult and most of the catches were belong to immature cohorts. Species richness in coastal waters were found at lower level than offshore, this would indicate that coastal ecosystem were already on pressure by fishing activity. Lower species richness remain that are not capable of sustaining abundant commercial catches in these local geographical area. Adopting the precautionary approach and using the bio-exploitation indicators of a general status of this fishery can be suggested at risk level. If further work has to be undertaken, an independent method would be valuable to clarify on rationale of the lower abundance of demersal fish in the area.

ACKNOWLEDGEMENTS

The authors wish to thanks to head of Tegalsari fishing port of Central Java, Indonesia and surveillance station who supports technical staffs during sampling period and providing temporary field wet laboratory. The authors also thanks to fishers and crews of demersal Danish seiners who shares the data during landing and distribution process.

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