The impact of ‘cantrang’ (Danish seine) fisheries on gill net fisheries in Tegal coastal area, Indonesia

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Abstract. The discourse of ‘cantrang’ (Danish seine) ban has become a national issue in Indonesia, including in Tegal region, both Tegal city and Tegal regency. The gill net fishermen in Tegal region complained about the decline of their production after the number of Danish seine (unit) increased. But the ban of Danish seine was rejected by Danish seine fishermen. This research developed a multi-gears bioeconomic model to estimate an impact of Danish seine effort to gill net production. The model in this research was modified from the Gordon-Schaefer model. Our bioeconomic model can explain the relationship between Danish seine and gill net fisheries. This research showed that Danish seine had a negative and significant impact on gill net fisheries in Tegal region. The Danish seine operation in 2008 to 2016 made an average production loss of gill net around 3 814 tonnes per year.
Key Words: bioeconomic, Danish seine, gill net, multi-gears, Tegal city, Tegal regency.

Introduction. Danish seine (‘cantrang’) has become one of the main choices fishing gear in Indonesia. But, the Ministry of Maritime Affairs and Fisheries (MMAF) in Indonesia considers that Danish seine is not environment-friendly. Danish seine is not a selective fishing gear, so it is feared that it can cause disruption for sustainability of fish resources. The Indonesian government has issued a regulation of Danish seine ban in Indonesian waters (Minister of MMAF Decree No. 2 of 2015). However, the ban was denied by Danish seine business actors, including Danish seine fishermen from Tegal region. According to Adhawati et al (2017a), the moratorium of Danish seine affected on the total revenue of Danish seine fishermen, both business owner and crews. Furthermore, the polemic of banning Danish seine has become a political issue.

Tegal region is one of coastal areas in Indonesia. Indonesia is the second largest producer of marine capture fisheries in the world, after China as the first largest (FAO 2016). Contribution of fisheries in economy of Tegal region is relatively large, including employment and economic growth. The coastal line of Tegal has a length of 40.5 Km. The Tegal coastal crosses two administrative regions, i.e. Tegal City (coast length of 10.5 Km) and Tegal Regency (coast length of 30 Km). Tegal coastal is one of the main fishing base in Central Java Province, Indonesia. There were 4,320 fishermen in Tegal Regency and 12,532 fishermen in Tegal City in 2016 (DKP Provinsi Jawa Tengah 2017). Therefore, the development of fisheries in the Tegal region has strategic value for Tegal Regency and Tegal City, and also for wider areas (provincial and national).

Fishing business in Tegal Regency is dominated by small-scale fisheries (artisanal fisheries), while in Tegal City tends to be larger scale (industrial fisheries). Small-scale fisheries in the world can employ more than 99 percent of fishermen, but produce approximately 50 percent of global marine fisheries (Daw et al 2009). In Indonesia, coastal villages have a high dependence on traditional fisheries (Blankenhorn 2007). The relationship between artisanal fisheries and industrial fisheries is interesting to be explored, including the relationship between ‘cantrang’ or Danish seine (industrial fisheries) and gill net (artisanal fisheries) in Tegal region using the multi-gears bioeconomic.

According to Padilla & Charles (1994), bioeconomic modeling can be used to analyze a complexity of fisheries problems by integrating several factors, including biological, economic and social. Multi-species and multi-gear problems in tropical fisheries, including in Indonesia, have encouraged the development of multi-species and multi-gears modeling. According to Ulrich et al (2001), in the conditions of multi-species and multi-gear fisheries, technical interactions tend to be high, including externalities in competing between fishing gears to catch the same types of fish in common resources.

The bioeconomic model can be used to develop scenarios for optimizing fisheries resource management, including in multi-gear fisheries, by controlling the total allowable catch or TAC (Brasão 2000). Bioeconomic model can be used to predict the impact of alternative strategies in fisheries management (Sobers 2010). Fisheries is not a static phenomenon, because human interventions or natural events that occur in certain period can have impact in the future (Évora 2016).

In 2016, there were 39 410 units of Danish seine in Tegal City and 301 units of Danish seine in Tegal Regency (DKP Provinsi Jawa Tengah 2017). Danish seine fisheries is an industrial fisheries in Indonesia, with relatively large capital requirements and relatively large fishing power (Adhawati et al 2017a). Danish seine in Indonesia has been popularly used by fishermen since the 1960s. In 1980, the Indonesian government banned the use of trawl (through Presidential Decree No. 39 of 1980). One of the fishing gear that fishermen choose as a substitute for trawl was Danish seine (Sasmita 2013).

Gill net tends to be more selective fishing gear than Danish seine even though the fishing power is relatively small. Gillnet is a vertical net hanging in the water. Gill net may have just one sheet of twine in which the fish are trapped at their gills when they try to swim through the net (entangled). Gill net is a passive fishing gear, but fish can be driven into it using accoustics (Emmanuel et al 2008). Gill net fisheries in Tegal region is artisanal fisheries. Artisanal fisheries involve skilled operators but not on an industrial scale. This type of fishing usually represents a small scale. Artisanal fisheries is usually oneday fishing using small boats. In Indonesia, 5% of fishing vessels have inboard engines, 20% use outboard engines and 75% use boats without engines in 1977-1995. So, the majority of fishermen depend on coastal resources close to the beach (Blankenhorn 2007). The gill net fishermen in Tegal region complained about the decline of their production after the unit number of Danish seine increased. The fish types caught from the gill net are partly the same as the catch of Danish seine. Danish seine catch are more diverse and Danish seine operation has been modified similar to trawl, therefore Adhawati et al (2017b) use the terminology of 'Danish trawl' for ‘cantrang’. The purpose of this research was to estimate the impact of Danish seine effort on gill net production in Tegal region.

Material and Method

Research location. The object of this research are Danish seine and gill net fisheries in Tegal region, both Tegal city and Tegal regency. Tegal city has one coastal fishing port, namely ‘Tegalsari’ coastal fishing port. Tegal regency has two fish landing places, namely ‘Suradadi’ and ‘Larangan’ fish landing place. Location of Tegal region could be seen on the map in Figure 1. This research was carried out in June to October 2018.

Data collecting. Our research used a combination of primary data and secondary data. We used data of fisheries production, and number of fishing gear of Tegal city and Tegal regency in 2008 to 2016 from DKP Provinsi Jawa Tengah (one of provincial government agency), both data of Danish seine and gill net. We also interviewed 30 gill net fishermen in Tegal region to collect the cost, price, and also to take their opinion about regulation of Danish seine ban. We made observations of fishing gears and fishing bases.

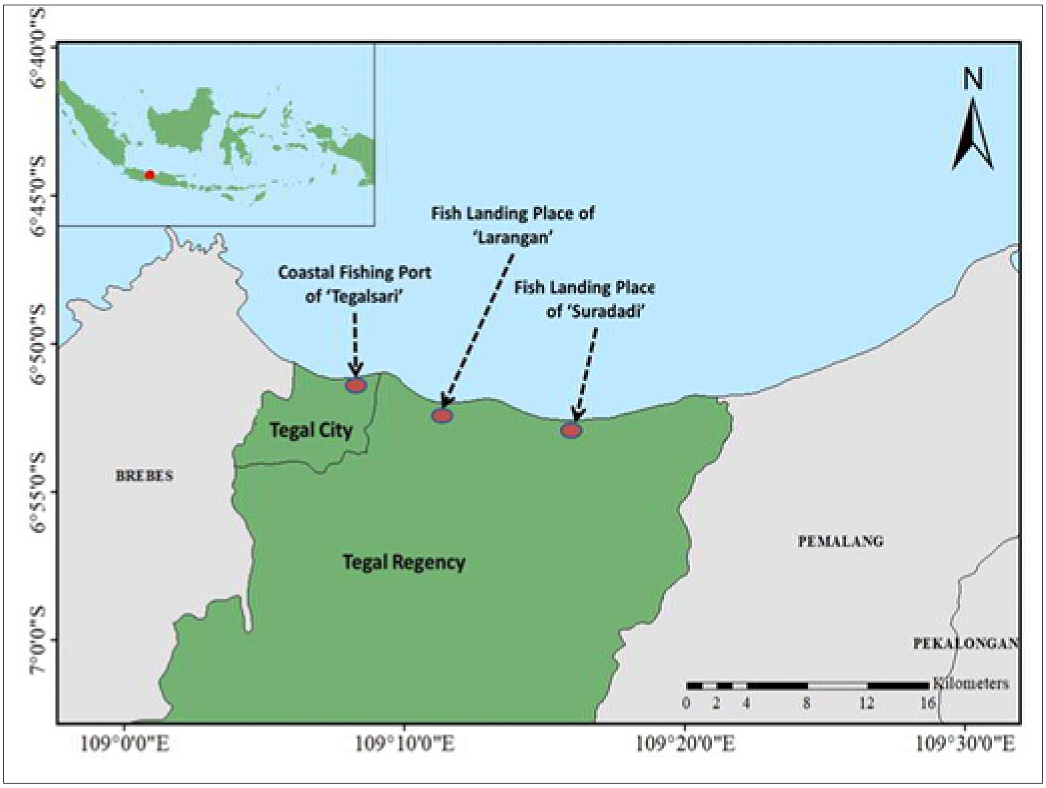

Figure 1. The research location.

Bioeconomic model. This research model use bioeconomic model that was developed by Wijayanto et al (2018). This bioeconomic model used Gordon-Schaefer Model (single gear) that was modified to multi-gears model. The production function of gill net and 'cantrang' or Danish seine follows the equation (Wijayanto et al 2016):

$$Cg = a.Eg - b.Eg^2 \quad (1)$$
$$Cc = d.Ec - e.Ec^2 \quad (2)$$

where: Cg is gill net production (tonnes per year);
Cc is 'cantrang' or Danish seine production (tonnes per year);
Eg is quantity of gill net (unit);
Ec is quantity of 'cantrang' or Danish seine (unit);
a, b, d, and e are constants.

If it is assumed that Danish seine have impact to gill net fisheries, then equation (1) is modified to the following equation:

$$Cgc = f.Eg - g.Eg^2 - h.Ec \quad (3)$$
$$Cgc / Eg = f - g.Eg - h.(Ec/Eg) \quad (4)$$

where: Cgc is gill net production is affected by Danish seine fishing effort (tonnes per year);
f, g, and h are constants.

The optimization of equation (3) with subject to Eg could generate an equation that identical to the E_{MSY} (fishing effort at the maximum sustainable yield or MSY) in the Gordon-Schaefer Model. The maximum gill net production occurs when Danish seine production is minimal. We used the following equation to estimate the profit:

$$TR = p.Cgc \quad (5)$$
$$TC = c.Eg \quad (6)$$
$$\pi = TR - TC \quad (7)$$

where: TR is the total revenue (IDR per year);
TC is the total cost (IDR per year);
Π is the profit (IDR per year).

The optimization of equation (7) with Eg as the constrain could generate an equation that is identical to the E_{MEY} (the fishing effort in the maximum economic yield condition) in the Gordon-Schaefer Model.

Results and Discussion

The progress of Danish seine and gill net. The use of Danish seine fishing gear is increasingly as an alternative technology to replace trawl. Badan Standardisasi Nasional or BSN (2006) (government agency for standardization) issued a standard design of Danish seine, i.e. SNI 01-7236-2006. However, the Danish seine design in various regions of Indonesia are very diverse (Riyanto et al 2011). In the beginning, Danish seine was operated using a boat with a length between 6 and 7 m, width of 1.5-2 m, depth of 0.5-1 m, the length of net from the end of the bag to the wing about 8-12 m. However, at the present, the size of Danish seine has changed a lot. According to Sasmita (2013), Danish seine has been used by a ship measuring 18 m long, 7 m wide, and 2.75 m depth with 200 PS engine power. CPUE of Danish seine and CPUE of gill net in Tegal coastal have a reverse relationship. This shows the relation between Danish seine and gill net fisheries. The progress Danish seine and gill net can be seen in Figure 2. The survey results of the investment costs, operational costs and fish prices in the gill net fisheries can be seen in Table 1.

The modified Danish seine in Indonesia is not an environment-friendly tool. Danish seine in Indonesia is trawl modified and could be used to swept fish schooling (Adhawati et al 2017a, 2017b). The types of aquatic animals caught by Danish seine vary, including *Rastrelliger* sp., *Selaroides* sp., *Loligo* sp., *Leiognathus* sp., *Johnius* sp., *Caesio* sp., *Priacanthus* sp., *Caranx* sp., *Nemipterus* sp., *Saurida* sp., grouper, *Trichiurus* sp., *Netuma* sp., *Lutjanus* sp. and *Sphyraena* sp. (Wijayanto et al 2018). There are several similar types of fish caught by Danish seine and gill net (multi species and multi gears).

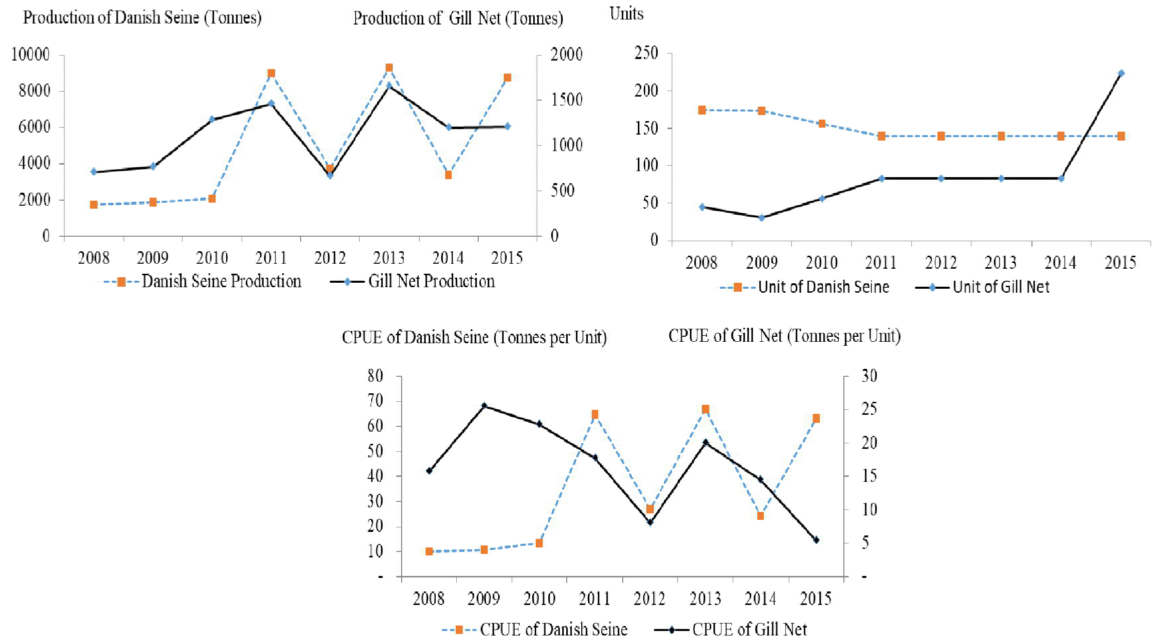

Figure 2. The progress of Danish seine and gill net.

Table 1

The cost of gill net fisheries and fish price

	The costs of gill net fisheries and fish price	Average value (IDR)	Note
A	Investment (IDR)	43,658,333	A=B+C+D
B	Boat	24,200,000	
C	Machine	11,400,000	
D	Fishing gear	8,058,333	
E	Depreciation (IDR per year)	8,729,167	E=F+G+H
F	Boat	2,420,000	
G	Machine	2,280,000	
H	Fishing gear	4,029,167	
I	Operational cost (IDR per year)	24,558,218	I=J+K
J	Energy, food and others	18,968,947	
K	Maintenance	5,589,271	
L	Cost per unit effort (IDR per year)	33,287,385	L=E+I
M	Price of fish (IDR per tonnes)	43,989,170	

The impact of Danish seine to gill net production. In this research, the relationship between gill net and Danish seine fisheries follows the following equation:

$$Cg(Eg) = 27.59\ Eg - 0.089\ Eg^2 \quad (8)$$
$$Cgc\ (Eg, Ec) = 73.39\ Eg - 0.100\ Eg^2 - 0.344\ Ec \quad (9)$$

There is a negative relationship between gill net production and the number of Danish seine units. When the number of Danish seine units is zero, the gill net production will be optimal. This research finding supports the research of Wijayanto et al (2018) and Wijayanto et al (2019) that the existence of Danish seine reduced gill net production in Pati regency and Rembang regency. However, the Indonesian government has a dilemma when implementing the ban of Danish seine because many stakeholders have a conflict of interest (Adhawati et al 2017a, 2017b). The problem of Danish seine in Tegal region, Pati regency and Rembang regency proves again that fisheries are one of the most complex problems of human activities, which are related to the aquatic and human environment, and also issues of sustainability of resources (Padilla & Charles 1994). The problem of common property is a fundamental problem that causes fisheries inefficiency as the impact of unclear property rights (Évora 2016). Conflict of interests is a classic problem in the management of fisheries resources. Each stakeholder has an interest that can be different or the same with other stakeholder. There is a diversity of interests, including the sustainability of natural resources, policies, economics, work environment, and politics (Edvardsson et al 2011).

The simulation results show that the loss of gill net production is relatively large compared to actual production. In the period 2008 to 2016, it was estimated that the loss of gill net production was due to the effect of Danish seine fishing operations on an average of 3,814 tonnes per year. If it is assumed that the fish price of gill net catch is IDR 43,989,170 per tonne, then the loss of gill net production is equivalent to IDR 167,759 million per year. The gill net production loss can be seen in Figure 3.

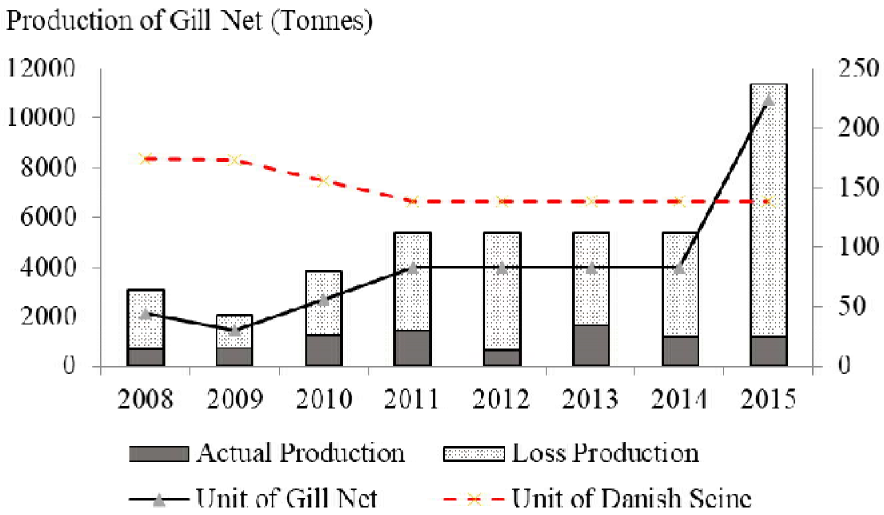

Figure 3. The simulation of gill net loss production.

The Indonesian government needs to pay more attention for gill net fisheries development, including in Tegal City and Tegal Regency. This is because the artisanal fisheries have strategic value, and can be empowered to improve coastal communities welfare. The research of Hay et al (2008) proves that gill net includes a selective and environmentally friendly fishing gear. The selectivity of gill net depends on the mesh size (Li et al 2017). Small-scale fisheries have a significant contribution in providing employment, especially in coastal area (Daw et al 2009).

Optimum production simulation results can be seen in Table 2 with assumption of cost per unit effort is IDR 33,287,385 per year and price of fish is IDR 43,989,170 per tonne. The fishing effort of gill net can be increased more than twice at the optimum production if the presence of Danish seine is prohibited. Production curves and fishing effort of gill net attempts with two scenarios (with and without Danish seine) show a significant difference (Figure 4). Production and profit of gill net (with and without Danish seine) can be seen in Table 3.

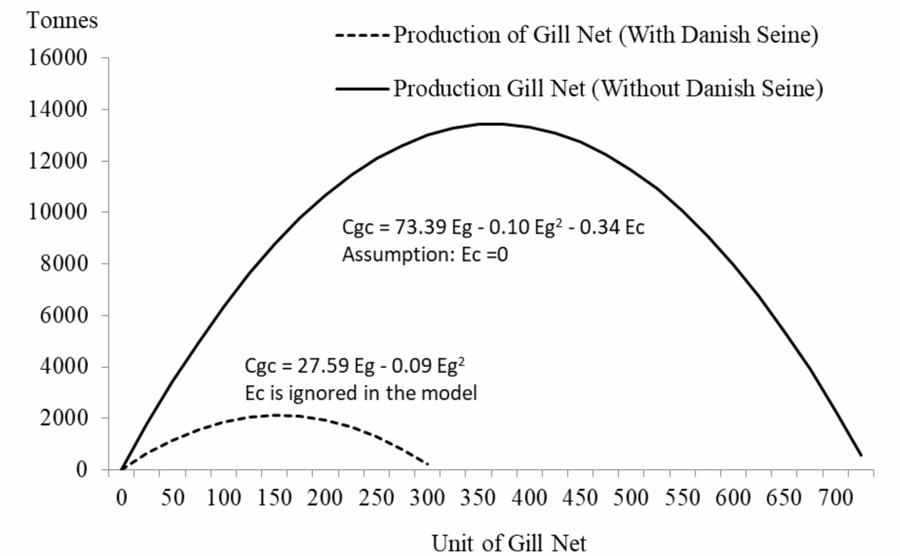

Figure 4. The curve of gill net production and fishing effort.

Table 2

Optimum production and profit of gill net fisheries

Production, effort, revenue, cost and profit	*Optimum production of gill net without impact of Danish seine*	*Optimum production of gill with impact of Danish seine*
Production (tonnes per year)	13 444	2 117
Fishing effort (unit)	366	152
TR (IDR million per year)	591 393	93 117
TC (IDR million per year)	12 195	5 068
Profit (IDR million per year)	579 199	88 048

Table 3

Production loss and profit loss of gill net fisheries

Years	*Actual production of gill net (tones)*	*Simulation of gill net production without Danish seine (tonnes)*	*Production loss of gill net (tonnes)*	*TC of gill net (IDR million)*	*Actual TR of gill net (IDR million)*	*Actual profit of gill net (IDR million)*	*TR of gill net without Danish seine (IDR million)*	*Profit of gill net without Danish seine (IDR million)*	*Loss of gill net profit (IDR million)*
A	*B*	*C*	*D=C-B*	*E*	*F*	*G=F-E*	*H*	*I=H-E*	*J=I-G*
2008	709	3,100	2,391	1,498	31,166	29,668	136,363	134,865	105,197
2009	766	2,112	1,346	999	33,691	32,692	92,892	91,893	59,201
2010	1,285	3,827	2,542	1,881	56,531	54,650	168,349	166,468	111,818
2011	1,465	5,402	3,936	2,763	64,462	61,699	237,617	234,854	173,155
2012	665	5,402	4,737	2,763	29,231	26,468	237,617	234,854	208,386
2013	1,657	5,402	3,745	2,763	72,878	70,116	237,617	234,854	164,738
2014	1,200	5,402	4,202	2,763	52,765	50,002	237,617	234,854	184,852
2015	1,210	11,414	10,204	7,456	53,231	45,775	502,106	494,649	448,874
2016	4,183	5,402	1,219	2,763	184,007	181,244	237,617	234,854	53,610

Note: Assumption of cost per unit effort is IDR 33,287,385 per year and price of fish is IDR 43,989,170 per tonnes.

In actual conditions (Danish seine exists), gill net fisheries has experienced overfishing, that the number of gill net units in 2015 was 224 units (exceeding the optimum level production or MSY). Overfishing often occurs in open access fisheries. According to Guillen et al (2013), most worldwide fish stocks were overexploited, and exploited beyond the Maximum Sustainable Yield (MSY) and the Maximum Economic Yield (MEY). In certain regions, fisheries are managed based on single species, however, in reality, most species are caught together with other species and by different gears. The MSY and MEY equations in the Gordon-Schaefer model (using the assumption of single species and single fishing gear) can produce invalid findings if applied to the case of multi-species and multi-gears fisheries. The phenomenon of overfishing on the coastal area of Tegal should be responsed by implementing an environment-friendly fisheries management while still taking into account a social interests in the short term.

The production of Danish seine is greater than the production of gill net. This is because Danish seine has greater fishing power than gill net. However, gill net is more selective in catching fish and produce higher fish prices than Danish seine. Figure 5 shows the loss of gill net production compared to the production of Danish seine. In general, loss of production of gill nets can be replaced by the production of Danish seine. However, economically the production value of gill net is greater than the production value of Danish seine. Fish caught by Danish seine has a lower price because the fish is under size and the fish meat is destroyed. While gill net fisheries produce more selective fish size and better quality product (Wijayanto et al 2018, 2019).

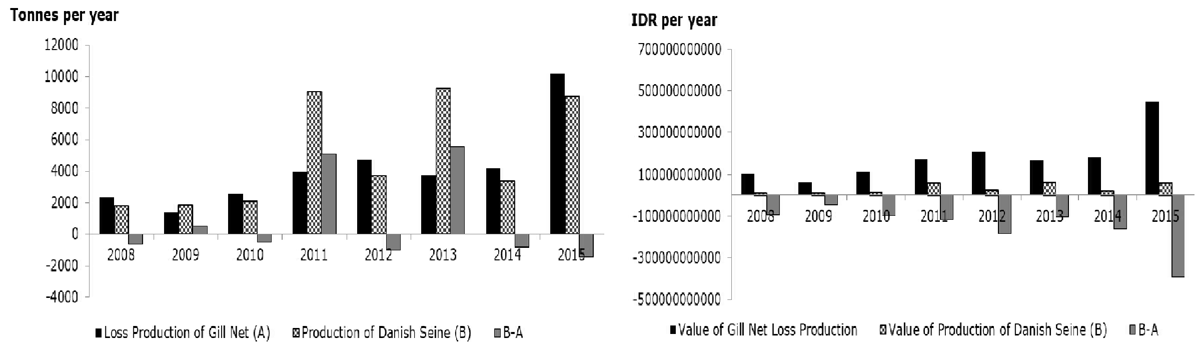

Figure 5. The loss production and value of loss production of gill net (assumption of fish price are IDR 44,445,167 per tonne (gill net) and IDR 6,607,576 per tonnes (Danish seine)).

The minimum catch size setting can control fish mortality based on age groups to protect small fish that cannot be used for human consumption. Consequently, the efficiency of capture can decrease, but can improve a stock of fish resources. The fish prices will be higher if fishermen use more selective fishing gears (Prellezo et al 2017). Large-scale fisheries can change the distributions of species. Changes in the distribution of stocks and catches may occur across regional and national boundaries (Daw et al 2009).

According to Sobers (2010) and Évora (2016), policy makers are confronted with the task of maximizing production, profit and maintaining employment on one hand and avoiding the risk of industry collapse in the near future due to resource depletion on the other hand. Measures of control are divided in two categories: the input control (including exclusive areas, seasonal closing, effort allocation, etc.) and output control (including TACs or total allowable catches and individual quota). According to Edvardsson et al (2011), most nations of the world have imposed either input (effort) control systems in fishing, or output controls. Input systems are based on restricting access, fishing gear, times of fishing, or fishing ground. These control systems are often referred to as total allowable effort (TAE). Output control systems place limits on the total allowable catch of nominated species.

Conclusions. Base on this research, the production function of gill net fisheries in Tegal region follow the equation: $Cgc = 73.39\ Eg - 0.100\ Eg^2 - 0.344\ Ec$. The Danish seine operation in the period of 2008 to 2016 had negative impact to gill net production. The average of gill net production loss was 3,814 tonnes per year and equivalent to IDR 167,759 million million per year. The loss production of gill net can be replaced by Danish seine production, but the loss value of gill net production is greater than the Danish seine production value.

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