Estimation of the utilization rate of fish resources in the northern coast of Java, Indonesia

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Abstract. Indonesia capture fishery potential is so abundant that it can be expected to become the leading sector of the national economy, therefore the potential must be utilized optimally and sustainably to increase public income and state revenues that lead to the welfare of the people. Fish resources on the northern coast of Java are in the Fisheries Management Area (FMA) 712. This study aims to determine the potential for sustainable, fishing effort and utilization level of fish resources on the northern coast of Java. Improving fishing technology will be related to the problem of fish stocks abundance, so it needs to be studied about the amount of stock abundance and determination of the Total Allowable Catch (TAC) in order to utilize the resources optimally while maintaining the stock preservation in nature. The method used to determine the level of utilization is to use the maximum potential sustainably according to the Schaefer model. The composition of fish resources on the northern coast of Java is small pelagic fish of 39%, big pelagic fish by 13%, demersal fish by 28%, 5% crustaceans, 12% mollusca, and coral reef fish 3%. The level of utilization of *Euthynnus affinis* is 1.092 and of *Rastrelliger* 1.108, which meansover-exploittion (fishing effort must be reduced) while of *Lutjanus bitaeniatus* is 0.704, *Caesionidae* is 0.7, *Portunidae* is 0.717 and *Teuthida* is 0.674 which are fully exploited (arrest effort is maintained with a strict monitor) from the government.
Key Words: fishing management area, fishing technology, Schaefer Method, TAC and MSY.

Introduction. One of the potential marine resources that have been long exploited by the population is the fishery resources. The Indonesian sea has a sustainable potential number of 9.931 million tons per year (Kepmen KP No. 47/2016). The potential for sustainability is the potential for fishing that still allows populations to regenerate so that the number of fish caught will not reduce the fish population. Based on international rules, the Total Allowable Catch amount is 80% of the sustainable potential or about 7.945 million tons per year. According to Dahuri (2010), the total allowable catch amount is 80% of the potential in order to be sustainable, with the knowledge then the profitability of the fishermen will be maximal.

The increasing of fish harvesting on the northern coast of Java is feared that will lead to overfishing or decreasing the number of catches in the next year. One step that needs to be done is to conduct stock assessments to determine the potential for sustainability, optimum efforts and utilization level of fish resources to remain sustainable and available in the future. The study of the sustainable potential and the level of utilization of fish resources in waters is very important to control and monitor the level of fishing exploitation carried out on these resources.

The level of fixed fishing effort can lead to the exponential decrease in indicators, where the rate of change as well as the value of the terminal depends on the level of business and the structure and function of society, as determined by the environment and the history of fishing (Piet & Jennings 2005).

Many models are used to estimate the magnitude of marine fisheries potentials: holistic models and analysis models. The holistic model considers a fish stock as a homogeneous biomass that does not care about the structure of the length and age of the stock, while the analytical model uses the length and age structure of the stock (Sparre et al 1996).

This study aims to determine the sustainability, the fishing effort and the utilization level of fish resources on the northern coast of Java. The benefits of this study are expected to provide information to the government on the potential for sustainability in the research area, what is the maximum number of catches allowed so the existing resources remain sustainable and as a consideration for the government to determine policies related to the utilization of fish resources.

Material and Method. The research was conducted at fishery ports on the northern coast of Java. This research was conducted from September 2017 to February 2018. The method used in this research was descriptive method. This research was performed by applying a theory to solve a particular problem. The theory used in this study was the Schaefer method used to estimate fish resources on the northern coast of Java. The data used was secondary data. The secondary data is derived from the report records of each fishery port and the Directorate General of Capture Fisheries.

The method of analysis used in this research is the potential analysis of fish resources.

Fish production. The potential of fish resources can be known from data and information on catches and fishing effort over the last 5 years using catch per unit effort (CPUE) or catch per capture. According to Sparre & Venema (1989), the formula used is:

$$CPUE = \frac{Catch}{Effort}$$

Where:

Catch(C) = Total catch (kg)
Effort(F) = Total fishing effort (trip)
CPUE = The catch per unit effort (kg / trip)

The CPUE value of the total catch (C) can be used for simple stock estimation. The model used for data that tends to be linear is the Schaefer model, with the following stages:

1) The relationship between the fishing effort (f) and the catch per unit of fishing effort (CPUE) is:
$$CPUE = a - bf$$

Where:
a = Intercept
b = Tilt (slop)
c = Catch
f = Attempts to catch

2) The relationship between the fishing effort (f) and the catch (c) is:
$$C = af - bf^2$$

3) The optimum effort is obtained by equating the first derivative of the catching effort with zero (C1 = 0), to obtain the formula:
$$C = a - bf^2$$
$$C^1 = a - 2bf$$
$$F_{opt} = \frac{a}{2b}$$

4) The maximum sustainable yield (MSY) is obtained by substituting the optimum effort value, so as to obtain:
$$C_{maks} = MSY = a^2/4b$$
$$C_{maks} = a\left(\frac{a}{2b}\right) - b\left(\frac{a^2}{4b^2}\right)$$
$$= \left(\frac{a^2}{2b}\right) - \left(\frac{a^2 b}{4b}\right)$$
$$= \left(\frac{2a^2}{2b}\right) - \left(\frac{a^2 b}{4b^2}\right)$$

$$MSY = \frac{a^2}{4b}$$

Based on the parameters of intercept a and slope b in mathematics can be searched using a simple linear regression equation, i.e. the equation Y = a + bx. The Surplus Production Model formulas it is only applied if parameter b is negative, meaning the addition of efforts to capture CPUE. On the other hand, if the calculation of the positive coefficient b is obtained, the calculation of the potential and the optimum capture effort need not be continued, it indicates that the addition of fishing effort is still possible to increase the catch (Sparre & Venema 1998).

Standardization of fishing gear. Generally in a water to catch a certain species of fish species can be used a variety of different fishing equipment. Regardless of the nature of the catch, the main or by-catch of a particular type of fishing equipment remains to be observed. According to Gulland & Rosenberg (1983) any fishing gear can catch various types of fish found in a fishing ground. Each fishing gear has different capabilities in catching a species of fish; therefore it is necessary to standardize the fishing effort first before determining the potential value of sustainable and optimum catching efforts in aquatic environments. The selection of a standard fish-scavenger can be based on the dominant or not of the fish catcher in an area. The ultimate goal of this method is to uniform fishing efforts as each fishing gear has different capabilities. The standard capture effort is expressed as the sum of all multiplication units between capture capabilities called the Fishing Power Index (FPI) in each year by the time unit of capture or by the number of fishing operations units. To determine the type of fishing equipment can be used as a standard is to see the value of the catch rate average (CPUE) of the largest fishing equipment or in other words the type of fishing equipment is the most dominant in waters. The formula used is as follows:

$$CPUE_s = \frac{C_s}{f_s}$$

$$FPI_s = \frac{CPUE_s}{CPUE_i}$$

$$StdEffort_i = FPI_i \times f_i$$

$$CPUE_i = \frac{C_i}{f_i}$$

$$FPI_i = \frac{CPUE_i}{CPUE_s}$$

$$StdEffort_s = FPI_s \times f_s$$

$$StdEffort_{total} = (\sum FPI_i \times f_i) + (FPI_s\ f_s)$$

Where:
C_S: The catch per year of standard fishing gear (kg);
f_s: The effort of catching per year of standard fishing gear (trip);
C_i: Catch per year other types of fishing gear (kg);
F_i: Attempts to arrest (effort) per year other types of fishing gear (trip);
CPUEs: catch per capture per year of standard fishing gear (kg/trip);
$CPUE_i$: catch per capture per year of other types of fishing gear (kg/trip);
FPI_s: Fishing Power Index (Fishing Power Index) standard fishing gear;
FPI_i: Fishing Power Index of other types of fishing gear;
$StdEffort_s$: Fish catching effort after standardization;
$StdEffort_i$: Other fishing gear after standardization;
Std $Effort_{total}$: Over all capture effort after standardization.

Estimation of utilization rate. The utilization rate of fish resources can be determined by calculating the proportion of total catches in a given year from the maximum sustainable production value (MSY). The formula of the utilization rate is:

$$\text{Level of utilization} = = \frac{C_i}{MSY} \times 100\ \%$$

Where:
C_i : Number of catches in year i;

MSY: Maximum sustainable yield (maximum sustainable production).

Result and Discussion. Production data of fish resources obtained from fishery ports located on the northern coast of Java consists of 1 Ocean Fishery Port (OFP), 5 Fishery Ports of Nusantara (FPN) and 16 Fishery Seaports. The development of fishery production on the northern coast of Java in the area of fisheries management (FMA 712) for six years (2011 - 2016) has been exposed annually. In 2011, total catches reached 861,711 tons, increasing annually until 2016 by 1,184,907, but in 2013 decreased by 1.4% and in 2014 occurred an increase of 5.4% (Table 1 and Figure 1).

Table 1

Production (tons) on the northern coast of Java

Province	*Year*					
	2011	*2012*	*2013*	*2014*	*2015*	*2016*
Banten	29.444	30.993	30.497	30.564	33.121	35.771
DKI Jakarta	180.198	219.836	209.733	226.060	289.214	312.351
West Java	168.012	176.744	190.198	188.055	192.137	207.508
Central Java	227.757	229.309	204.441	226.305	309.863	334.652
East Java	256.300	250.977	260.227	272.185	272.801	294.625
Amount	861.711	907.859	895.096	943.169	1.097.136	1.184.907

Source: Directorate General of Capture fisheries 2016.

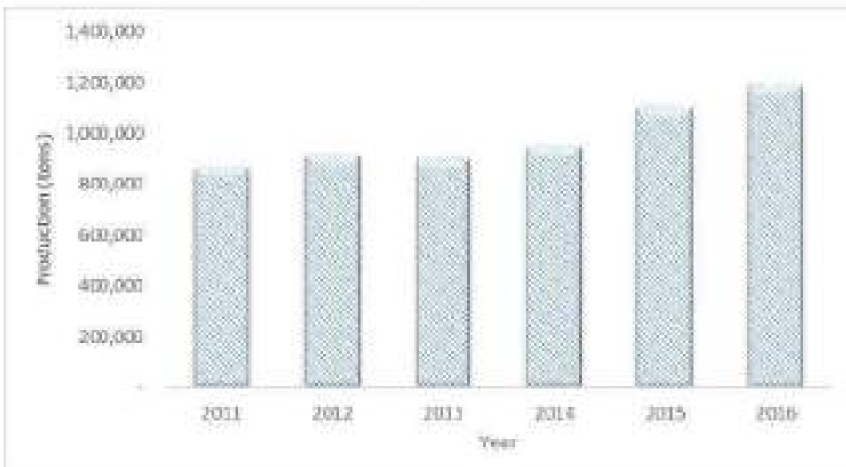

Figure 1. The development of fish production (tons) on the northern coast of Java from 2011- 2016.

The effort of catching on the northern coast of Java, in this case is the number of ships decreasing (2011-2016). In 2011 effort amounted to 83,142 vessels until 2016 of 50,933 vessels with a decreasing percentage (2011-2016) of 38.7% (Table 2 and Figure 2). The decrease of effort is followed by the increase of the number of catches, this is likely due to the existence of a policy from Kepmen-Kp No. 2/2015 concerning the prohibition on the use of trawls and seine nets.

Table 2

Number of vessels on the northern coast of Java

Province	Year					
	2011	*2012*	*2013*	*2014*	*2015*	*2016*
Banten	4.866	4.853	4.873	4.916	5.269	5.164
DKI Jakarta	5.292	4.751	5.677	4.920	5.140	5.037
West Java	12.955	13.046	13.242	14.056	9.132	8.949
Central Java	16.681	16.643	16.660	17.970	16.859	16.522
East Java	43.348	42.232	43.196	45.146	15.572	15.261
Amount	83.142	81.525	83.648	87.008	51.972	50.933

Source: Directorate General of Capture fisheries 2016.

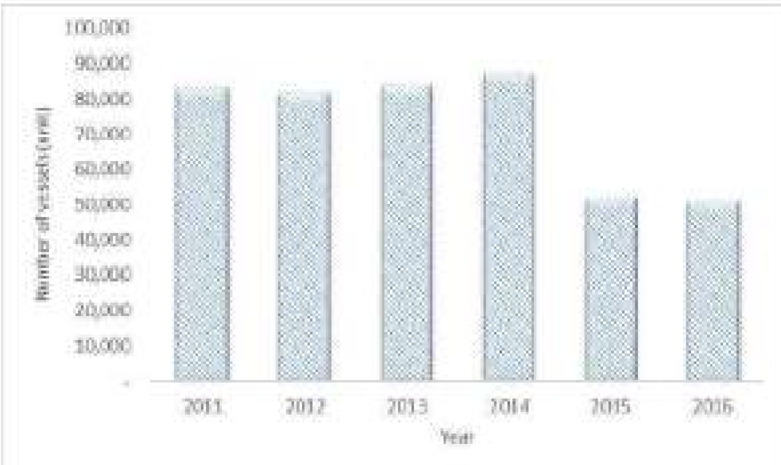

Figure 2. The development of the number of vessels on the northern coast of Java from 2011 to 2016.

Productivity of fishing gear. According to Sibagariang et al (2011), that Catch per Unit Effort (CPUE) is a method used to determine the results of the amount of marine fishery production averaged over the year. The increment or decrease of fisheries production in an area can be seen from the results of CPUE. CPUE is calculated based on standardization of fishing gears because based on production data, fishing gears can capture various types of fish. Standardization of fishing gear needs to know the number of vessels so that later the CPUE value of each fishing gear will be known so that FPI values will be known. Based on the production and number of ships, the CPUE value can be calculated for each fishing gear, with the catch (production) formula for each fishing gear divided by effort of each fishing gear.

Fishing gear used by fishermen on the North coast of Java consists of various types, including: purse seine, Danish seines, pair seines, boat life net, drifting gill nets and others. Evaluation of the status of capture fisheries resources needs to be carried out in a standard manner according fishing gear. The standard fishing gear used is purse seine, with consideration is the most effective fishing gear for catching fish that are clustered and produce the most catches among other fishing equipment (Figure 3).

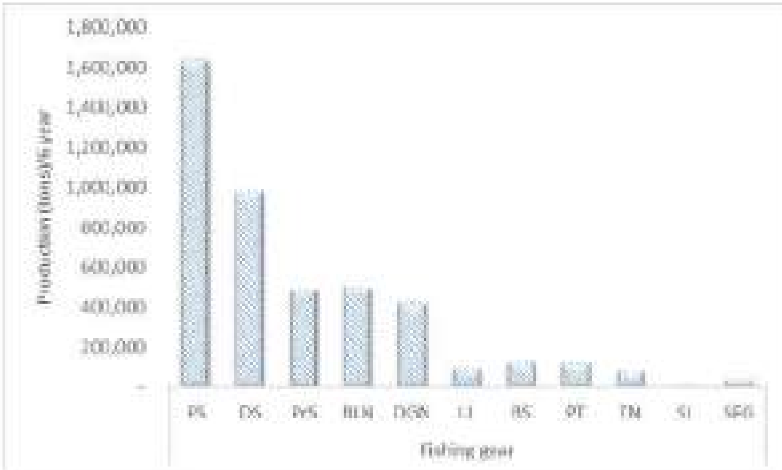

Figure 3. Production (2011-2016) by type of fishing gear; PS (purse seine), DS (Danish seine), PrS (pair seine), BLN (boat litf net), DGN (drift gill net), LL (long line), BS (beach seine), PT (portable trap), TN (trammel net), SJ (squid jigger), SFG (shell fish gear).

Based on Figure 5 the fishing gear that gets the biggest catch is the purse seines with 1,631,764 tons/6 years and the smallest catch was realized by squid fishing with 10,592 tons/6 years. From the Figure 3 it can be seen that the type of fishing gear used as a standard fishing gear for estimation procedures of MSY and F_{MSY} / F_{Opt} in estimation of catching large and small pelagic fish on the Northern coast of Java is purse seines because this tool is active in catching fish. According to Saputra (2009) so that the production surplus model can be implemented, adjustments are made by standardizing all types of fishing gears against one particular fishing gear. CPUE values for each fishing gear can be seen in Table 3.

Table 3

CPUE per fishing gear on the northern coast of Java for the period of 2011-2016

Fishing gear	*Year (ton)*						*Average*
	2011	2012	2013	2014	2015	2016	
Purse Seines	64,267	37,015	57,245	59,570	98,563	113,638	71,716
Danish Seines	11,649	12,189	10,936	10,680	66,104	71,980	30,590
Pair Seines	5,855	6,282	6,376	4,638	12,668	24,829	10,108
Boat Lift Net	47,509	56,973	54,720	63,210	71,435	72,890	61,123
Drift Gill Net	5,549	5,697	4,878	7,978	7,461	8,124	6,614
Long Line	7,472	5,554	54,130	48,897	94,580	116,543	54,529
Beach Seines	8,971	9,508	6,034	3,959	186	252	4,818
Portable trap	0,795	0,890	0,648	1,423	3,631	2,641	1,671
Trammel Net	1,145	0,816	0,887	1,474	2,625	2,556	1,584
Squid Jigger	2,599	2,143	0,598	0,663	1,843	1,575	1,570
Shell Fish Gear	1,948	1,599	2,389	3,074	13,651	8,965	5,271

Fish composition. Based on data obtained from the Directorate General of Capture Fisheries in 2016, the catch results consist of big pelagic fish, small pelagic fish, demersal fish, reef fish, crustaceans, mollusca and other aquatic animals. The composition of fish resources on the northern coast of Java can be seen in Table 4.

Table 4

Composition of fish resources on the northern coast of Java

Type of fish resources	*Production (tons)*	*Percentage (%)*
Big pelagic fish	144.928	13.2
Small pelagic fish	431.411	39.3
Demersal fish	303.012	27.6
Coral fish	32.166	2.9
Crustaceans	56.027	5.1
Mollusca	126.169	11.5
Other aquatic animals	3.425	0.3
Amount	1.097.136	-

Based on Table 4 can be seen the composition of fish resource types located on the northern coast of Java. The largest composition of fish resources are small pelagic fish of 39.3%, demersal fish of 27.6%, big pelagic fishes of 13.2%, mollusca of 11.5%, crustaceans of 5.1%, reef fish of 2.9% and other aquatic animals of 0.3%.

Big pelagic fish. According to our study, in Java's northern coastal port, the big pelagic fish population consisted of 26 species. The dominant big pelagis fish are skipjack tuna (*Katsuwonus pelamis*), frigate tuna (*Auxis thazard*), Spanish mackerel (*Scombridae*), yellowfin tuna (*Thunnus albacares*), bigeye tuna (*Thunnus obesus*), kawakawa (*Euthynnus affinis*) and longtail tuna (*Thunnus tonggol*). The dominant fish composition can be seen in Figure 4.

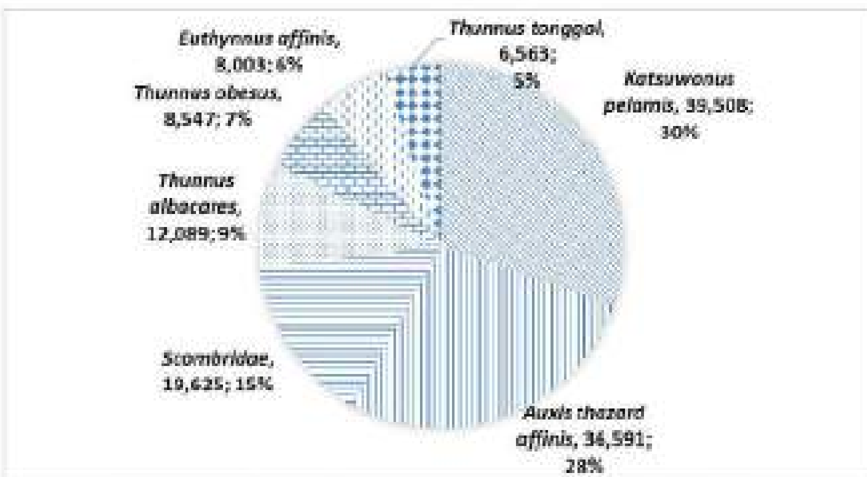

Figure 4. Composition of big dominant pelagic fish (tons).

Based on Figure 5 the highest amount of pelagic fish consisted of *K. pelamis* with 39,508 tons, followed by the *A. thazard* with 36.591 tons. The value of *K. pelamis* production (1,200 USD/ton) was estimated at 47,409,600 USD and *A. thazard* (1,866 USD/ton) at 68,303,200 USD. *A. thazard* landed at the fishing port in East Java of 14,025 tons.

Small pelagic fish. According to our study, in Java's northern coastal port, small pelagic fish population consisted of 27 species. Small dominant pelagic fish were the short mackerel (*Rastrelliger brachysoma*), shortfin scad (*Decapterus macrosoma*), Indian scad (*Decapterus russelli*), goldstripe sardinella (*Sardinella gibbosa*), yellowstripe scad (*Selaroides leptolepis*), anchovies (Engraulidae) and other small pelagic fish. The dominant fish composition can be seen in Figure 7.

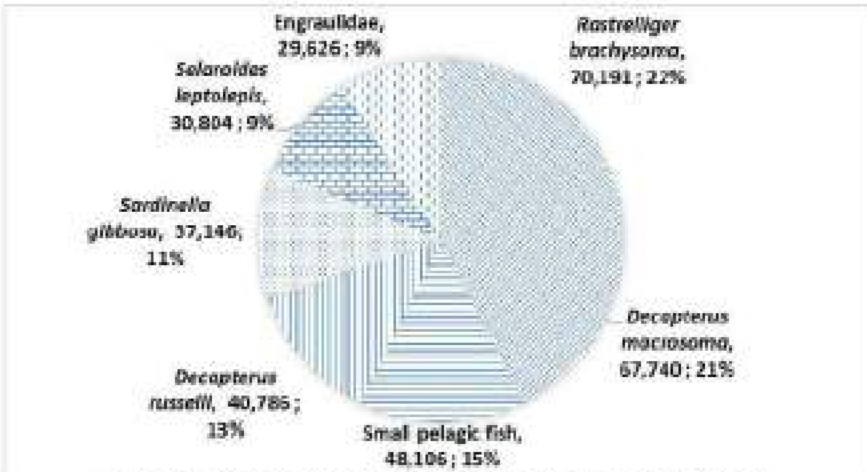

Figure 5. Composition of small dominant pelagic fish (tons).

Based on Figure 5 the composition of small pelagic fish was dominated by *R. brachysoma* with 70,191 tons and with production value of 156,759,900 USD (2,233 USD/ton). *R. brachysoma* landed at the fishing port in East Java of 22,881 tons.

Demersal fish. According to our study, in Java's northern coastal port, demersal fish population consisted of 45 species. The dominant demersal fish were slipmouths (Leiognathidae), northern red snapper (*Lutjanus campechanus*), gold-saddle goatfish (*Parupeneus cyclostomus*), black pomfret (*Parastromateus niger*), red bigeye (*Priacanthus macracanthus*), golden threadfin bream (*Nemipterus virgatus*) and other demersal fish. The dominant fish composition can be seen in Figure 6.

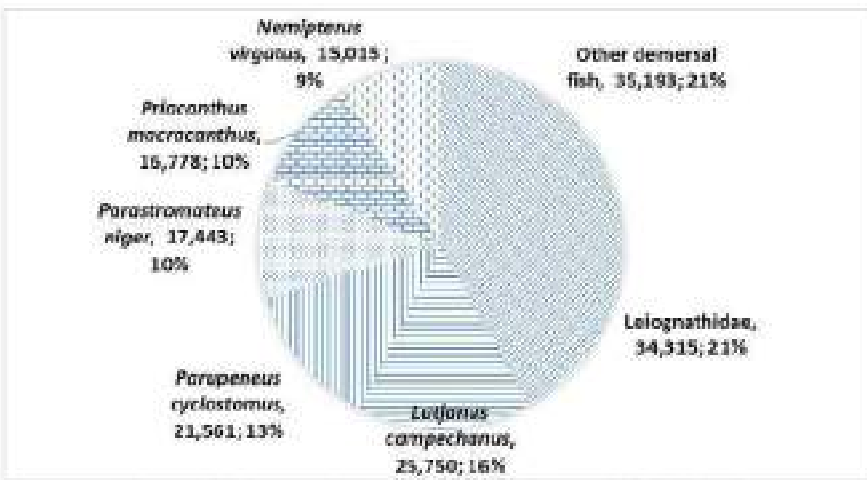

Figure 6. Composition of dominant demersal fish (tons).

Based on Figure 6 the composition of the demersal fish was dominated by Leiognathidae with 34,315 tons, followed by *L. campechanus* with 25,750 tons. The production value of Leiognathidae was estimated at 4,575,333 USD (133 USD/ton) and the *L. campechanus* at 78,966,666 USD (3,066 USD/ton). *L. campechanus* landed at fishery ports in East Java at 8,709 tons.

Reef fish. The reef fish landed at the north coast port of Java consisted of 11 species. The dominant demersal fish were yellowtail (Caesionidae), bluelined hind (*Cephalopholis formosa*), greasy grouper (*Epinephelus tauvina*), leopard coralgrouper (*Plectropomus leopardus*), orange-spotted spinefoot (*Siganus guttatus*), white-spotted spinefoot (*Siganus canaliculatus*) and other reef fish. The dominant fish composition can be seen in Figure 7.

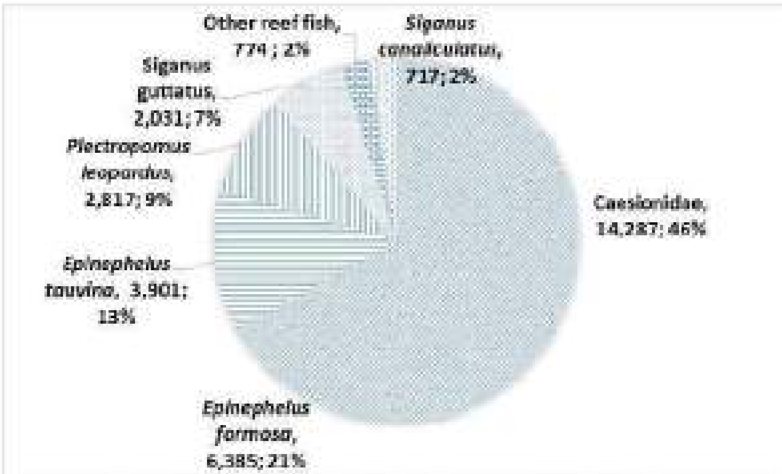

Figure 7. Composition of dominant reef fish (tons).

Based on Figure 7 the composition of reef fish wasdominated by the Caesionidae with 14,287 tons (4,000,000 USD/ton) with a production value of 57,148,000 USD. Caesionidae mostly landed at the fishing port in Central Java at 7,655 tons.

Crustaceans. Crustaceans landed at Java's northern coastal port of 11 species. The dominant crustaceans were swimming crab (Portunidae), endeavour prawn (*Metapenaeus monoceros*), banana prawn (*Penaeus merguiensis*), crab (*Brachyura*), rainbow shrimp (*Penaeus semisulcatus*), tiger prawn (*Penaeus monodon*) and other shrimps. The dominant composition of crustaceans can be seen in Figure 10.

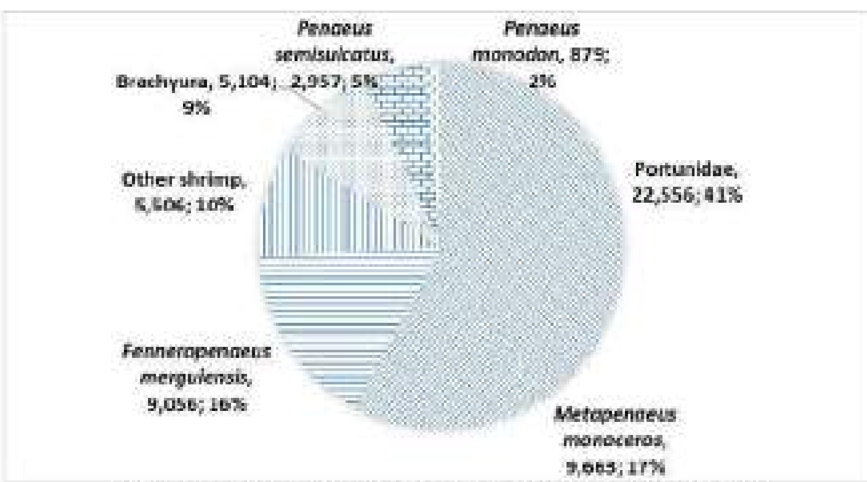

Figure 8. Composition of the dominant crustaceans (tons).

Based on Figure 8 the composition of the hard crustaceans was dominated by *Portunidae* with 22,556 tons (4,000,000 USD/ton) with a production value of 90,224,000 USD. *Portunidae* landed at fishing ports in East Java where at 7,209 tons.

Mollusca. According to our study, in Java's northern coastal port, mollusca population consisted of 9 species. The dominant mollusca were squid (Teuthida), blood cockles (*Tegillarca granosa*), cuttle fish (*Sepiida*), green mussels (*Perna viridis*), octopus (*Octopoda*) and other mollusca. The dominant mollusca composition can be seen in Figure 9.

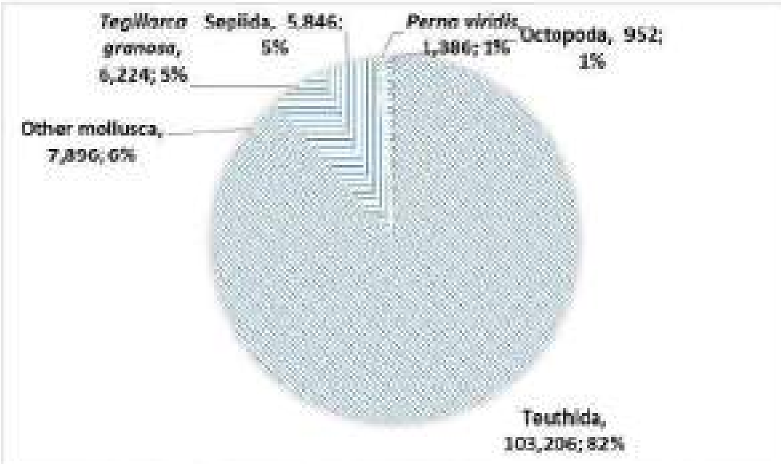

Figure 9. Composition of the dominant *mollusca* (tons).

Based on Figure 9 the composition of *mollusca* was dominated by Teuthida with 103,206 tons, with a production value of 447,226,000 USD (4,333 USD/ ton). The Teuthida landed at the fishery port in Jakarta at 76.747 tons.

Maximum sustainable yield (MSY). Maximum Sustainable Yield (MSY) is a reference in the management of fisheries resources on how it is possible to exploit without reducing a population, so that the stock of fishery resources remain at a safe level. According to Widodo & Suadi (2006), MSY is the biggest catch that can be produced from year to year by a fishery. The MSY concept is based on a very simple model of a fish population that is considered a single unit. MSY is a management parameter produced by the nature of fisheries resources assessment. Estimating these parameters requires time series capture data. The data used in the MSY calculation is data in the last 6 years (2011 - 2016). The following is a description of the MSY of each of the dominant fish resources on the Northern coast of Java.

Auxis thazard. The catching of *A. thazard* on the Northern coast of Java is carried out using fishing gear such as purse seines, drifting gill nets, trolling other fishing gear.
Based on Figure 10 the production relationship curve with effort on *A. thazard* obtained optimum fishing effort value of 5,736 trips per year and the maximum fish catches amounted 398,164 tons per year and the number of total allowable catch (TAC) of 318,891 tons per year.

Based on the comparison between the TAC catch of 318,891 tons with the actual catch of 348,340 tons, the catch obtained every year exceeds TAC. Arrest efforts that exceed the optimum effort should be done by reducing fishing efforts and no additional fishing efforts will be carried out for fishing activities of *A. thazard* on the Northern coast of Java.

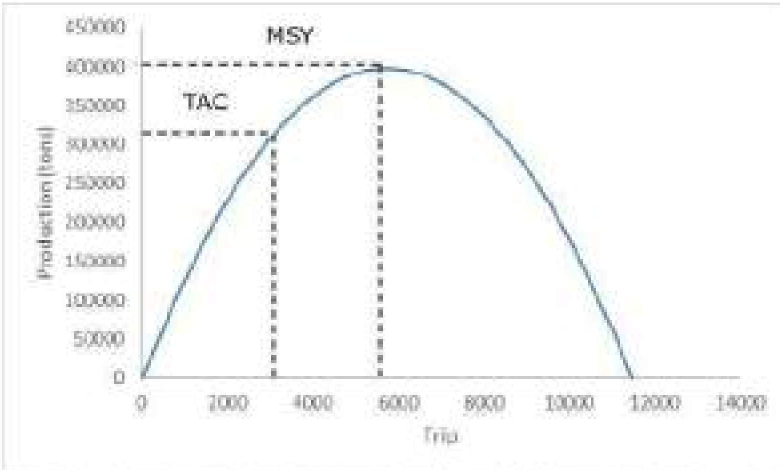

Figure 10. Production relationship curve (ton) with effort on *Auxis thazard* on the northern coast of Java from 2011 to 2016.

According to the Kepmen-Kp No. 47/2016 estimation of potential, amount of catch allowed, and level of utilization of fish resources on WPPNRI, as referred to in the FIRST Dictum is used as a consideration determining the allocation of fish resources.

According to Ilhamdi et al (2016) the potential of the marine fisheries resources in Prigi waters for *A. thazard* production in 2013 was 7,291 tons, with MSY of 7,783 tons. The level of utilization of *A. thazard* in Prigi is 94%. The utilization status of *A. thazard* has been fully exploited. According to Sriyani (2017) the research conducted at the fish landing site of Barek Motor Village, Riau Islands, the Maximum Sustainable Yield (MSY) based on Schafer model in May and June was 218.57 kg with an optimal catching effort of 277.21 trips with the utilization rate at May and June amounting to 80.245%.

Rastrelliger brachysoma. Catching *R. brachysoma* on the Northern coast of Java is done by using fishing gear such as purse seine, Danish seines, pair seines, boat life net, drifting gill nets and other fishing gear.

Based on Figure 11 about the production relationship curve with effort on *R. brachysoma* resources, the optimum fishing effort is 11,026 trips per year and the maximum number of fish catches is 757,134 tons per year and the number of total allowable catch (TAC) of 605,707 tons per year.

Based on the comparison between the TAC catch of 605,707 tons and the actual catch of 670,929 tons, the catch that is obtained each year exceeds TAC. Arrest efforts that exceed the optimum effort should be done to reduce the fishing effort and no additional fishing efforts will be carried out for *R. brachysoma* fishing activities on the Northern coast of Java.

The results of Permata et al (2016) study Maximum Sustainable Yield (MSY) resources of *R. brachysoma* in Belawan waters in the last 10 years amounting to 6,276,538.129 kg / year with the number of permeated fish catches which amounted to 5,021,230,503 kg / year. Percentage of utilization rates of *R. brachysoma* in Belawan waters over the last 10 years with an effort of 179.49%. According to Aminah (2011) the maximum potential for sustainable *R. brachysoma* in Tanah Laut Regency is 3,297 tons per year with a utilization rate of 77%.

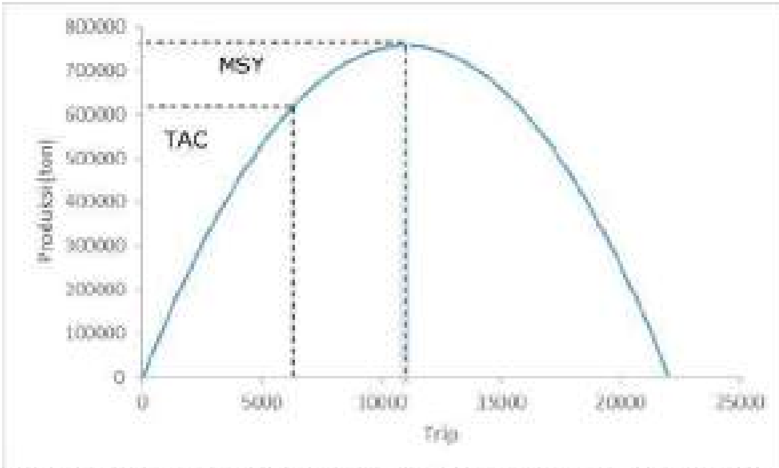

Figure 11. Production relationship curve (ton) with the effort of *Rastrelliger brachysoma* resources on the Northern coast of Java from 2011 – 2016.

Lutjanus campechanus. Catching *L. campechanus* on the Northern coast of Java is done by using fishing gear such as trap, bottom long line, murcami, Danish seines, and other fishing gear.

Based on Figure 12 the production relationship curve with the effort on the resources of *L. campechanus* obtained optimum fishing effort value of 7,364 trips per year and the maximum fish catches was 346,431 tons per year and the number of total allowable catch (TAC) of 277,145 tons per year.

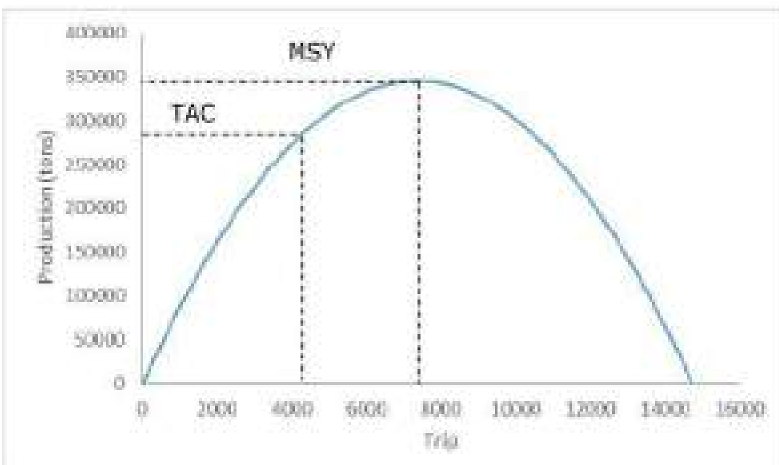

Figure 12. Production relationship curve (ton) with the effort of resources of *Lutjanus campechanus* on the Northern coast of Java from 2011 to 2016.

Based on the comparison between the TAC catch of 277,145 tons and the actual catch of 195,202 tons, the catch obtained every year is below TAC. Arrest efforts that are less than optimum efforts should be carried out additional fishing efforts for fishing activities of *L. campechanus* on the Northern coast of Java.

Santoso (2016) reported maximum sustainable yield (*MSY*) on *L. campechanus* of 205.8 tons/year with utilization status of 65.7% which is a moderately exploited status. According to Sriati (2011) maximum sustainable yield (MSY) of *L. campechanus* is 5,862 kg/year. The optimum capture effort (E_{OCE}) is obtained when the catch rate is 157,206.59 trips and the catch result maximum economic yield (MEY) obtained is 5,374.12 kg indicating an effort that exceeds the maximum capacity so that it leads to over fishing conditions.

Caesionidae. Catching *Caesionidae* on the northern coast of Java is done by using fishing gear such as Danish seines, trap, muroami and other fishing gear.

Based on Figure 13 the production relationship curve with effort on *Caesionidae* resources obtained optimum fishing effort value of 7,039 trips per year and the maximum fish catches amounted 327,901 tons per year and the number of total allowable catch (TAC) of 262,321 tons per year.

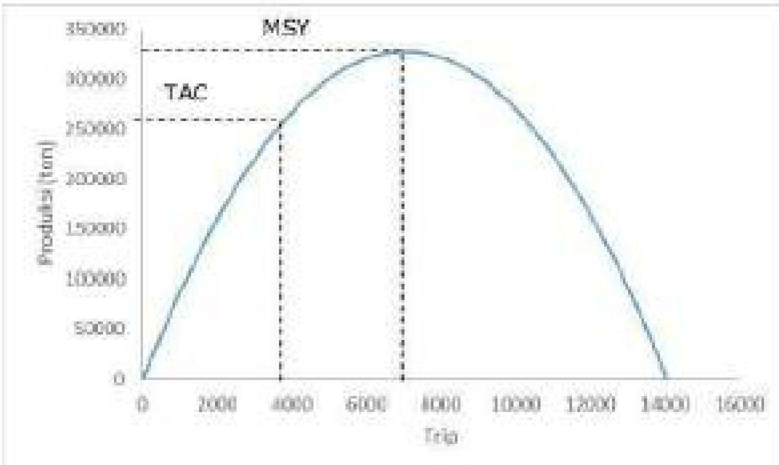

Figure 13. Production relationship curve (ton) with effort of *Caesionidae* resources on the Northern coast of Java from 2011 to 2016.

Based on the comparison between the TAC catch of 262,321 tons and the actual catch of 183,720 tons, the catch that is obtained every year is below TAC. Arrest efforts that are less than optimum efforts should be carried out additional fishing efforts for fishing activities of *Caesionidae* on the Northern coast of Java.

Abdurachman et al (2012) obtained an MSY value of 157.71 tons/year and an optimum effort (f_{opt}) of 1051 trips/year equivalent for muroami fishing gear. The level of utilization of *Caesionidae* in fish landing center (FLC) Pramuka Island is 86.71%. According to Prihatna et al (2009) *Caesionidae* in the waters of the Seribu Islands has an optimal production level of 917.49 tons per year the optimal level of effort is 1,219 trips per year, indicating that the utilization of *Caesionidae* in the Seribu Islands waters can be categorized as not degraded and not experienced biological overfishing and economical overfishing.

Portunidae. The catching of Portunidae on the Northern coast of Java is carried out using fishing gear such as set gill net, Danish seines, trap, and other fishing gear.

Based on Figure 14 about the production relationship curve with effort on the Portunidae resources, the optimum fishing effort is 8,473 trips per year and the maximum catches is 410,869 tons per year and the number of total allowable catch (TAC) is 328,695 tons per year.

Based on the comparison between the TAC catch of 328,695 tons with the actual catch of 235,726 tons, the catch obtained every year exceeds TAC. Excessive arrest efforts from optimum efforts should be carried out by reducing fishing efforts for Portunidae fishing activities on the Northern coast of Java.

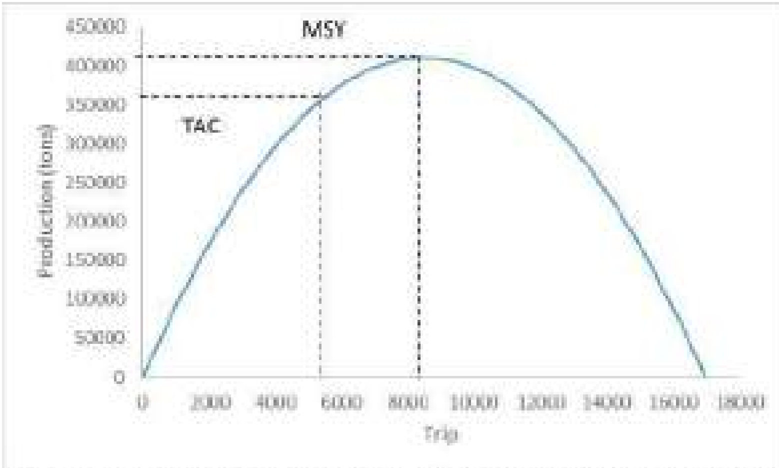

Figure 14. Production relations curve (ton) with Portunidae resource effort on the Northern coast of Java from 2011 to 2016.

Badiuzzaman et al (2014) reported maximum sustainable yield (MSY) of crab resources of 8.47 kg per year. The knitting biomass resource in Demak waters with an area of 189.46 km^2 is estimated at 9.64 tons. These results show that the Portunidae resource potential is increasingly critical because the annual production value exceeds the MSY value. Adam (2016) for the sustainability of Portunidae fishing in Pangkep waters obtained optimum capture effort (E_{opt}) of 768.90 trips, the maximum economic yield (MEY) amounted to 2963.75 tons/year so that TAC was obtained at 2371 tons/year with utilization rates reaching 85%.

Teuthida. The catching of Teuthida on the Northern coast of Java is done by using fishing gear such as Danish seines, boat lift net, Teuthida fishing and other fishing gear. Based on Figure 15 about the production relationship curve with effort on Teuthida resources, the optimum fishing effort is 10,064 trips per year and the maximum fish catches is 461,324 tons per year and the number of total allowable catch (TAC) is 369,060 tons per year.

Based on the comparison between the TAC catch of 369,060 tons and the actual catch of 248,688 tons, the catch obtained every year is below TAC. Arrest efforts that are less than optimum efforts should be carried out by additional fishing efforts for catching Teuthida on the Northern coast of Java.

Permana et al (2015) reported maximum sustainable yield (MSY) Teuthida landed in Archipelago fishing port Kejawanan values of 2,186.47 tons/year with optimum effort (E_{opt}) 5848 trips/year. The average utilization rate of Teuthida resources for the last 5 years in Archipelago fishing port is 97.54%. According to Oktariza et al (2016) the optimal level of Teuthida resources in the waters of Bangka Regency in MEY conditions is 767.13 tons per year with a level of catching 5.544 trips per year. The optimal production level in the MSY condition is 768.33 tons per year with a catch rate of 5,733 trips per year.

Based on the production data of each type of fish resource in the last 6 years (2011-2016), the sustainable production of fisheries or maximum sustainable yield (MSY) can be calculated with the surplus production method from Schaefer, on the Northern coast of Java, it can be determined when overfishing occurs by comparing the efforts and catches each year.

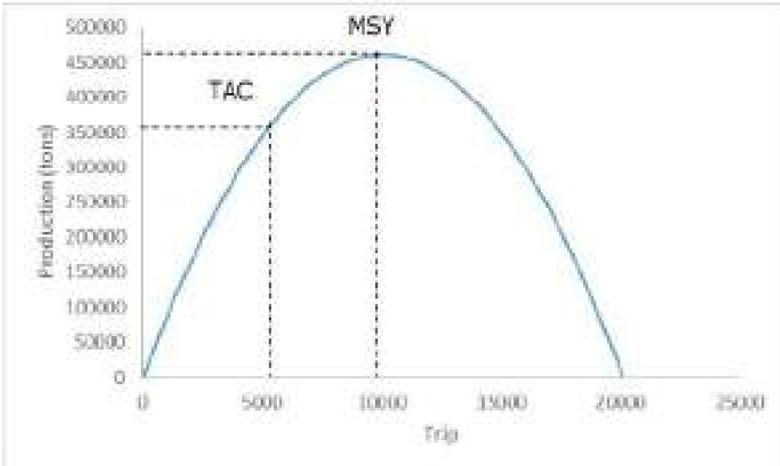

Figure 15. Production relationship curve (ton) with Teuthida resource effort on the Northern coast of Java from 2011 to 2016.

The value of effort, MSY and TAC for each fish resource can be seen in Table 5.

Table 5

Effort, MSY, fish resource TAC on the Northern coast of Java

Resources	*Result*		
	Trip	*MSY (ton)*	*TAC (ton)*
Auxis thazard	5.736	398.164	318.891
Rastrelliger brachysoma	11.026	757.134	605.707
Lutjanus campechanus	7.364	346.431	277.145
Caesionidae	7.039	327.901	262.321
Portunidae	8.473	410.869	328.695
Teuthida	10.064	461.324	369.060

Source: 2018 research results.

Based on Table 5, the highest sustainable maximum catches were 757,134 tons of *R. brachysoma* and 327,901 tons of Caesionidae. This wass possible due to the effort of fishing trip to catch more *R. brachysoma*, which was 11,026 trips compared to the trip used to catch Caesionidae, 7,039 trips.

According to Purwanto (2002) the catch depends on the level of catching effort and the amount of fish stocks in the fishing area. The increase in fishing effort was caused by the increasing number of vessels and fishing gear, so that the fishing effort and competition among fishermen increased, and the level of fish production decreased (Rahmawati et al 2013).

According to Sriati (2011) fluctuations in catches are affected by the presence of fish, the number of fishing attempts and the success rate of fishing operations. According to Widodo & Suadi (2006) some of the characteristics that become the benchmark of a fishery is heading for more catching efforts is that when fishing duration is longer than usual, the fishing location becomes farther, the size of the net becomes smaller accompanied by a decrease in catch productivity per unit effort.

Level of fish resources utilization. Fish resources can be known about utilization rates after obtaining MSY, then calculated by presenting the amount of catch in a particular year to TAC. According to Dahuri (2010) the TAC is 80% of the maximum sustainable potential (MSY). The level of utilization of fish resources on the Northern coast of Java can be seen in Table 6.

Table 6

Level of utilization of fish resources on the North coast of Java

Coastal waters		*Auxis thazard*	*Rastrelliger brachysoma*	*Lutjanus campechanus*	*Caesionidae*	*Portunidae*	*Teuthida*
Northern Java	Production (tons)	348.340	670.929	195.202	183.720	235.726	248.688
	TAC (tons)	318.891	605.707	277.145	262.321	328.695	369.060
	Utilization rate	1.092	1.108	0.704	0.700	0.717	0.674

Description Level of utilization (E): $E < 0.5$ = Moderate, fishing effort can be increased; $0.5 \le E < 1$ = Fully-exploited, the fishing effort is maintained with a tight monitor; $E \ge 1$ = Over-exploited, fishing effort should be reduced. (Kepmen-Kp No. 47/2016).

Based on Table 6, it can be concluded that in the last 6 years the level of utilization of fish has been excessive for *A. thazard* by 1.092 and *R. brachysoma* 1.108. Viewed from the level of utilization greater than 1, means over-exploited, in this case the fishing effort must be reduced in order to remain sustainable. The utilization rate of *L. campechanus* 0.704, Caesionidae 0.700, Portunidae 0.717 and Teuthida 0.674 means full-exploitation by fisherman (fishing efforts were maintained with a strict monitor) from the government. The utilization rate between 0.5 and 1 of the total catch allowed, indicates that fish resources is fully exploited (Saputro et al 2014).

Overfishing that occurs is a biological overfishing when the level of utilization in a fishery has exceeded the MSY level. The level of effort needs to be limited because the level of utilization and the level of effort that exceeds sustainable potential (MSY) can threaten the sustainability of fish resources.

According to Hutabarat (2002) in Mulyani et al (2004), fish resources are resources that are renewable, but in renewing themselves they run very slowly. If exploitation far exceeds the ability of resources to form themselves again, resulting in these resources becoming non-renewable. Good management of fish resources is by utilizing fish populations without having to deplete the fishery resources. If the management of fisheries resources is carried out by fishing continuously without taking into account the ability of these resources to renew, it will be dangerous for fish stocks (overfishing).

Conclusions. The composition of fish resources on the northern coast of Java is small pelagic fish of 39.3%, demersal fish of 27.6%, big pelagic fishes of 13.2%, mollusca 11.5%, crustaceans, 5.1%, reef fish 2.9% and other aquatic animals 0.3%. The level of utilization of *A. thazard* is 1.092 and of *R. brachysoma* 1.108 which means it is over-exploited (fishing effort must be reduced) while *L. campechanus* is 0.704, Caesionidae 0.7, Portunidae 0.717 and Teuthida 0.674, which means fully exploited capture effort is maintained with a strict monitor of the government).

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