

Fishery Performance Indicators (FPIs) and Production Analysis: What Works  
Before and After the Ban of *Cantrang* Trawl Fishing in the Java Sea–Indonesia

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Abstract

Fishery Performance Indicators (FPIs) and Production Analysis: What Works Before and After the Trawl Ban *Cantrang* Fishery in The Java Sea–Indonesia?

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The Fishery Performance Indicator (FPI) and production analysis are used to assess and evaluate the impacts of a partial ban on performance of the *Cantrang* -a modified Danish seine that targets demersal species and squid- in the Java Sea. The goal of the ban was to limit ecological impacts of fishing by limiting effort. Although called a “ban”, 46% of the vessels were reissued permits to fish shortly after total prohibition. We find that there is no improvement in the ecological outcome after the implementation of the ban, as the proxy data shows declining catch per trip of almost all harvested species. The ban reduced the supply of key fish species, resulting in price increases that benefitted the fishermen, but with increased price volatility. High scores for metrics of local labor participation and involvement to the fishery, as well as the better wage of local crews, skippers, and workers compared to other similar occupations during the post-ban, indicate the ban benefitted the community of the primary port. Despite the fleet reduction, employment decreases arising from the ban were much smaller, as it coincided with 30% increases in crew sizes. This was driven

primarily by an increase in the portion of the fleet with onboard freezers, which require more packing and sorting labor, but facilitate longer trips. Controlling for prices, production models suggest the increase in crew size accounted for 90% of the increase in revenue, which reveal a significant revenue increased at post-ban because of the substantial effect of the crew, while the GT size and trip length contributing only 8% increase of the revenue.

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## 1. INTRODUCTION

As an archipelagic nation, Indonesia has 13,472 islands positioned beneath the Equator between the Indian Ocean and the western Pacific Ocean. With 95,181 kilometers of coastline, Indonesia is also the second largest marine capture producer in the world (FAO, 2017). Recently, the global capture data from the FAO stated that Indonesian marine capture production had increased significantly from 6,016,525 tons in 2014 to 6,584,419 tons in 2016. Indonesia has also revised its standing stock estimation from 6.4 million tons in 2015 to 12.4 million tons in 2017, an almost two-fold increase, as a result of the authority re-assessment of stock in 2016 (Ministerial Decree of Ministry of Marine Affairs and Fisheries Republic of Indonesia Number 50 of 2017).

Indonesia has long followed a policy that is likely to expand its fishing capacity rather than lead to a sustainable fishery resource management policy. Particularly in the Java Sea, the densest fishing ground within the country, very little action has been taken to diminish new entrants into the fishery. Several factors have contributed significantly to the expansion of fishing capacity in the Java Sea including the distribution of new and advanced fishing technology, infrastructure expansion, and human overpopulation along the northern coast of Java (Squires et al. 2003). As a result, the number of new entrants has increased, particularly during the period before the trawl ban implementation in 2015. According to the Tegal port landing annual report, the number of *Cantrang* vessels that landed during 2007 was 1,484, and it almost doubled to 2,545 in 2016. The initial data collected from the Tegal port also showed that the majority of the crews consisted of young people who worked as seasonal *Cantrang* fishing labor. The considerable increase of young, local workers who rely on the fishing industry, along with

the increased market demand for the commodity exploited by *Cantrang* for the surimi market, the market of minced fish product, shows that the fishery is vital to the community.

Due to a lack of specific regulations and insufficient government monitoring, Indonesia's fishery has been gradually drained of its resources, particularly in the Java Sea. Fishing in the Java Sea is open access, with no exclusive rights or total allowable catch quotas, as is generally practiced in countries with well-managed fisheries. The problem of lax regulation has persisted for more than 40 years. From 1978 to the present, a handful of regulations have been enacted in an effort to manage the fishery.

The Ministry of Marine Affairs and Fisheries (MMAF) implemented one of the most important by imposing a ban on trawl fishing in all Indonesian waters in 1980 due to the escalating fishing-gear and fishing ground conflicts that often occurred among fishing vessels in the Java Sea. This regulation, however, still allowed other fishing methods such as purse seining and longlining without explicitly limiting the number of permits. This regulation fundamentally changed fishing behavior and shifted the use of fishing gear from the trawl to the purse seiner.

In another example, the recent Ministerial Decree of Ministry of Marine Affairs and Fisheries Number 71 of 2016 imposed limits on the sizes and fishing zones of purse seiners and longliners without limiting the number of vessels. The details of the decree allow vessels sized at 5–10 gross tonnage (GT) to get permits at the district level and fish up to four nautical miles from the shore. Vessels sized between 10–30 GT can obtain permits from the provincial management authority and can operate 4–12 miles from the shore. Meanwhile, vessels over 30 GT must get a permit from the ministerial management authority and can fish in the Indonesia Economic Exclusive Zone (IEEZ). There was no regulation imposed to limit the number of boats, which could have helped to regulate the fishery. In the meantime, many boat owners and

managers have down-sized and practice doubled-permit manipulation to avoid the lengthy process of getting a fishing license at the ministerial level.

The Danish seine-like trawl fishing technique known locally as *Cantrang* was introduced to the Java Sea in 1978. Since its introduction, *Cantrang* has become the fishing method that contributes most significantly to Indonesian marine capture production. *Cantrang* fishing in the Java Sea accounted for 30% of the total national marine capture landings (Nugroho et al. 2017). Although *Cantrang* fishing mainly targets high-value commercial fish such as squid and threadfin bream, the vessels also catch low-value demersal species such as goatfish and purple-spotted bigeye. According to the statistical data of the Indonesian Ministry of Marine Affairs and Fisheries (MMAF), the total standing stock of demersal fish in the Java Sea is 354,692 tons with an estimated potential/target yield of around 283,700 tons in 2012. Although *Cantrang* fishing has contributed to most of the landings of demersal species in the northern Java Sea, information on the effect of its regulation is minimal. The government, through the MMAF, enacted a regulation to ban trawler fishing—including *Cantrang* fishing—in the Java Sea in 2015. The ministry perceived *Cantrang* as a harmful technique because it often catches small fish and causes physical damage to the seabed ecosystem. On the other hand, thousands of fishers and boat owners, as well as the industries related to the fishery, have suffered losses since the decree implementation and have raised massive protests against the regulation.

Because fishers and stakeholders have protested the ban, the Ministry would like to gather a set of baseline information regarding the management performance of *Cantrang* fishing in the Java Sea both before and after the implementation of the 2015 ban. Information about the management performance of the fishery is beneficial for the government to re-evaluate the effectiveness of the policy. Information concerning how *Cantrang* fishing contributes to

community income, the economic benefits the fishery brings to the community, and whether the community accepts and supports the fishery are some critical points that should be well known before and after enacting the regulation. Such research could help the management authority to develop a proper management approach.

The Fishery Performance Indicators (FPIs) are a powerful assessment tool that can be used to assess the fishery management performance of *Cantrang* fishing. The tool could help in broadly evaluating the effectiveness of the fishery management system as well as figuring out what works best in a particular fishery (Anderson *et al.*, 2015). Knowing the key indicators regarding the three pillars (ecological, economic, and community) of the *Cantrang* fishery might help the management authority to build a solid foundation for implementing proper regulations. Therefore, to achieve this goal, an assessment of the Fishery Performance Indicators (FPIs) of *Cantrang* trawl fishery is of urgent need.

Additional research on the production function is also critical to better understanding fisher behavior in the fishery. Such research helps to identify the factors that may contribute to fishing revenue, catches, how those factors interact with one another, and how the impacts of the trawl ban policy have affected the fishery. The FPIs assessment of *Cantrang* fishing will provide a wide-range description of how management of the fishery conveys benefits to the community, stakeholders, and the fish stock itself, while the study of the production function of *Cantrang* fishing provides comprehensive knowledge on the behavior of the fishers and the technological changes of the fishery.

This study assesses and evaluates the performance of the management system of *Cantrang* fishing in the Java Sea by evaluating 68 performance indicators based on expert judgment and scientific documentation. The aims of this study are: (1) to evaluate the

performance of the *Cantrang* fishery management system in the Java Sea before and after the ban imposed on the fishery by examining its Fishery Performance Indicators (FPIs) (the FPIs also evaluate which indicators are at work on the triple bottom line [TBL] aspects: Ecology, Economic, and Community, of the fishery), and (2) to identify any changes in the technological input in the fishery by analyzing the effects of the capital, labor, and effort factors in the fishery. The production analysis can also determine whether the gross tonnage (GT), number of crew, and inter-trip days of the vessels have a positive contribution to the total revenue of the harvesters.

### **1.1. Technical Specification of the *Cantrang***

A *Cantrang* is a modified Danish seine that is operated like a trawl. The net is deployed by releasing and submerging two sets of warp wires to the seafloor while keeping the boat moving at 1–2 nautical miles per hour. After the net is wholly submerged, the leading boat then pulls out the two sets of warp wires horizontally. A modified roller powered by an auxiliary engine helps to optimize lifting during the net setting.

The total length of the warp rope ranges between 1,000 and 6,000 meters. A boat of greater than 30 GT generally has 6,000 meters of warp rope, while a boat of less than 30 GT has a warp rope length of about 1,000 meters. The warp rope is generally made from polyethylene with a diameter size range from 1 to 1.5 inches.

The fleet of active *Cantrang* vessels based in the Tegal port range from 10 to 100 GT, with vessels of 30 GT to 60 GT dominating the composition of the active vessels. The average fishing trip duration for *Cantrang* vessels was 14 days for vessels of 5–10 GT, 12 days for 11–20 GT, and 95 days for 21–30 GT (Ernawati et al. 2011). Although the vessel size registered on the

permit is predominately within the range of 30–60 GT, the actual size of the vessel may exceed the size on the permit. Many boat owners have reported smaller sizes than the actual sizes of their vessels.

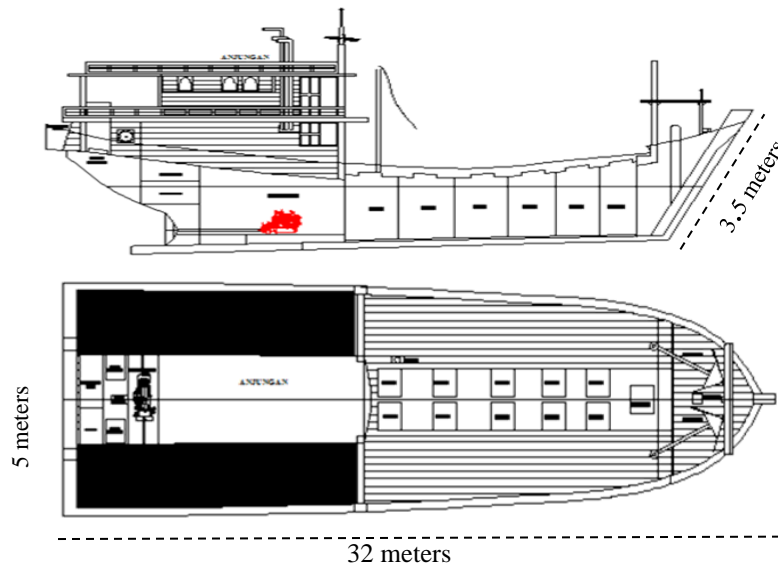


Figure 1. Construction design of *Cantrang* vessel (Radhiya et al., 2016).

## 1.2. Net Design of *Cantrang*

The Indonesian Ministry of Marine Affairs and Fisheries has categorized the *Cantrang* as a boat-towed seine that is hauled by a vessel with an auxiliary engine to pull up the towing wrap. Although categorized as a towed seine or Danish seine based on its operational method, the net itself has a design that looks similar to, but is simpler than, a trawl net. The net has a tickler chain on the bottom and headline floats on the upper side of the body that help it open when the boat tows it.

Like a trawl, the net is targeted to operate down through the seafloor. The preliminary study (Ernawati and Sumiono, 2009) has shown that most of the *Cantrang's* catch is dominated

by demersal fish such as goatfish, purple-spotted bigeye, striped pony fish, Indian halibut, and giant catfish. The *Cantrang* net comprises three main parts. The first part consists of the left and right wings, which are designed to narrow the schooling fish through the belly part. The second part is the belly, constructed to trap and lead the catch through the cod-end of the net. The last part, the cod-end of the net, is designed to retain the catch.

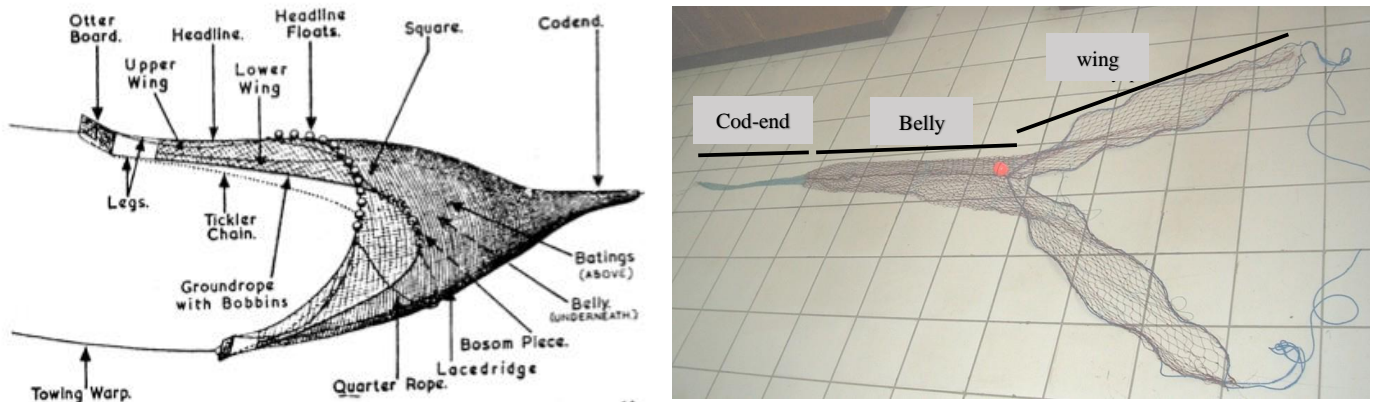


Figure 2. Net design of a New England otter beam trawl (left) and miniature design of *Cantrang* trawl net (right).

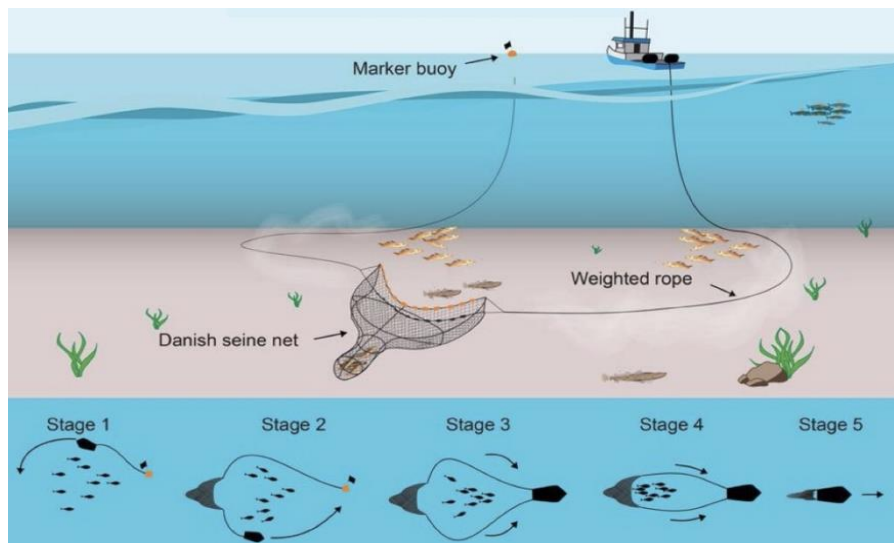
Table 1. Vessel and net specification of *Cantrang*.

Vessel and Gear Component		Vessel and Net Material
<b>Vessel Specification</b>		
Vessel length		18–25 m
Vessel width		5–7 m
Height		2.5–3 m
Vessel material		Wooden
Engine Horse Power (HP)		80–300
GT		20–172
<b>Net Specification</b>		
Headline	Length:	2400–2500 m
	Material:	Polyethylene (PE)
	Diameter:	40 mm
Ground-rope	Length:	50 m
	Material:	Polyethylene (PE)
	Diameter:	40 mm
Upper-rope	Length:	50 m
	Material:	Polyethylene (PE)
	Diameter:	40 mm

	Code-end	Material: Polyethylene (PE)
		Mesh size: ½ to ¾ inch
	Belly	Material: Polyethylene (PE)
		Mesh size: 1 to 10 inch
	Left and right-wing	Material: Polyethylene (PE)
		Mesh size: 21 inch

### 1.3. The Operational Method of *Cantrang*

The *Cantrang* is similar to the Danish seine, but is modified and operated like a trawl. Most of the net lengths range from 2,400 to 2,500 meters, with warp wires measuring 1,000 to 6,000 meters. It is operated by first releasing the warp rope at the side of the vessel with a circular motion while constantly moving, then by releasing the net (see Figure 3). After the net has submerged, the other side of the warp rope is released until it reaches the first warp rope, then the warps are joined together and pulled by the vessel simultaneously. When setting the net, the boat is in constant motion for 1–2 nautical miles. Figure 3 illustrates how the *Cantrang* is operated.



Source: (Maritimeneews, 2018)

Figure 3. The operational method of *Cantrang* in the Java Sea.

#### 1.4. The Market and Product of *Cantrang*

*Cantrang* fishery is a vital source of income for thousands of fishers along the north coast of Java and has become a critical source of raw materials for the surimi industry in Indonesia, both for the export market and local consumption. The development of the surimi industry in Southeast Asia could help to utilize 40–60% of the trawl bycatch, which consists primarily of low-value fishes, and minimize waste from trawl fishing (Siriraksophon et al. 2009). The raw materials used for Indonesia's surimi production are dominated by threadfin bream (68%), goatfish (13%), croaker fish (10%), bigeye snapper (8%), and other species (1%) which come from the Java Sea and the seas around Riau, Jambi, and the west and south Kalimantan Provinces (Siriraksophon et al. 2009). According to the UN's trade statistical data, Indonesia is ranked sixth among the top 10 largest exporter countries in the world for fish meat products in 2016. The country exported about 43,700 metric tons (MT) and generated 156 million USD of value in 2016, slightly above Thailand, which exported 34,600 MT during the same year. The list of the top nine largest exporter countries of fish meat products is shown in Table 2 below:

Table 2. Top 9 exporter countries of fish meat products in 2016.

No	Country	Total Volume (tons)	Total Value (USD)
1	USA	230,184	545,096,920
2	Viet Nam	103,076	358,443,403
3	China	79,074	398,924,480
4	India	72,703	152,102,611
5	Norway	70,907	143,114,805
6	Indonesia	43,746	155,919,980
7	Thailand	34,641	98,906,662
8	Chile	31,894	307,531,918
9	Iceland	29,558	57,244,940

Indonesia’s fish meat products are mostly exported to Japan, Korea, China, the USA, and Thailand based on the United Nations Trade Statistics in 2019, as shown in Figure 4 below:

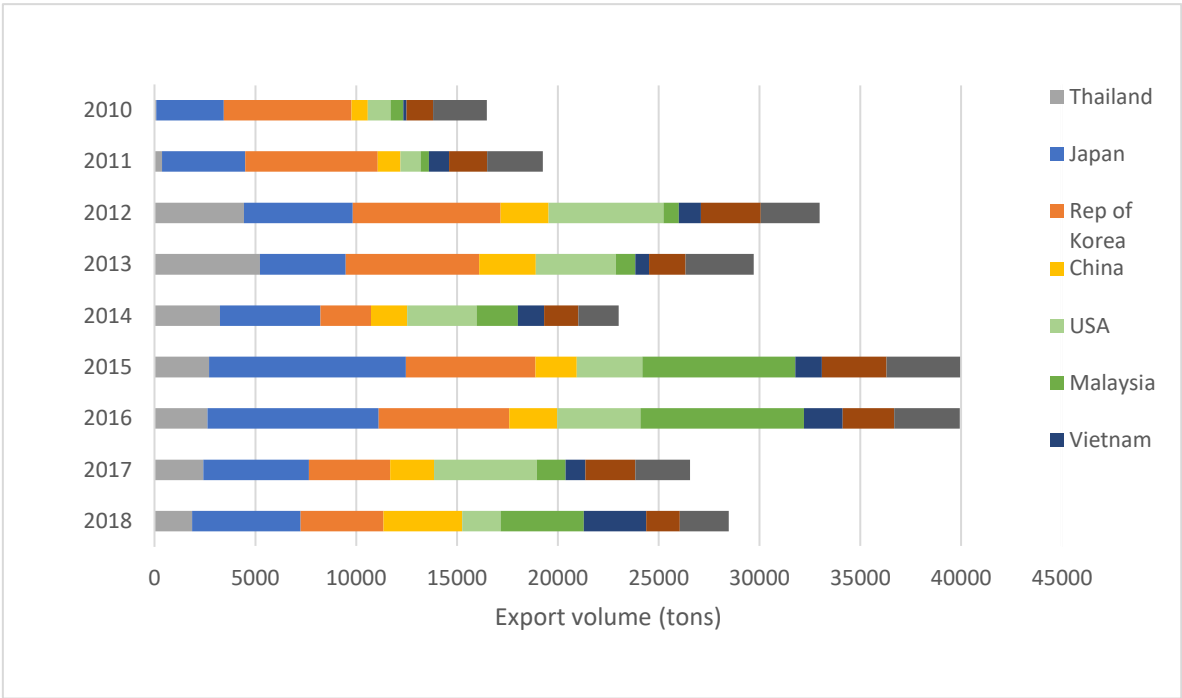


Figure 4. Indonesia's export of fish meat and its destination countries.

### 1.5. A Brief Description of the Ban on *Cantrang* Fishing

In 2015, the Ministry of Marine Affairs and Fisheries (MMAF) of Indonesia ordered Decree No. 5/2015 to halt fishing for any trawl-like fleets in all Indonesian waters. The decree listed *Cantrang* as one of the banned vessels. Although the regulation was first enacted in 2015, the ministry issued a formal request in 2016 to accommodate a transition period for the ban until 2017, during which time those vessels with active permits that had done the GT re-measurements could continue operating. During the transition time, all vessels were supposed to switch their fishing gear from the *Cantrang* net to the "millennial" net, a kind of gillnet assumed to perform unlike the *Cantrang* economically and environmentally.

Since the ban was implemented in 2015, the initial data collected from the Tegal port shows a significant decrease in the number of boats landing after the ban compared to before the ban. In 2015, the number of vessels operating in the Tegal port was 2,683. That number fell to 779 vessels in 2017—a drop of 70% in the two years following the ban’s implementation. Vessels with expired licenses were not allowed to fish since no new permits were issued during the ban, while vessels with active licenses that passed the GT re-measurement program could continue fishing. This evidence indicates that the ban effectively impacted the fishery.

In 2016, the Ministry ordered Decree No. 72/2016, which instructed fishermen to switch their fishing gear from *Cantrang* to gillnet as soon as possible. However, following this second order in 2016, only a handful of fishers followed the regulation. Most of the fishermen declined to follow the new rule because they believed the gillnet would not be able to catch as much or generate as much revenue as the *Cantrang*. As stated in the latter ministerial decree, no permits were issued for new entrance vessels during the transition phase, while existing vessels were able to extend their permits even if the permits were due to expire during the transition. To be able to get the permit extension, each vessel was required to conduct size re-measurement (of GT) to minimize the practice of marking down real GT size.

## **1.6. Objectives**

This study aims to (1) evaluate the management system performance of *Cantrang* fishery in the Java Sea in Indonesia by comparing its Fishery Performance Indicators (FPIs) from before and after the trawl ban regulation imposed on the fishery (the FPIs will also determine what indicators affect the TBL aspects of the fishery), and (2) in the production analysis, to assess whether production inputs such as capital, labor, and effort have significant impacts on the total

revenues of the fishery. The production analysis determines whether the gross tonnage (GT), the number of crew, and inter-trip days of the vessels make a positive contribution to the total revenue of the harvesters.

## **2. METHODS**

### **2.1. Research Methods**

#### **2.1.1. Assessment of Fishery Performance Indicators (FPIs)**

This study applied multiple metrics of FPIs developed by Anderson et al. (2015). The metrics assess the essential aspects of the three-dimensional pillars (triple bottom line/TBL) using a 1-to-5 scale that is scored based on an expert assessment or the availability of the proxy information for each metric in question. The three indicators/outcomes of TBL (ecology, economics, and community) for *Cantrang* fishery consist of 68 metrics that precisely measure the performance of the fishery in a range of 1 to 5, where 5 reflects best performance and 1 indicates the worst performance.

In this FPI scoring, the author acted as the scorer. All the FPI matrices were scored (both prior to and after the ban) by considering the scorer's extensive knowledge of *Cantrang* fishery. Field visits and consultations were conducted to collect data on landings, income, asset value, catch prices, and socio-economics. Scores were not given directly during the interviews in the field; rather, the author used the information collected from the interviews and other quantitative data to facilitate scoring. All scores and justifications behind the given scores were then reviewed by the FPI developer to control for and assure the quality of the scores.

Adjustments were required for scores with potential biases based on the author's experience. For instance, the output metric "Functionality of the Harvest Capital" was given a

score of 4 in both 2012 and 2017, as the author believed the harvest capital units (vessels, weirs, etc.) of the fishery were well maintained. However, based on relative scores from Indonesia FPI databases from similar fisheries, it was determined these scores were not as good as previously thought. Therefore, both scores were adjusted and downgraded.

### 2.1.2. Production Function Analysis

A production function describes the relationship between the physical quantity of output of goods (landing or revenue) and the specific combinations of the physical quantities of inputs used in a production process. In this model, the Cobb-Douglas production function was used to describe the relationship between the total revenue generated by the *Cantrang*, while effort and capital (gross tonnage, number of crew, and inter-trip days) were used as the physical inputs of quantities to generate the revenues.

One of the aims of this research is to define whether changes in gross tonnage (GT), the number of crew, and inter-trip days over 11 years have made a positive contribution to the total revenues of *Cantrang* fishery. The available data were the gross tonnage (GT), number of crew, and inter-trip days over a span of 11 years (2007–2017) for the individual vessels. The data is categorized as a panel since it has both time and cross-sectional aspects (the numbers of individual vessels). The basic model is the stochastic Cobb-Douglas production function written as follows:

$$y = AK^{\alpha}L^{\beta_1}T^{\beta_2} \dots\dots\dots (i)$$

where:

- A is the technology
- $\beta_1$  is the elasticity of labor (number of crew) ( L )
- $\beta_2$  is the elasticity of capital ( K )
- $\beta_3$  is the elasticity of inter-trip days ( T )

Hannesson (1983) assumed the above function could multiply an error term  $u$  whose logarithm has an expected value of zero and a constant variance. Transforming the function into the logarithms gives the parameters to be estimated as follows:

$$\ln y = \ln A + \beta_1 \ln L_{it} + \beta_2 \ln K_{it} + \beta_3 T + \ln u_{it} \dots \dots \dots (ii)$$

In this model  $i$  refers to an individual vessel,  $t$  denotes the time, and  $u$  is the error term. The presence of individual vessels for each month in the fishing season is included to estimate the seasonality effect (months of fishing) on the total revenue. It is assumed that the parameters of intercept  $A$  and the slope of the log-linear model are different for each of the individual vessels over the fishing season each month. Next, the dummy  $(n - 1)$  variable months, using dichotomous values (0, 1), were introduced into the model. Adding the monthly dummy variables into the model give the parameters estimated as follows:

$$\ln y = \ln A + \beta_1 \ln L_{it} + \beta_2 \ln K_{it} + \beta_3 \ln T_{it} + d(M) 1 + d(M) 2 + \dots d(M) 11 + \ln u_{it} \dots \dots \dots (ii)$$

In this model, the month of 12 is the reference. The significance test on the input variables and the seasonal effect were also conducted using the z-test. The model parameterization and the hypothesis test were conducted using the *plm()* function in *plm package* in *R*.

## 2.2. Data Requirement

The time-series data of catches, effort, number of crew, and inter-trip days were collected from the Tegal port landing for an 11-year data series from 2007 to 2017. Besides the landing data, the technical information of the vessels, including size, operational cost, fuel consumption, and crew insurance information was also collected. Fisher insurance data helps with estimating the age range of the skippers and the origin and seasonality pattern of labor workers engaged in

the fishery. All the data was collected by the enumerators hired by the local ministry office in the Tegal port. The data covers the daily landing activities of 20 commercial species harvested by *Cantrang* fishers for 2007–2017, including the catch of each species, the ex-vessel price, the GT size of each vessel, the number of crew, the vessel ID, the origin of the vessel, and information about the fishing ground. There were 20 commercial species landed and recorded along with the daily prices of each species per vessel during the period.

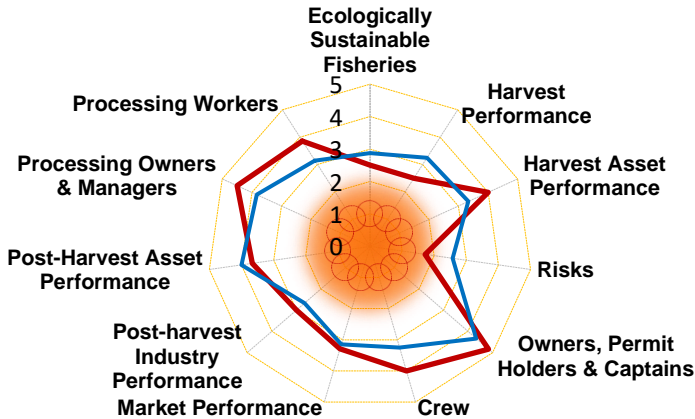
### **3. RESULTS**

#### **3.1. Fishery Performance Indicator (FPI)**

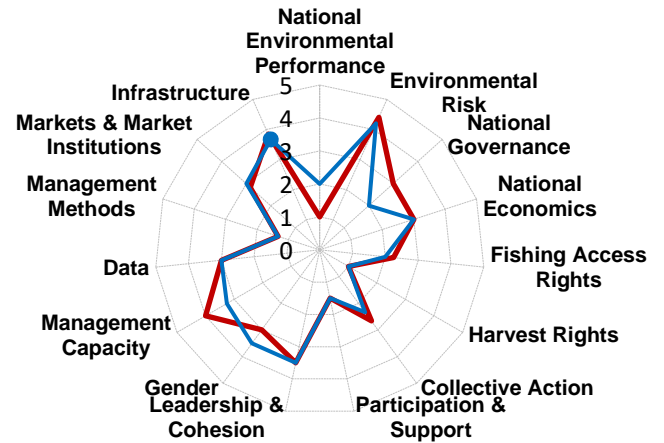
In this research, 54 input and 68 output metrics are used to measure the management system performance of *Cantrang* fishery before and after the ban. Among the output dimensions, landing volatility, degree of overfishing, and fishing regulation are some of the critical indicators evaluated to identify the impacts of the fishing ban on the *Cantrang* fishery management system. On the other hand, input indicators such as quality management systems and market conditions have also been weighted to reflect what changed over the 11 years, in pre-ban and post-ban terms. The output indicators are meant to determine whether the fishery is contributing economically viable and socio-ecologically sustainable outcomes, while the input indicators reveal enabling conditions that contribute to the process of incentivizing socio-ecologically sustainable use of the resources (Anderson et al., 2015).

Figure 5A compares the average output performance of the *Cantrang* fishery before and after implementation of the ban, while Figure 5B compares the average input performances.

## 5A. Output Dimension Scores



## 5B. Input Dimension Scores



Figures 5A and 5B compare output and input dimension performances of *Cantrang* fishery before and after the ban. Blue color represents pre-ban, and red color represents the post-ban.

When comparing the before and after, the TBL reflects a development in some dimensions, but underperformance in others. The average outputs on performance of the *Cantrang* fishery system on stock health, risk, and harvest performance are at 2.5, 1.7, and 2.5, respectively, and this shows these dimensions are underperforming. There are sizeable average performance gaps in the harvest, harvest asset performance, crew, and risk dimensions. The harvest performance outperforms 3.5 in 2012 at pre-ban and declines to 3.2 in 2017 post-ban. The local labor dimension in the community sector shows scores of 4.5 in 2012 and 5 at post-ban.

Interestingly, the risk dimension shows a large underperformance gap during the period after the ban in 2017 compared to the score before the ban. The volatility of the revenue, landings, and catch price at post-ban causes very low scores for metrics in the risk dimension. These high fluctuations of price, revenue, and landing during the pre-ban and post-ban term are described clearly in the proxy data that is used when scoring the metrics in the risk dimension as shown in Figures 10, 11, and 12.

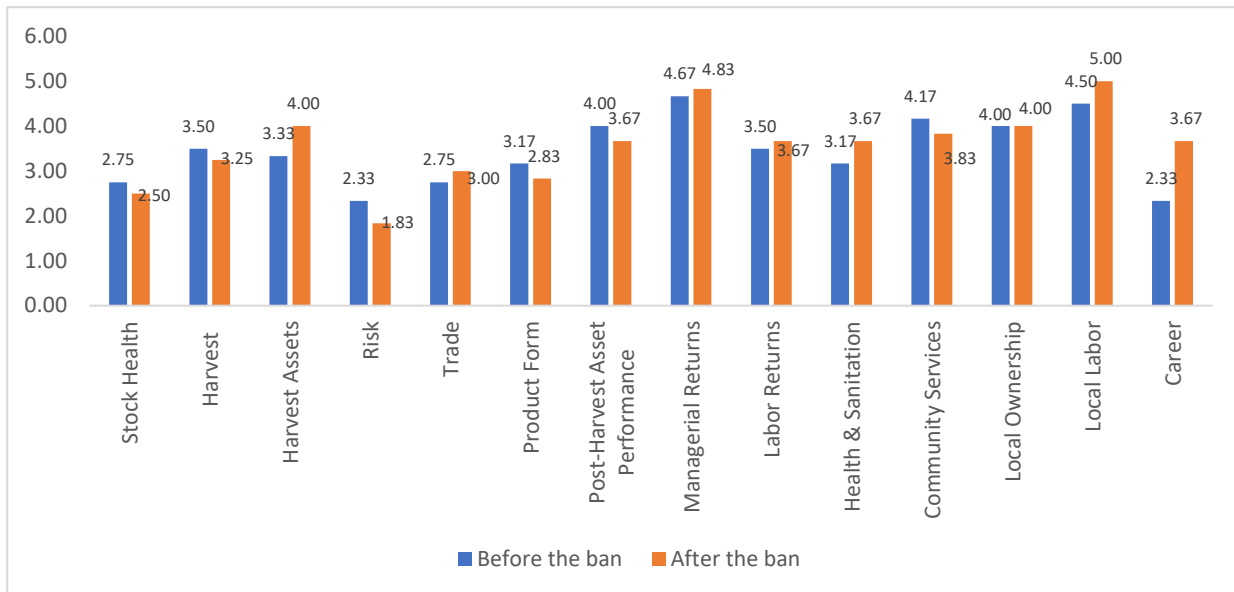


Figure 6. Fishery Performance Indicators: Outputs by triple bottom lines indicator

Figure 5B compares the performance of input dimensions before and after implementation of the ban. It shows slight improvement on four indicators from 2007 to 2017: the national government, management capacity, infrastructure, and environmental risk. However, the Environmental Performance Index (EPI) shows a poor score in 2017 compared to the score in 2012. The other input indicators, such as the fishing access rights, the harvest rights, the management methods, and markets and market institutions, still show underperformance over the 11-year period. Improvements in the national government, management capacity, infrastructure, and environmental risk indicate investment in the fisheries management system and may have facilitated a change in performance outcomes (Chu et al., 2017). Improvements based on the TBL outputs are summarized in Figure 6 and Table 3.

In ecological health performance, the scores are relatively low at 2.75 and 2.5 at pre- and post-ban periods, respectively. This low score is given as a result of the declining trend of abundance index (catch per landing) of the majority species harvested by *Cantrang* (Figure 10).

This evidence confirms the occurrence of a massive exploitation of the fishery that reflects ongoing overfishing, and it does not imply a positive sign that leads to better stock health recovery. The ecological health performance is scored based on the proxy data of 11 years of daily landing and catch data collected from the Tegal port since 2007. The summary of this stock health proxy data can be seen in Figure 10.

In the economic performance, the harvest dimension received a low score and underperformed, from 3.25 in 2012 to 2.5 in 2017. This low score is related to the poor performance of the stock, as shown in Figure 10. In the risk dimension, low scores of some metrics have caused poor performance; the score was 2.4 in 2012 and then fell to 1.7 post-ban. This decline can be explained by the high volatility of the landing and price of almost all 16 harvested species, as shown in the proxy data of Figures 10–14. The high deviation ratio of the landing and prices reflect the uncertainty about the future income stream of the harvesters, particularly at the post-ban term compared to the stable price and landings before the ban in 2012 (Figures 10, 11, 12, and 13). This situation has consequences for the continued production of the processing plants that relied heavily upon the raw material supplied from *Cantrang*, since they are affected from shortages of supply resulting from the ban.

A significant improvement in community performance (Figure 6) is attributed to the high score on earning ratio of the local community, vessel crews, local boat owners, and the processor workers compared to the non-local. The career and local labor dimensions have also improved substantially. In 2012, the career dimension had a lower score of 2.3, then increased to 3.7 in 2017.

Table 3. Fishery performance indicators output performance.

INDICATOR	DIMENSION	Before	After
		AVERAGE SCORE	AVERAGE SCORE
Stock Performance	Ecologically Sustainable Fisheries	2.75	2.50
Harvest Sector Performance	Harvest Performance	3.25	2.50
	Harvest Asset Performance	3.33	4.00
	Risks	2.43	1.71
	Owners, Permit Holders & Captains	4.67	4.83
	Crew	3.25	4.00
Post-Harvest Performance	Market Performance	3.14	3.29
	Post-harvest Industry Performance	3.00	3.00
	Post-Harvest Asset Performance	4.00	3.67
	Processing Owners & Managers	4.50	4.50
	Processing Workers	3.43	3.86

### 3.2. The Production Analysis

The total revenue, as the single output of the model, is assumed to be the function of input factors such as labor (number of crew/skippers), capital (gross tonnage/GT), and effort (inter-trip days). These three input factors, and the constant variable, together reflect the technological progress that contributes to the total revenue of the fisheries within a certain period. Based on the Cobb-Douglas model, the total revenue of *Cantrang* has been positively affected by the substantial changes in the number of crew and inter-trip factors, as well as the seasonal effect. To isolate the collinearity effect of price on the revenue, three models have been used in this analysis. Model 1 represents the revenue calculated based on a fixed price of all-year data. Model 2 represents the revenue calculated by a fixed price of the pre-ban data (2007 to

2014), while Model 3 represents the revenue calculated by a fixed price of the post-ban term data (2015 to 2017).

All three models in Table 4 show that the number of crews contributes significantly to the total revenue in the fishery. Models 1 and 2 reveal that the number of crews together with the inter-trip day inputs are the essential factors that contribute to the total revenue of the fishery. Model 3 illustrates that only the number of crew affects significantly the revenue of the fishermen. Interestingly, although the total number of crew declined substantially during the post-ban (Figure 8), the number of crew per vessel is higher at post-ban compared to the pre-ban, with the crew and skipper still able to generate high revenue. The number of crews dropped more than 50%, from 75,834 people in the period before the ban (2007 to 2014) to 36,413 people post-ban, but the number of crew per fleet increased by 30% post-ban (Table 5 in the Appendix).

Based on model 1, the number of crew and the inter-trip days have a significant effect ( $p < 0.05$ ) on the total revenue of *Cantrang*, while the gross tonnage (GT) doesn't significantly impact fishermen's revenue ( $p > 0.05$ ). The model shows a substantial effect of the inputs, especially the number of skippers and the inter-trip days, reflecting the immense technological inputs of onboard freezer that have impacted the fisheries over 11 years.

Table 4 summarizes the parameter estimates and hypothesis tests of the gross tonnage (GT), inter-trip days, and number of crew, as well as the seasonal effect on the total revenue.

Table 4. Parameter estimates of three different models of Cantrang trawl fishery in the Java Sea.

Dependent variable:	Model 1 (fixed price of all data)			Model 2 (pre-ban fixed-price)			Model 3 (post-ban fixed-price)		
	log(Total Revenue)			log(Total Revenue)			log(Total Revenue)		
Variable	Estimate	std.error	Pr(> z )	Estimate	std.error	Pr(> z )	Estimate	std.error	Pr(> z )
log(Crew)	1.611	0.208	< 2.2e-16 ***	0.501	0.1130	< 2.2e-16 ***	0.501	0.1135	< 2.2e-16 ***
log(GT)	0.024	0.037	0.510	-0.018	0.0180	0.305	-0.018	0.0178	0.305
log(Intrip)	0.119	0.025	< 2.2e-16 ***	0.022	0.0270	< 2.2e-16 ***	0.022	0.0270	0.137
Jan	-0.044	0.048	0.354	-0.048	0.0150	0.137	-0.048	0.0149	0.102
Feb	0.075	0.044	0.088.	0.019	0.0290	0.102	0.018	0.0295	0.495
Mar	0.087	0.043	<b>0.042*</b>	-0.003	0.0270	0.495	-0.003	0.0273	0.909
Apr	-0.055	0.043	0.186	-0.057	0.0260	0.909	-0.088	0.0267	<b>0.0006***</b>
May	-0.013	0.045	0.774	-0.057	0.0260	<b>0.0006***</b>	-0.058	0.0260	<b>0.038 *</b>
Jun	-0.125	0.044	<b>0.005**</b>	-0.139	0.0270	<b>4.831e-07 ***</b>	-0.139	0.0278	<b>4.831e-07 ***</b>
Jul	-0.135	0.046	<b>0.0023**</b>	-0.113	0.0270	<b>3.553e-05 ***</b>	-0.113	0.0276	<b>3.553e-05 ***</b>
Aug	-0.062	0.044	0.177	-0.049	0.0270	0.080.	-0.050	0.0274	0.080.
Sep	0.104	0.044	<b>0.017*</b>	-0.035	0.0280	0.199	-0.035	0.0284	0.199
Oct	0.139	0.044	<b>0.0015**</b>	-0.041	0.0270	0.128	-0.041	0.0272	0.128
Nov	0.004	0.044	0.928	-0.025	0.0270	0.361	-0.025	0.0272	0.361
Constant	<b>13.310</b>	0.208	< 2.2e-16 ***	<b>16.672</b>	0.0270	< 2.2e-16 ***	<b>17.763</b>	0.0271	< 2.2e-16 ***
Observations	6,171			6,171			6,171		
R2	0.958			0.982			0.984		
Adjusted R2	0.958			0.982			0.93968		

Note: \*p<0.1; \*\*p<0.05; \*\*\*p<0.01

Model 1: The revenue calculated by fixing the price of all year data (pre and post-ban)

Model 2: The revenue calculated based on pre-ban-fixed-price

Model 3: The revenue calculated based on post-ban-fixed-price

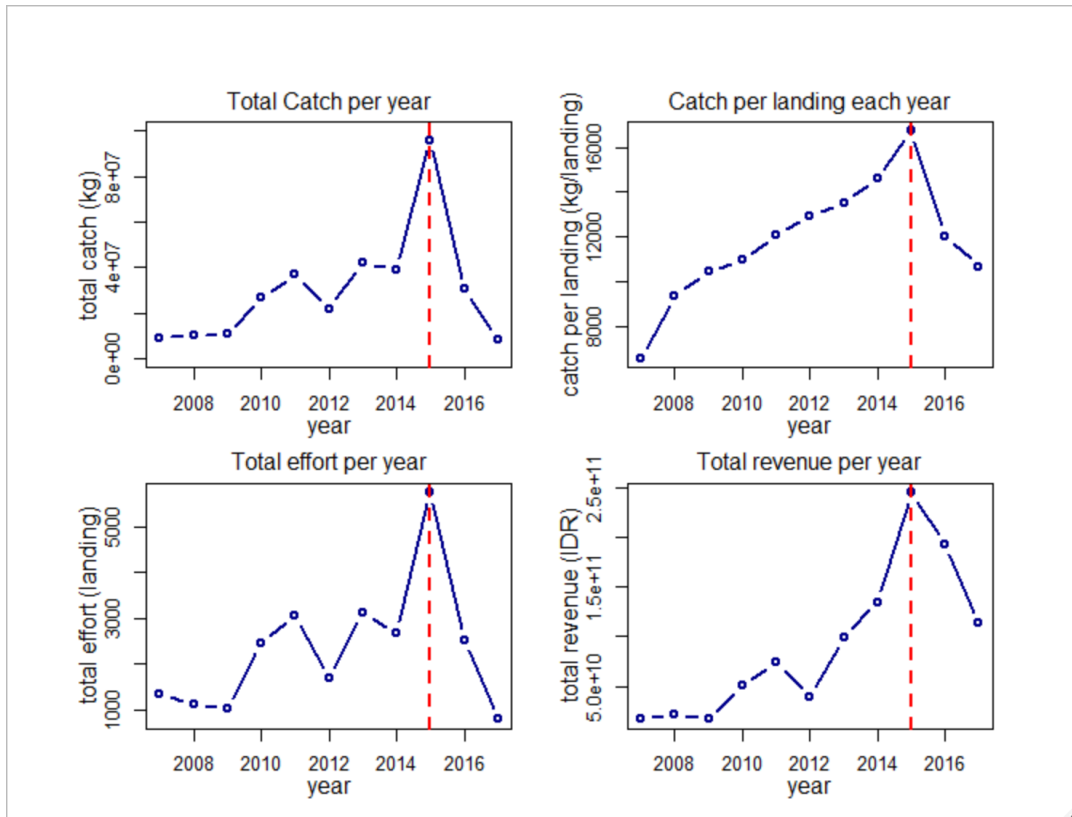


Figure 7. Total catch, catch per landing, total effort, and total revenue before and after the ban of *Cantrang*.

Figure 7 shows changes in catch, effort, catch per landing, and the revenue of *Cantrang* before and after the ban. Figure 8 below describes the development of whole crews at the pre-ban and the post-ban periods, while Figure 9 shows the development of crews per fleet, showing higher crews per fleet at post-ban.

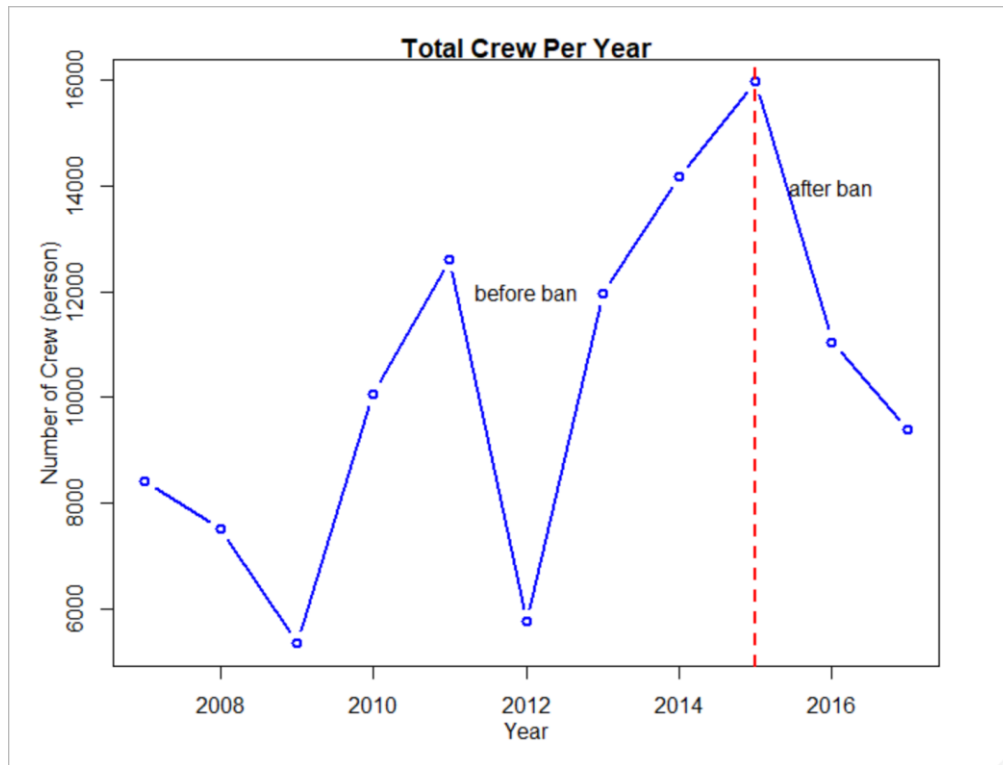


Figure 8. Total crew comparison before and after the ban of *Cantrang* fishing in the Java Sea.

The total number of *Cantrang* crews fluctuated over the 11 years from 2007 to 2017 based on the data gathered from the Tegal port, as shown in Figure 9. The decreased number of landings during 2012 resulted directly from the decreased number of total crews. The same pattern occurred in 2009, where the number of crews dropped to about 6,000 people. This phenomenon is related to external factors such as increased gasoline prices in 2009 and 2012, which doubled the cost of fishing and halted most of the vessels from trawling.

In contrast, the total number of crews shot up within a year of the ban implementation in 2015. The increased total number of crews is an effect of the increased total number of effort or active fishing fleets, as shown in Figure 7. This evidence, as shown in Graph 8, illustrates that the number of crews engaged in the fishery almost tripled from about 6,000 crews in 2012 to

16,000 crews in 2016, which might be related to the shock effect of the ban during the year of implemented in 2015, resulting in “race to fish” in the same year. Since the commercial-fishing enterprises are profit-driven and adding more crews in the Cantrang fishing would increase the revenue, the “race to fish” phenomenon becomes more severe during the post-ban period.

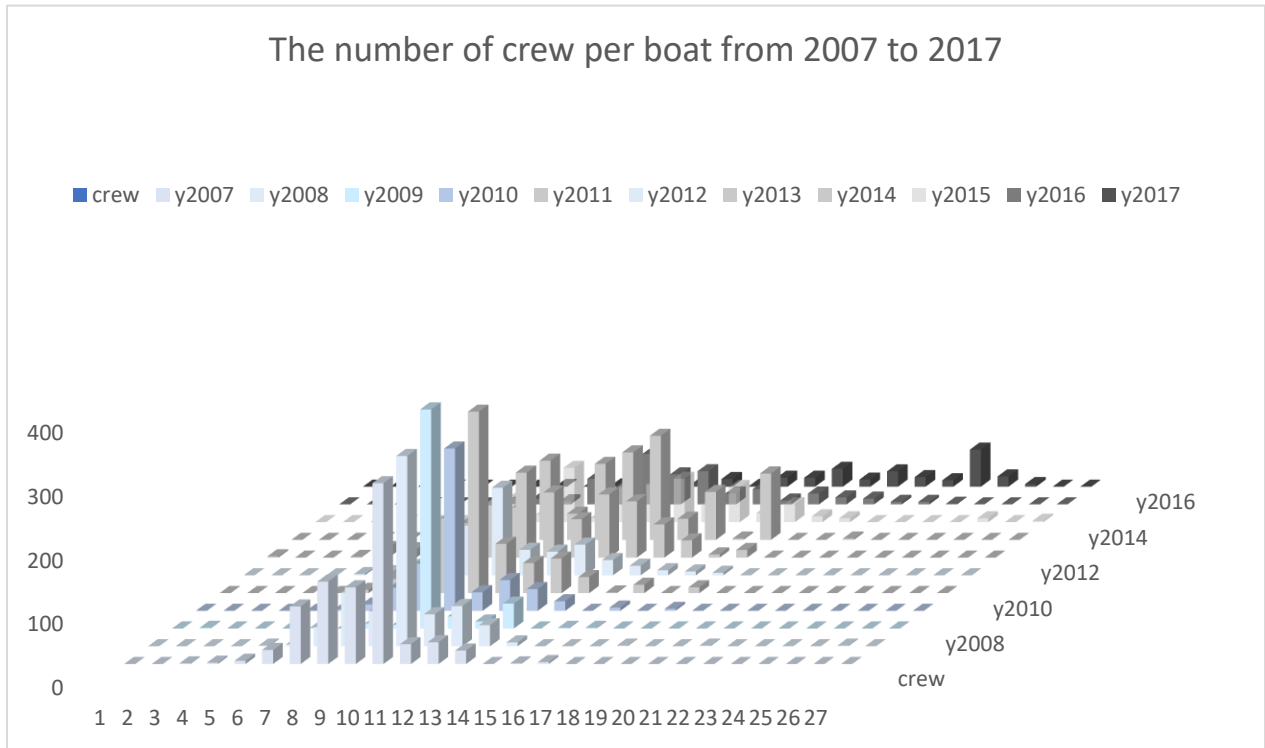


Figure 9. The development of number of crew per vessel from 2007 to 2017.

### 3.3. The Seasonal Effects on the Total Revenue

Fisheries in the Java Sea are seasonal since they are affected by the monsoon season. The amount and type of catch for some fisheries, such as those using purse seiners or gillnets, fluctuate and change seasonally. The rainy monsoon usually occurs during the period of mid-December to March and is indicated by intense windy periods with heavy rainfalls persisting for several days. The dry monsoon (involving strong winds) occurs from June to September and is more regular (Potier & Nurhakim, 1995). The severe weather could cause delays in transit to and from the fishing grounds and prevent both the setting and retrieving of nets.

The Cobb-Douglas frontier model in Table 4 shows the effects of the monthly seasonal pattern on the total revenue of the harvesters. Based on Models 1 and 2, the fishery gained low revenue from June to October and May to July, respectively. The similar seasonal pattern occurred during the post-ban period in Model 3, which shows a negative trend in revenue from April to July. These 3 models clearly show that declining revenues for *Cantrang* vessels most likely occurred from May to July and September to October over the years. Figure 10 depicts the average of the stock abundances (catch per landing) of the 16 species that landed in the Tegal port during the pre and post-ban terms, while Figure 11 summarizes the average price trend on a yearly basis. In Figure 13, the total revenue of *Cantrang* trawl fishery is graphed in yearly fluctuation to show the changes in revenue over the years, while Figure 12 and 14 shows the monthly basis changes of the revenue and catch/landing for each species, respectively.

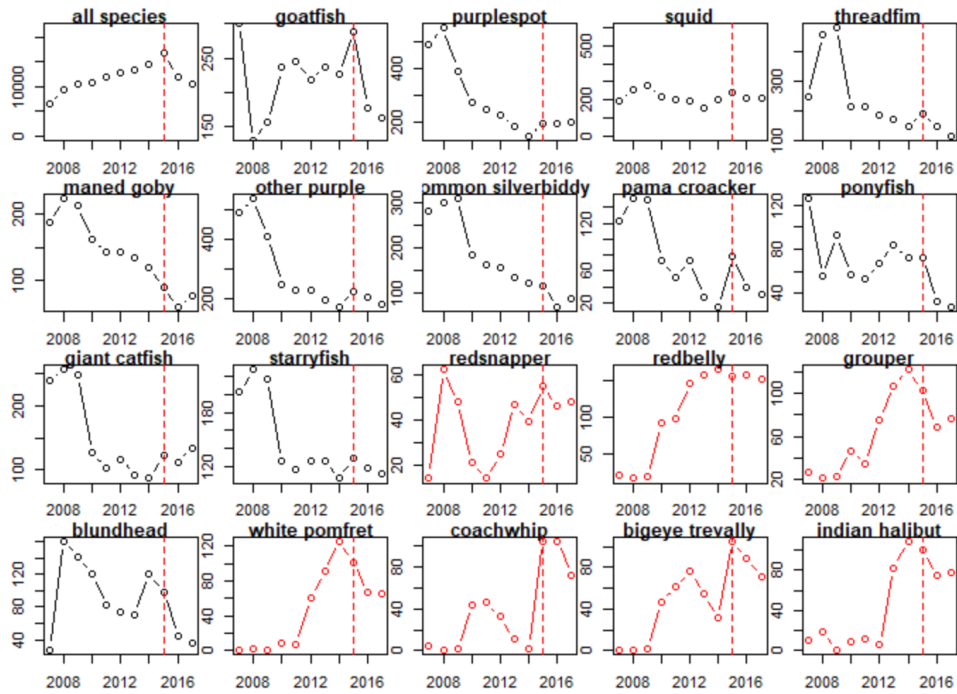


Figure 10. Yearly average landing (kg/year) of 16 species harvested by Cantrang in the Java Sea

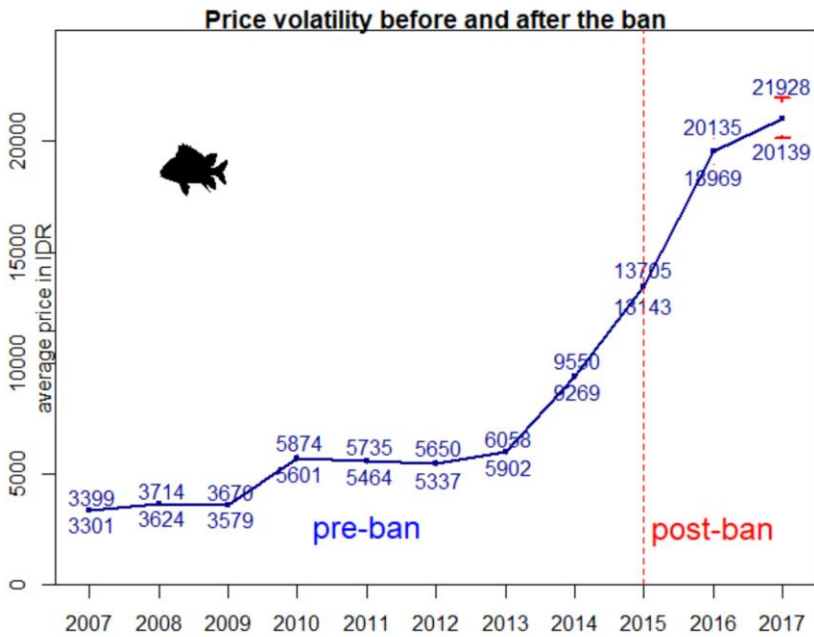


Figure 11. Price volatility before and after the ban implementation in 2015

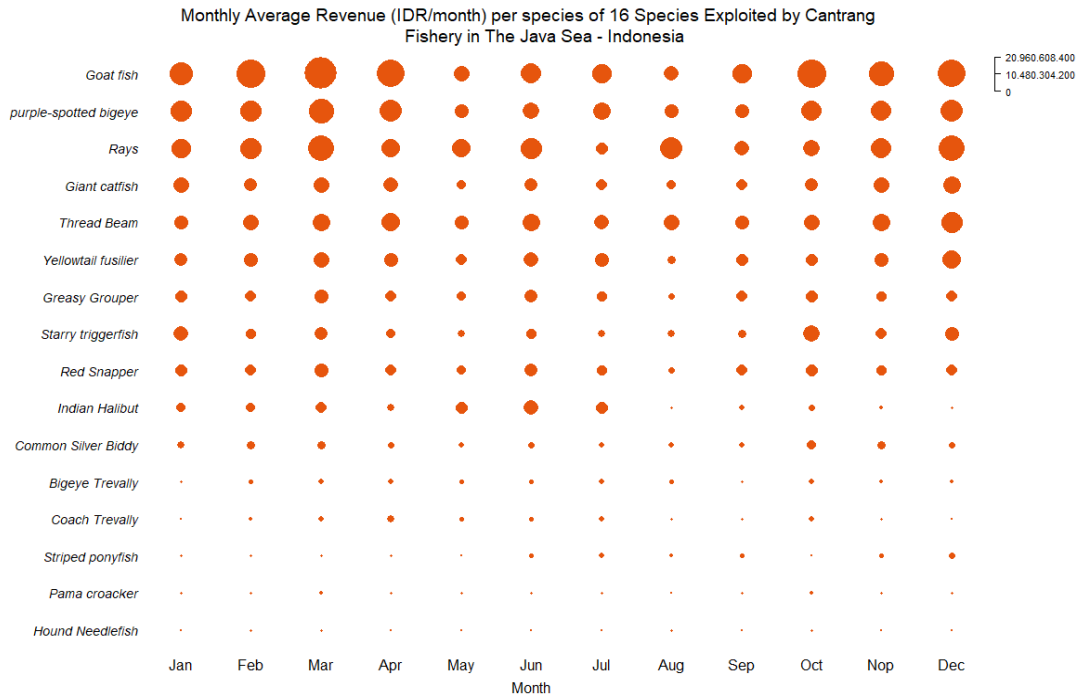


Figure 12. Monthly average revenue (IDR/month) of 16 species harvested by Cantrang fishery in the Java Sea

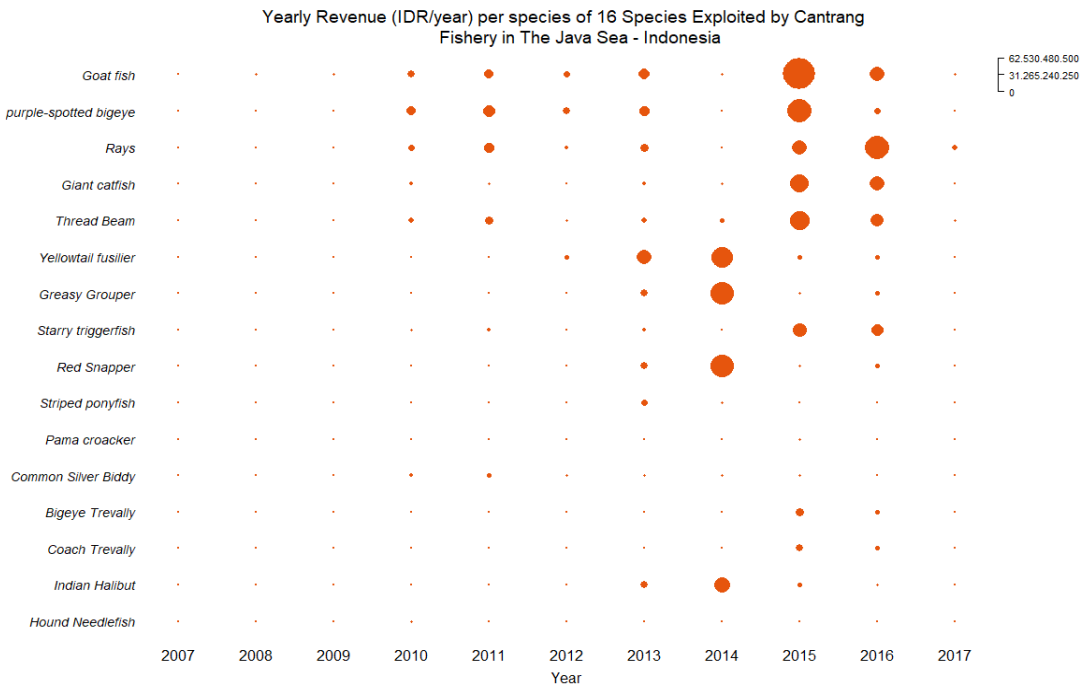


Figure 13. Yearly revenue (IDR/year) of 16 species harvested by Cantrang in the Java Sea

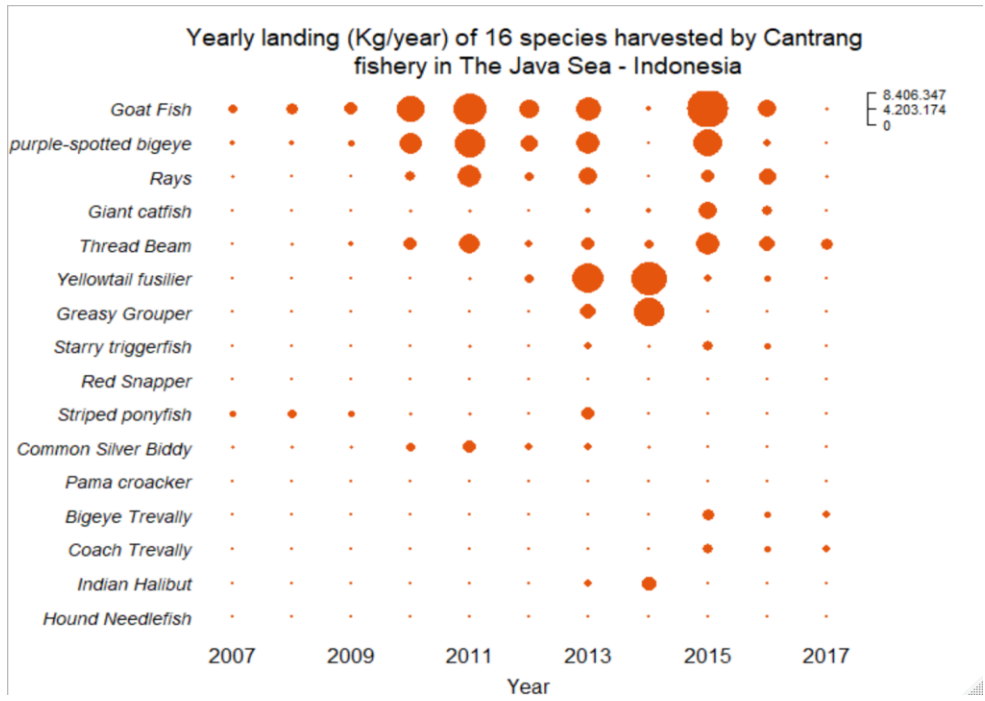


Figure 14. Yearly landing (kg/year) of 16 species harvested by Cantrang in the Java Sea

## 4. DISCUSSION

### 4.1. The Fisheries Performance Indicator (FPI) of *Cantrang* Fishery

*Cantrang* fishery contributes a significant amount to the production of demersal fish in Indonesia. Nugroho and Atmadja (2014) reported that if 60% of the total active *Cantrang* fleet in the Java Sea normally operated in 2012, their production could reach 1.9 to 3.1 million tons per year. At that time, the total production of Indonesian demersal fish was only 1.1 to 1.3 million tons, meaning that 0.8 to 1.8 million tons of potential catch was probably not recorded.

In 1980, a race-to-fish phenomenon likely occurred at the point when *Cantrang* was first introduced in the Java Sea. Since the ministry issued a decree allowing the provincial government to issue fishing permits for vessels with size less than 30 GT, unproductive fishing fleets such as purse seiners and gillnet fleets raced to switch to *Cantrang*, and as a result the number of *Cantrang* rose enormously. Based on the report of Nugroho and Atmaja (2014), most purse seiners switched their fishing gear to become *Cantrang* because of high competition among purse seiners and the declining trend of their catch at the time. The diminished catch of the purse seiners, combined with the momentum of authority transfer from the ministerial level to the provincial level for issuing fishing permits has prompted shifts from purse seiners to the *Cantrang*. This regulation also triggered additional GT mark-down practices, with purse seiners that mostly varied from 60 to 100 GT reporting sizes of less than 30 GT. All these stipulations have initiated race-to-fish evidence in the fishery as an impact of missed regulatory opportunities.

In 2015, the Ministry of Marine Affairs and Fisheries of Indonesia issued a ban on all trawlers, including *Cantrang*, in all Indonesian waters. The regulation seems to have effectively

reduced the number of active *Cantrang* on the north coast of Java, but it has not entirely halted the *Cantrang*, since those fleets with active permits that have passed the re-measurement of GT are still able to fish. With this new policy, the impacts on ecology, economics, and the social community in the fishery may be changed before and after the ban implementation. This research applies FPIs to investigate what works on the TBL of the fishery before and after the ban imposed on the fishery.

It is clearly shown that the ecology performance of *Cantrang* fishing is underperforming with a score below 3. Interestingly, it has a slightly lower score post-ban compared to the period before the ban. This evidence confirms that the stock health of the fish harvested by *Cantrang* is still in poor health, even after the ban. The catch per trip was used as proxy data when scoring the health of the harvested fish stocks of *Cantrang*. Ray Hilborn and Trevor Branch (2013) argue that the catch data may not be used to assess the health stock of the fish since it does not necessarily reflect the number of fish at sea. The amount of catch relies on the number of hauling and crew on each vessel. Changes in the numbers of hauling and crews, therefore, can affect the catch. However, by using the catch data as a proxy in this case, it at least helps in determining the status of the stock despite the sparse data available in this fishery. Other proxy information used when scoring is the information gathered from the fishermen during the field visit interviews. Most of the fishermen confirmed that the catch had diminished over the previous 10 years since *Cantrang* entered the fishery.

Another proxy data point used when scoring the ecological indicators is the stock assessment report issued by the Ministry of Marine Affairs and Fisheries. The stock status in the Java Sea, as reported in Ministerial Decree No. 50 issued in 2017, indicated that most of the

harvested demersal fish had reached 80% of their potential target yield. Although the overall fish stock was slightly less than the TAC threshold, the data from the Tegal port also indicated that the catch per unit effort (CPUE in kg/trip landing) of 16 commercial species had declined substantially (Figure 10). In the stock rebuilding performance, the trend of catch per trip of the top three harvested species reveals a declining trend, and the scoring of the stock rebuilding metric is low. Overall, based on the proxy data in Figures 10 and 14, the indicator of ecology still underperforms even at the period after the ban.

Over the 11 years both before and after the ban, there was little improvement in the product certification. Not one of the exported raw materials from *Cantrang* fishery, such as minced fish meat for surimi products, has been certified with an MSC certification. However, the exported products, such as the fish meat of golden threadfin bream, have met global quality standard requirements since the products are processed in high-quality standard processing plants.

In economic performance, substantial improvement was recorded in the harvest asset performance, but the harvest performance and the risk dimension are still underperforming. Unlike others Indonesian fisheries such as blue swimming crab, tuna, and demersal fisheries (as reported by Anderson et al. in 2016), *Cantrang* trawl fishery in the Java Sea outperformed in the harvest asset dimension because of the significant increase in the total all-year revenue of the fishers, both in the pre-ban and the post-ban periods. It clearly shows that the average revenue increased substantially during the ban, which is caused by massive onboard freezer installation, as well as the significant price increases in almost all species harvested by *Cantrang*.

The average price for all commodities rose about 73% during the ban in 2017 due to the lack of raw materials supplied by *Cantrang* fishery to the processor plants. This reality was

reinforced by the claims of fishermen during the field trip interviews. Anderson et al. (2016) reported that most Indonesian fishery systems performed below the FPI economic average, especially in the harvest asset returns, since none of the fisheries are managed with access permits or quotas, and fishing vessels are typically canoes, so there is little cost to enter most fisheries, and there is little to no accumulation of wealth in harvest assets. *Cantrang* fishery is exceptional in this, as most of the vessels' sizes are significant, ranging from 30 to 120 GT, with crew members varying from 8 to 26 people on board, and the fishery is managed under fishing permits.

About 40% of landed fish used for supplying the processing plants are intended for export to South Korea, China, Japan, and the United States, while the rest of the catch is sold locally. Interestingly, although processed products such as the minced fish meat of golden threadfin bream and red mullet have a 270% higher export price compared to local gate price, their prices are still lower than the average global export prices. For the non-export products sold in the local market, most of them are sold as whole raw materials with meager prices.

Although the fishery outperformed in the harvest asset performance, the risk dimension had a substantially lower score during the ban (1.7 in 2017) compared to the score before the ban (2.6 in 2012). The score of 1.7 in the risk dimension post-ban corresponds to the high ratio of the standard deviation of the annual revenue to the mean of the revenue over the last five years, according to the proxy data collected from 2013 to 2017. This situation reflects the high volatility of the *Cantrang* fishery's revenue, especially post-ban due to the dramatic price increase of harvested fish from *Cantrang* fishing. The low score of the risk dimension reflects the riskiness of the industry (Anderson et al., 2014). In Indonesian *Cantrang* fishing, the shortage

of raw materials supplied by *Cantrang* harvest (for surimi products intended for the export market) threatened the continued production of the processing plant since the plant is highly dependent on raw materials supplied by *Cantrang* vessels.

In the community outcome, the ban benefitted the local people. For instance, local people such as boat owners, crews, and the processing plant workers received high average wages compared to similar occupations like rice paddy farmers or other horticulture farmers. Although working on a *Cantrang* crew has been perceived as a low-level job in the community, the number of individuals working in the fishery increased significantly over the 11 years (Table 5). Most of the crews working on *Cantrang* vessels are seasonal, so job turnover in *Cantrang* fishing is relatively high. The peak season to work in *Cantrang* fishing for the local people usually occurs from May to October when most of them are no longer working in the rice field. Although many *Cantrang* crews work seasonally, most of the captains are highly skilled laborers as they have been working on *Cantrang* vessels for more than 10 years. More than 90% of the crews and captains originate from local communities, and only a small amount of processing plant workers are people from outside Central Java Province. The health and sanitation dimensions have improved since the local government renewed some public facilities in the Tegal port to allow more docking space for loading and unloading of vessels. Women have predominantly been working in the processing plant for almost five years, while the majority of men work as crews seasonally or as boat captains.

## 4.2. The Seasonal Effect

The models in Table 4 indicate that the revenue of the harvesters is not only affected by the input of capital, labor, and effort, but it is also affected by the monthly seasonal pattern. The fishers gain low revenues from May to July and September to October every year, both at pre-ban and post-ban terms. This evidence reveals that the seasonal factor plays a vital role in generating revenue in *Cantrang* fishery. Figure 13 precisely describes the fluctuation of fishers' revenue over the years from 2007 to 2017. A recent study on the social-economic conditions of some small *Cantrang* fishers in Central Java province, as reported by Nababan et al. (2018), found that the peak season of *Cantrang* fishing revenue generally occurs from December to April, while lower revenue often occurs from May to September.

## 4.3. The Production Analysis of *Cantrang*

The Cobb-Douglas Production Function clearly shows an extensive technological input introduced to the fishery from 2007 to 2017. The expansion in vessel size (GT), the number of crews, and trip lengths during the period of 2007 to 2017 reflects this input. In some ways, the trawl ban has been effective at ensuring that this technical influx did not result in an increase in harvest capable of wiping out key fishery stocks. Models 2 and 3 clearly show that the increase in crew size was substantial in generating revenue of the *Cantrang* fleet both before and after the ban, contributing 90% of the increased revenue of the vessels while controlling for prices. The models also show the increased GT and trip length contributed only 8% to the total revenue. This evidence confirms that the ban affects the increased price of almost all key species because of the shortage in supply during the post-ban period. In contrast, similar products that sold from other countries such as the Philippines and Taiwan did not experience as much price fluctuation during

that period. Therefore, the increased price of almost all key species that caught by *Cantrang* are affected by the trawl ban implementation.

Interestingly, the effect of the trawl ban reveals an interesting phenomenon in the labor input, where the number of crews per vessel increased substantially in the years after the ban was implemented in 2015. This phenomenon reflects the consolidation of the crews from inactive fishing fleets to the active fleets. The vessels that were still fishing most likely recruited extra crews to maximize their revenue. Despite the fleet reduction, employment decreases arising from the ban were much smaller, as it coincided with a 30% increase in crew sizes. This was driven primarily by an increase in the portion of the fleet with onboard freezers, which require more packing and sorting labor, but facilitate longer trips. Based on the interview information, the increased number of crew per vessel is mostly due to the increased capacity of the fleets. Since 2010, according to the fishermen, many vessels have installed onboard freezers that attract and accommodate more crews to work on the fleets. High number of crewmembers could help to minimize the fishing duration (per hauling duration) and reduce sorting time and packaging of the catch into the onboard freezer. The significant increase in the number of crewmembers per vessel is one of the facts that shows how the ban directly affects the crews' structure as well as the technological changes such as the increase number of installed onboard freezers since 2010.

The revenue of the active vessels shows a considerable increase during the post-ban period since the price of almost all key species increased substantially. For instance, the revenue per crew of the Agung Jaya vessel (Figure 15) increased considerably from about 60,000,000 IDR in the year before the ban to more than 120,000,000 IDR in the post-ban period. Other vessels also show a substantial increase in revenue per crew post-ban, as described in Figure 15.

On average, based on the production models, the fishers' revenue increased by about 66% as the impact of increased prices influenced their compensation post-ban. Therefore, this evidence confirms a direct impact of the ban on the revenue of the fishermen, as a result of increased price.

According to the fishermen, the small number of vessels that operated during the post-ban has affected the supply of minced fish meat, the primary raw material used for making surimi. According to the provincial statistical data, seven processing plants in the Tegal port used and relied upon the supply of *Cantrang* catch. Based on the national data, the total production of Indonesian minced fish used for surimi shrank from about 40,000 tons in 2015 to 26,000 tons in 2017.

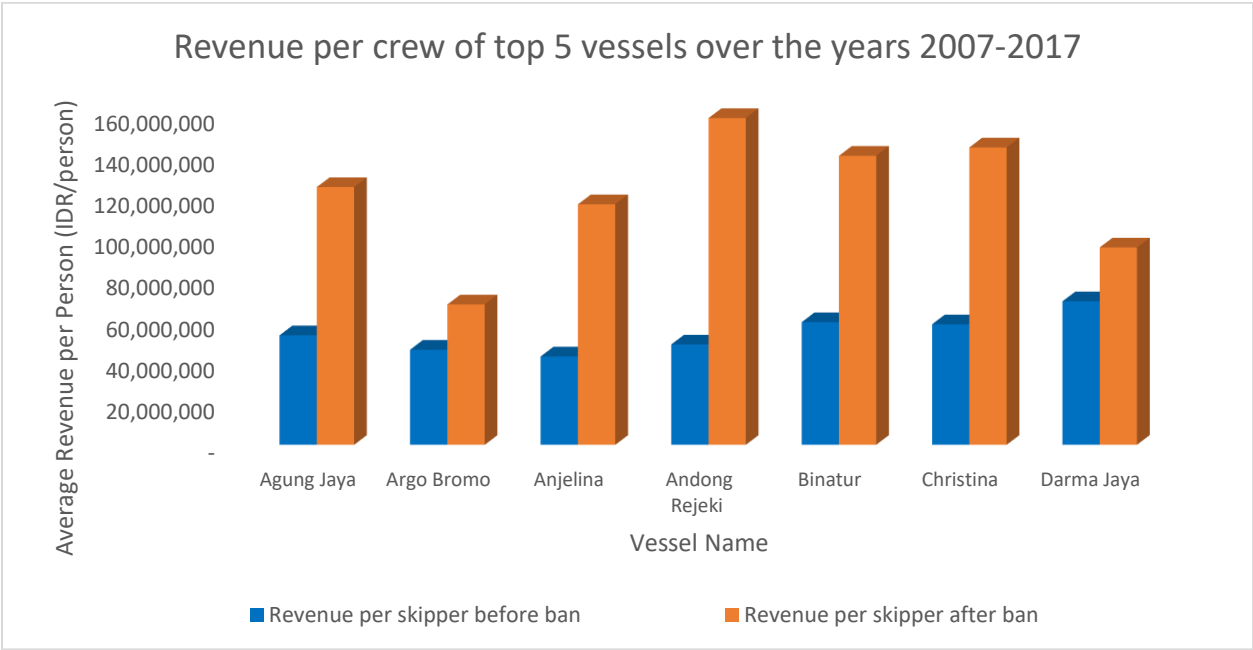


Figure 15. Revenue per *Cantrang* crew changes before and after the ban

## 5. CONCLUSION

*Cantrang* fishery underperformed in ecological impact both before and after the ban. The majority of the fish stocks harvested by *Cantrang* fishing are declining, as indicated by the decreased abundance index (CPUE) of the 16 species harvested in the fishery. In economic performance, the *Cantrang* fishery scored poorly in harvest performance and risk dimension. The high volatility of price and landing caused poor performance in the risk dimension for the post-ban period. Variations in revenue reflect the riskiness of *Cantrang* fishing and have threatened the continuity of raw material supplies to surimi processing plants, which rely heavily upon the *Cantrang* catch for the export market.

In the community performance, the ban generates more benefits to the community since most of the crews have gained higher income than other similar occupations post-ban as a result of the increased price of key species. The high participation and involvement of the community as reflected by the excellent score in the career dimension have shown the vital role of *Cantrang* fishing in the community. The poor performance on stock health does not necessarily lead to worse economic and community outcomes. Even though it is harmful to the stock health in the Java Sea, *Cantrang* fishing is still critical to the livelihood of the fishers and their communities.

Despite the armada reduction, employment on fleets did not fall as much as expected, as the post-ban period corresponded with a 30% increase in crew sizes. The expansion of the fleet capability with onboard freezers has demanded more packing and sorting employment and increasingly longer trips. Controlling for prices, the production models suggest the expansion in crew size estimated for 90% of the increase in revenue, which shows a significant revenue

growth post-ban because of the substantial effect of the crew, while the GT size and trip length contributing only 8% to the increase in revenue.

## APPENDIX

Table 5. Data tabulation number of crew onboard per year from 2007 - 2017

Number of the crew onboard	Year										
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
1	0	0	0	0	0	0	0	0	0	0	0
2	0	0	1	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	0	0	0	0	0
4	2	0	0	0	0	0	1	1	0	0	0
5	5	1	0	0	0	2	15	1	0	0	0
6	22	3	1	2	5	5	13	6	0	0	0
7	90	30	0	10	22	15	11	2	0	1	0
8	129	84	8	36	43	30	54	55	38	9	1
9	120	55	6	74	117	78	82	51	12	5	0
10	283	298	343	254	284	137	133	124	85	40	2
11	31	50	19	29	77	40	102	41	7	26	0
12	34	63	11	48	47	37	60	119	56	79	3
13	21	33	39	34	54	48	99	137	59	47	7
14	0	6	0	15	25	24	88	163	68	52	12
15	1	0	1	0	1	15	52	33	28	17	1
16	3	0	1	5	13	8	27	75	55	24	14
17	0	0	0	0	0	6	5	2	14	6	14
18	0	1	0	3	9	4	12	104	28	17	28
19	0	0	0	0	0	0	0	0	9	11	11
20	0	0	0	0	0	0	0	0	6	9	24
21	0	1	0	0	0	0	0	2	0	4	15
22	0	0	0	0	0	0	0	0	0	4	10
23	0	0	0	0	0	0	0	0	0	1	58
24	0	0	0	0	0	0	0	0	0	0	16
25	0	0	0	0	0	0	0	0	6	0	4
26	0	1	0	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0	2	0	0

Table 6. List of species caught by *Cantrang* trawl in the java sea

No	Local Name	Latin Name	Trade Name
1	Kuniran	<i>Upeneus sp.</i>	Yellow striped goatfish
2	Swangi / Mata Goyang	<i>Priacanthus tayenus</i>	Purple-spotted bigeye
3	Ekor Kuning	<i>Caesio cuning</i>	Redbelly yellowtail fusilier
4	Kurisi/Abangan	<i>Nemipterus peronii</i>	Notchedfin threadfin bream
5	Pari	<i>Dasyatiidae</i>	Rays
6	Balong	<i>Epinephelus tauvina</i>	Greasy grouper
7	Kapasas	<i>Gerres oyena</i>	Common silver-biddy
8	Tiga Waja / gulamah	<i>Otolithoides pama</i>	Pama croaker
9	Peperek	<i>Aurigequula fasciata</i>	Striped ponyfish
10	Manyung	<i>Netuma thalassina</i>	Giant catfish
11	Cumi - cumi	<i>Loligo sp.</i>	Squid
12	Kembung	<i>Rastrelliger kanagurta</i>	Indian mackerel
13	Kacangan	<i>Sphyræna spp</i>	Barracudas
14	Ikan Kambing /Etong	<i>Abalistes stellaris</i>	Starry triggerfish
15	Kakap merah	<i>Lutjanus sp.</i>	Red snapper
16	Smadar / Beronang	<i>Siganus sp.</i>	Streaked spine foot
17	Buntel	<i>Sphoeroides pachygaster</i>	Blunthead puffer
18	Swangi Batu / Coklatan	<i>Scolopsis taeniopterus</i>	Lattice monocle bream
19	Beloso	<i>Oxyurichthys microlepis</i>	Maned goby
20	Bawal	<i>Pampus Argenteus</i>	White pomfret
21	Selok / Gatep / Kwee	<i>Carangoides oblongus</i>	Coachwhip trevally
22	Selar / Gontor	<i>Caranx sexfasciatus</i>	Bigeye trevally
23	Ikan Sebelah/ Pihhi	<i>Psettodes erumei</i>	Indian halibut
24	Layur	<i>Lepturacanthus savala</i>	Savalai hairtail
25	Selayar	<i>Istiophorus platypterus</i>	Indo-Pacific sailfish
26	Ikan lainnya /campuran	NA	Mixed species

Table 7. Input scores for the *Cantrang* fishery in the Java Sea Indonesia for 2012 and 2017

Dimension	Metric	2012	2017
General Environmental Performance	Environmental Performance Index (EPI)	2	1
Exogenous Environmental Factors	Disease and Pathogens	5	5
	Natural Disasters and Catastrophes	3	3
	Pollution Shocks and Accidents	5	5
	Level of Chronic Pollution (Stock effects)	4	4
Governance	Level of Chronic Pollution (Consumption effects)	4	5
	Governance Quality	2	3
Economic Conditions	Governance Responsiveness	2	3
	Index of Economic Freedom	3	4
Fishing Access Rights	Gross Domestic Product (GDP) Per Capita	3	2
	Proportion of Harvest Managed Under Limited Access	1	1
	Transferability Index	NA	NA
	Security Index	3	3
	Durability Index	3	3
	Flexibility Index	NA	NA
	Exclusivity Index	1	2
Harvest Rights	Proportion of Harvest Managed with Rights-based Management	1	1
	Transferability Index	NA	NA
	Security Index	NA	NA
	Durability Index	NA	NA
	Flexibility Index	NA	NA
	Exclusivity Index	NA	NA
Collective Action	Proportion of Harvesters in Industry Organizations	3	3
	Harvester Organization Influence on Management & Access	2	3
	Harvester Organization Influence on Business & Marketing	2	2
Participation	Days in Stakeholder Meetings	2	2
	Industry Financial Support for Management	1	1
Community	Leadership	3	3
	Social Cohesion	4	4

Gender	Business Management Influence	5	2
	Resource Management Influence	3	4
	Labor Participation in Harvest Sector	1	1
	Labor Participation in Post-Harvest Sector	5	5
Management Inputs	Management Expenditure Compared to Value of Harvest	4	5
	Enforcement Capability	2	3
	Management Jurisdiction	3	3
	Level of Subsidies	4	5
Data	Data Availability	4	4
	Data Analysis	2	2
Management Methods	MPAs and Sanctuaries	2	2
	Spatial Management	1	1
	Fishing Mortality Limits	1	1
Markets & Market Institutions	Landings Pricing System	2	2
	Availability of Ex-vessel Price & Quantity Information	1	3
	Number of Buyers	5	2
	Degree of Vertical Integration	3	3
	Level of Tariffs	2	2
	Level of Non-tariff Barriers	5	5
Infrastructure	International Shipping Service	4	3
	Road Quality Index	4	4
	Technology Adoption	4	5
	Extension Service	2	3
	Reliability of Utilities/Electricity	4	4
	Access to Ice & Refrigeration	4	4

Table 8. Output scores for the *Cantrang* fishery in the Java Sea Indonesia for 2012 and 2017

Dimension	Metric	2012	2017	
Ecologically Sustainable Fisheries	Percentage of Stocks Overfished	2	1	
	Degree of Overfishing- Stock Status	2	2	
	Stock Declining, Stable or Rebuilding - Stock Dynamics	2	1	
	Regulatory Mortality	5	5	
	Selectivity	5	5	
	Illegal, Unregulated or Unreported Landings	2	2	
	Status of Critical Habitat	3	3	
	Proportion of Harvest with a 3rd Party Certification	1	1	
	Harvest Performance	Landings Level	1	1
		Excess Capacity	5	2
Season Length		5	5	
Harvest Safety		2	2	
Harvest Asset Performance	Ratio of Asset Value to Gross Earnings	4	5	
	Total Revenue Compared to Historic High	5	5	
	Asset (Permit, Quota, etc...) Value Compared to Historic High	3	5	
	Borrowing Rate Compared to Risk-free Rate	3	3	
	Source of Capital	2	3	
	Functionality of Harvest Capital	3	3	
	Risks	Annual Total Revenue Volatility	2	2
Annual Landings Volatility		2	2	
Intra-annual Landings Volatility		3	2	
Annual Price Volatility		2	2	
Intra-annual Price Volatility		3	1	
Spatial Price Volatility		2	2	
Contestability & Legal Challenges		3	1	
Owners, Permit Holders & Captains (Those holding the right or ability to access)	Earnings Compared to Regional Average Earnings	5	5	
	Owner/Permit Holder/Captain Wages Compared to Non-fishery Wages	5	5	

	Education Access	5	5
	Access to Health Care	4	4
	Social Standing of Boat Owners and Permit Holders	4	5
	Proportion of Nonresident Employment	5	5
Crew (Those depending on others for access)	Earnings Compared to Regional Average Earnings	5	5
	Crew Wages Compared to Non-fishery Wages	5	5
	Education Access	4	4
	Access to Health Care	2	4
	Social Standing of Crew	2	2
	Proportion of Nonresident Employment	4	5
	Crew Experience	2	3
	Age Structure of Harvesters	2	4
Market Performance	Ex-vessel Price Compared to Historic High	3	5
	Final Market Use	3	3
	International Trade	3	4
	Final Market Wealth	5	5
	Wholesale Price Compared to Similar Products	1	1
	Capacity of Firms to Export to the US & EU	2	2
	Ex-vessel to Wholesale Marketing Margins	5	3
Post-harvest, Processing & Support Industry Performance	Processing Yield	3	3
	Shrink	3	3
	Capacity Utilization Rate	4	4
	Product Improvement	1	1
	Sanitation	3	3
	Regional Support Businesses	4	4
Post-Harvest Asset Performance	Borrowing Rate Compared to Risk-free Rate	4	4
	Source of Capital	4	4
	Age of Facilities	4	3
Processing Owners & Managers	Earnings Compared to Regional Average Earnings	5	5
	Manager Wages Compared to Non-fishery Wages	5	5
	Education Access	5	5
	Access to Health Care	5	5

	Social Standing of Processing Managers	4	4
	Nonresident Ownership of Processing Capacity	3	3
Processing Workers	Earnings Compared to Regional Average Earnings	3	3
	Worker Wages Compared to Non-fishery Wages	4	5
	Education Access	4	4
	Access to Health Care	3	4
	Social Standing of Processing Workers	2	2
	Proportion of Nonresident Employment	5	5
	Worker Experience	3	4

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