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Technical Efficiency of the Shrimp Trawl Fishery in Aru and the Arafura Sea, the Eeastern Part of Indonesia

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Abstract

Purpose: This paper aims to study the fishing capacity of the shrimp trawlers in the Aru and Arafura Sea. **Research design, data and Methodology:** The abundant shrimp resources call for its sustainable use to advance economic activity. Time-series data of effort and catch from shrimp trawlers from 1980-2015 were utilized. The technical efficiencies of the vessels and the target capacity of the shrimp fishery were estimated using Peak to Peak Method. **Results:** Arafura's shrimp fishery presents high technical efficiency, which is suggested by the high scores of its fishing capacity utilization. The issuance of a ministerial decree on the prohibition of the use of trawls has impacted the plummeting of Arafura's shrimp trawler production right after the regulation implemented in 2015, which is far below the total production of the Arafura's shrimp trawler in 1980. Today, the Aru and Arafura Sea has different sets of fishing gears that are dominated by Squid Jigging and gillnet vessels. **Conclusions:** Arafura shrimp fishery performs high technical efficiency, which is indicated by the high utilization value of its catching capacity ranging from 71% to 100% annually from 1980 to 2015 This has shown that the resource-utilization has shifted from shrimps to other economically important species during the post trawl ban such as squid and pelagic. Any future intention to utilize shrimp resources, interaction of gears harvesting shrimp with current gears should be well considered in the policy making process.

Keywords : Shrimp Fishing Environment, Shrimp fishery, Technical efficiency, Fishing capacity utilization

JEL Classification Code: Q22, Q28, Q50, Q58.

1. Introduction

The Aru and the Arafura Sea are known to have high potential in shrimp and demersal fish resources because of the characteristics of its ecosystem, such as muddy or sandy mud substrate, large mangrove coverage, and sloping seabed contour. The shrimp fishery has contributed up to USD 58 million in 2014 from one association (Himpunan Pengusaha, Pukat Udang Indonesia, 2015). This value is one-third of the total vessels exploiting the shrimp resource at the Aru and Arafura Sea (Ministry of Marine Affairs and Fisheries, 2015).

Until 2015, the fishing gear practices that exploited the shrimp resources were mostly big trawl vessels. The ocean dynamic of Aru and Arafura Sea requires strong vessels made of iron most of the time to be able to exploit the shrimp resources. That is strengthened by the need to utilize strong vessels such as vessels made from iron. The shrimp caught need to be landed to big fishing ports that are far

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from the fishing grounds. The shrimp catch is usually exported to Taiwan and Japan. The catches of these large vessels consist of 70% of total shrimp from these fishing grounds, and the other 30% of it captured by small vessels < 30 GT (Personal communication with Ministry of Marine Affairs and Fisheries staff in Sorong Fishing Port, May 2016).

1.1 Shrimp Fishery in Aru and Arafura Sea

The Arafura Sea is one of the most productive fishing grounds in Indonesia for harvesting shrimp and demersal fish. They are managed under the Fishery Management Area (FMA) 718 (Ministry of Marine Affairs and Fisheries, 2014a). The high productivity of the Arafura Sea is due to the process of nutrient upwelling and nutrient inputs from the watershed. That has made the area as a nursery and feeding ground of some highly commercial species of shrimps. The upwelling in the Banda Sea and the Arafura is formed due to the influence of the southeast wind season (Wyrtki, 1961). Upwelling improves nutrient (Wetsteyn, Ilahude & Baars, 1990) and organic carbon (Cadée, 1988), which promotes the growth and biomass of phytoplankton, increased oxygen production (Tijssen, Mulder & Wetsteyn, 1990), and the abundance of zooplankton (Baars, Sutomo, Oosterhuis & Arinardi, 1990). Meanwhile, water flowing in the rivers carries nutrients from the dense forests in the interior of Papua to the Arafura Sea during the rainy season. Nutrients are also transported to the Arafura Sea from dense mangrove forests along the western coast of Papua (Sadhotomo, Rahardjo & Wedjadmiko, 2003).

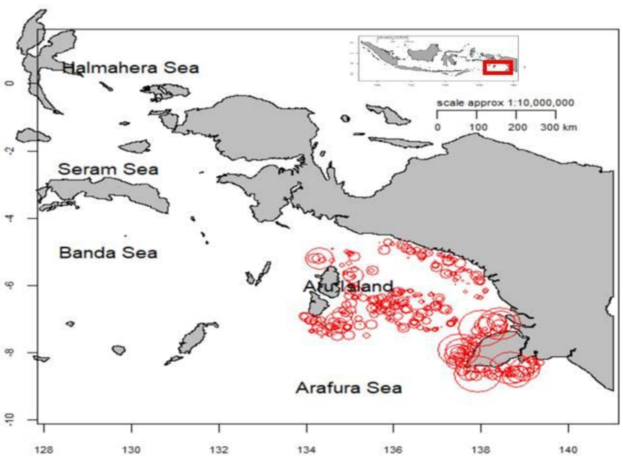

Figure 1. Fishing ground locations of shrimp trawl fishery activities

The diversity and extensive mangrove forests of the south coast of Papua, which borders the Arafura Sea, are among the highest in the world (Huffard, Erdmann & Gunawan, 2012). Mangrove ecosystem is spread over three provinces: Province of Papua, West Papua, and Maluku. Mangrove forests in the Aru Islands and Southeast Maluku (Maluku) reach 833 km2 and 18 km2, respectively.

High primary productivity in the sea southeast of Arafuru (especially during the peak season of June – to August) is not caused by the flow of the river but a vertical mixing that brings nutrient-rich water from the deeper sea-water layers (Wetsteyn, Ilahude & Baars, 1990).

Figure 1 shows the Fishing grounds of shrimp trawlers in the Aru and the Arafura sea.

Some researches stated that the condition of Shrimp Fishery in Arafura sea has been over exploited (Suman & Satria, 2014) and that the total biomass of shrimp was dominated by *Penaeus semisulcatus* and *Metapenaeus endeavouri* (Hargiyatno & Sumiono, 2016). According to the official statistics, the shrimp catch from the Fisheries Management Area (FMA) 718 is about 28,969 tons in 2016 (Figure 2).

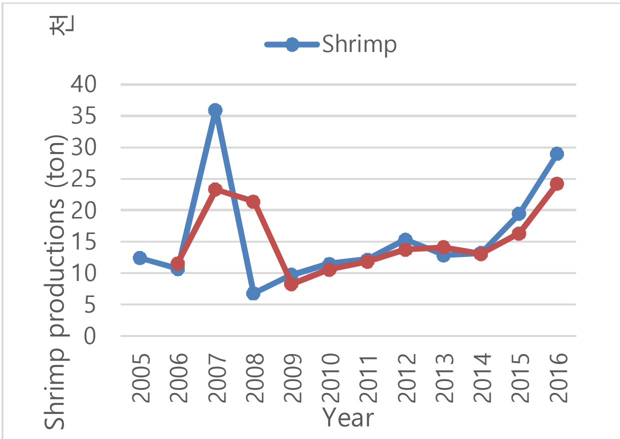

Figure 2. Shrimp production (tons) in FMA 718

Figure 2 shows the production trend of shrimp at FMA 718, particularly the banana shrimp (*Penaeus merguiensis*) and tiger shrimp (*P. monodon*). Banana prawn is found in waters adjacent to mangrove forests, while the black tiger shrimp is more common in the waters covered with seagrass. The Concentration of fishing effort for shrimp trawlers is around the island of Aru. In terms of stock recovery, a policy is needed to improve the sustainability of shrimp fisheries stock, such as the closure of the area and the time of fishing capture in the Arafura Sea.

There are two seasonal closures of fishing, January and August to September (Wijopriono, Wiadnyana, Dharmadi & Suman, 2019). Another research from Sumiono (2012) initiated several alternative management for shrimp resources, such as: 1) controlling shrimp species and catching effort, 2) controlling the allowable size of the catch, and 3) management of the habitat of shrimp.

The goal of this paper is to quantitatively estimate the technical efficiency of the Shrimp trawlers in FMA 718 using time-series data from shrimp trawlers from the 1980s to 2014 to estimate the capacity utilization of the shrimp fisheries from its industrial fleets. What lessons can be drawn from this policy that has an impact on the management of shrimp fisheries in Aru and the Arafura Sea?

2. Literature Review

Arafura and Aru Seas are well known as the most productive fishing grounds of the penaeids fishery in Indonesia. Bailey et.al (1987) reported that the Aru and Arafura Seas have been known as the shrimp nursery grounds since they have frequently been enriched by upwelling events. A study by Wyrtki (1961) as reported in Purwanto (2012) found that Arafura Sea is one of the few areas within the Indonesian EEZ having nutrient upwelling all the time. The supplied nutrients from the regular upwelling events along with the nutrient inputs from the surrounding river flows have made the areas as the ideal habitat for the shrimps, promotes the growth and biomass of phytoplankton, increased oxygen production (Tijssen, Mulder & Wetsteyn, 1990) and the abundance of zooplankton (Baars, Sutomo, Oosterhuis & Arinardi, 1990).

Three species of penaeids are the major commercial species in the Arafura Sea Shrimp Fishery (Evans & Wahju, 1996). They are endeavour prawns (*Metapenaeus spp*.), the banana prawn (*Penaeus merguiensis*) and the tiger prawn (*P. semisulcatus*) As reported in the study, these penaeids resources were utilized by the commercial shrimp trawlers which was firstly introduced in 1966. Since then, the shrimp trawler had rapidly developed and diminished the resources, and shortly became the source of conflict between trawlers and small-scale fishermen who were competing for the same resources in inshore waters prior to the 1980s. According to Af-Idati & Lee (2009), this situation prompts Indonesian government to have an action to manage the number of commercial trawls in Indonesia, by issuing a Presidential Decree no 39 of 1980; a ban on trawl operations enforced to all Indonesian waters through several stages of implementation. However, this policy had excluded shrimp trawlers operating in the Arafura and Aru Seas. As a result, Arafura and Aru Seas were the remaining waters in the country where commercial trawling was still permitted until 2015. The second ban of trawls was issued that applied nationally without exception.

According to Endroyono (2016), the Presidential Decree no 39 of 1980 allows fishers to operate shrimp trawlers in the Aru-Arafura Sea with the following conditions:

a. Defining the operation area that it should be at the east at the coordinate of 130ºE until the waters reach a depth of 10 meter.
b. The by-catch fish should be utilized.
c. Installing Turtle Excluder Device (TED) at least 3 inches bars of the shrimp trawl.

After the long-massive resource utilization of the commercial trawl fishing in the Arafura Sea, in 2015, a new minister under the new regime, has ordered a decree that bans all the commercial trawling in Indonesia waters. The ban itself is not merely aimed to restore the depleted resources as the impact of the commercial trawl, but it is also intended to combat the IUU Fishing that often occurs due to rampant illegal fishing vessels entering into the waters of Indonesia, the misuse of the flag as well as the human trafficking issues (Endroyono, 2016).

The moratorium decree has a great impact on the shrimp fishery in the Aru-Arafura Sea. The impact was greater because the fishing industry generally used vessels that were constructed abroad. Under this new moratorium policy, the vessels that are constructed abroad should be evaluated on valid legal documents and to ensure compliance for carrying out fishing activities in Indonesia. For vessels that passed the evaluation process, they can undertake fishing activities until the end of the business license granted, while others, the inactive-license vessels are totally not allowed to fish (Endroyono, 2016).

Study that conducted by Naamin (1984) found that Arafura Sea is the only waters that has the best potential of penaeid shrimp resources among Indonesian waters. In 1983, about 30% of the total value of Indonesian fisheries export came from the Arafura fishery. According to the study, the Maximum Sustainable Yield (MSY) of the penaeid shrimp in Arafura was about 14.700 – 15.000 tons with optimal effort 39.400 – 61.500 days of fishing, while the fishery categorized as underexploited at the time. However, the latest study found the effort rates of the endeavour shrimp and the black tiger prawn in Arafura have been overexploited and recommends to reduce 22 – 38% of the effort to get the optimum and sustainable fishery (Suman & Satria, 2017). Another study also indicates high fishing pressure to the penaeid resources in Arafura Sea. Hargiyatno, Sumiono & Suharyanto (2013) reported that average biomass density of *Metapenaeus marguensis* was only about 32,3 kg/km sq., dropped substantially from 96.6 kg/km sq (Naamin, 1982).

Technical Efficiency and Capacity utilization have been utilized to analyze impact evaluation for major fisheries programs such as the changes in the Fisheries Act. García, Espino & Toribio (2004) has analyzed fisheries utilization in the Gulf of Cadiz for the Purse Seine Fleet. Felthoven (2002) also evaluated the impact of the Fisheries Act on fisheries Capacity utilization in the U.S. It turned out that from multi-input, multi-output models indicate that fishing capacity fell by more than 30% and that harvesting Technical Efficiency increased relative to past years.

Technical Efficiency technique only requires information about one input and one output. Consequently, it represents the most widely applicable and least demanding of data in all mathematical methods for estimating capacity and capacity utilization (Kirkley & Squires, 1999). A disadvantage of the technique, however, is that it does not allow for changes in the stock between years or any other structural changes affecting input-output relationships. Changes in catch rates are assumed to be a function of changes in technology only. A decline in stock size between two peak years would be interpreted as capacity underutilization. Peak-to-peak analysis has been applied in fisheries (Ballard & Roberts 1978; Ballard & Blomo, 1978; Okamoto, Miyabe & Matsumoto, 2001). Further information on the technique, including the mathematical specification of the approach, is provided by Kirkley & Squires (1999).

3. Materials and Method

This section will describe the shrimp fishery data and analytical framework for estimating the technical efficiency and estimating target capacity for shrimp fishery in the Aru and the Arafura Sea.

3.1 The Data

Time series data of catch and efforts of shrimp trawls fleet from 1980-2015 have been used for the purposes of this study. These vessels have targeted shrimp, although they have also caught some fish as non-target fish.

Table 1. Shrimp Trawlers Characteristics of the Samples.

	Number of boat	Size of boat (GT)	Total days	Total hauling
Min	9	150	1430	13600
Max	12	300	3461	32585
Average	-	-	2870	24465

The total number of vessels varied from year to year between 5-9 units during 1980-1994 and between 10-12 units after 1994. Those vessels were relatively homogeneous in terms of characteristics. They also faced identical economic conditions, such as output prices and input costs, and environmental conditions, such as weather. However, in this study, the stochastic factor was not incorporated in the analysis due to limited data availability, such as estimating the impact of the captain's skill.

3.2. Analysis Method

The peak-to-peak analysis was used to predict a direct relationship between the level of input and output. An index of catch-per-day and catch-per-hauling is obtained from the data. A theory is made that peak points of catch-per-boat, catch-per-day, and catch-per-hauling are equal to complete capacity utilization. The peaks are supposed to exemplify the years that the fishery was achieving the maximum output in the short run, given harvesting technology and capital stock. Therefore, lower catch rates are assumed to indicate underutilization of capacity.

The technique also allows for technological change over time, such that the difference in catch rates between two peak years is assumed to be the result of changes in technology. "Capacity" catch rates in the years between the peaks are estimated as a function of the estimated change in technology between the peaks, which is assumed to be a linear trend. Capacity utilization is then estimated as the ratio of the observed catch rate to the derived "capacity" catch rate. The capacity output is estimated as the product of the level of inputs and the "capacity" catch rate.

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The technique also allows for technological change over time, such that the difference in catch rates between two peak years is assumed to be the result of changes in technology. "Capacity" catch rates in the years between the peaks are estimated as a function of the estimated change in technology between the peaks, which is assumed to be a linear trend. The peak-to-peak analysis is based on an underlying assumption that output is a function of the level of inputs and a technology trend, such that

$$Y_t = \alpha_0 V_t T_t \qquad (1)$$

where Y_t is the output in time, t, a_0 is a proportionality constant, V_t is a composite or aggregate index of inputs, and T_t is the technology trend that represents productivity change. An implicit assumption in the use of a composite index of inputs is that the technology displays constant returns to scale. That is, increasing all inputs will result in a proportional increase in output. The level of technology is determined by the average rate of change in productivity between peak years, where productivity is given by Yt/Vt (i.e. average output per unit of input). The technology in any one year is thus

$$T_t = T_{t-m} + \left(\frac{\frac{Y_{t+n}}{V_{t+n}} - \frac{Y_{t-m}}{V_{t-m}}}{\frac{m+n}{m}} \right) \qquad (2)$$

where m is the length of time from the previous peak year, n is the length of time to the following peak year, and T_{t-m} is the level of technology at the previous peak (i.e. year m) equivalent to the average productivity (e.g. catch per unit of effort) in that period. The terms in the bracket represent–the cumulative change in productivity between the two peaks. This is then added to the average productivity in the previous peak year (i.e. year m) to give an estimate of the average productivity of capacity in subsequent years.

An alternative way of estimating the level of technology between peaks is given by

$$T_t = T_{t-1} + \left(\frac{\frac{Y_n}{V_n} - \frac{Y_m}{V_m}}{n-m} \right) \qquad (3)$$

where Ym/Vm is the average productivity in the upper peak and Ym/Vm iis the average productivity in the lower peak. The terms in the brackets represent the average change in productivity between the two peaks. Both approaches produce identical results.

Assuming the proportionality constant has a value of 1, the estimate of the level of technology is equivalent to the capacity level of productivity (i.e. $T_t = Y_t^*/V_t$, where Y_t^* is the capacity level of output). From this, the capacity level of production can be estimated from the product of the inputs and the capacity level of productivity, such that

$$Yt* = V_t T_t \qquad (4)$$

and capacity utilization can be estimated by

$$CUt = \frac{Y_t^*}{Yt} \qquad (5)$$

A particular difficulty in interpreting the results of a peak-to-peak analysis in fisheries is that no consideration is given to changes in the stock level. Apparent changes in productivity may be due to either changes in technology (the underlying assumption of the technique) or changes in the stock level.

4. Results

The estimated capacity utilization based on fishing days, number of boats, and number of hauling of Arafura shrimp trawler have shown the average fishing capacity of 92%, 91%, and 89%, respectively, during the 36 years of data from 1980 to 2015. As the most of Arafura shrimp fishery are trawlers, the issuance of Ministerial Decree No.2/2015 on Prohibition of the use of Trawls and Seine Nets (trawl ban) has a significant impact on the fishing capacity of Arafura shrimp fishery.

The fishing capacity of Arafura shrimp trawler based on the number of boat measurement units has dropped dramatically by half of its potential production in 2015, right after the issuance of the trawler ban regulation. Estimated Capacity utilization of shrimp trawlers from 1980-2014 using fishing days, hauling number, and number of boats has been shown in Figure 3.

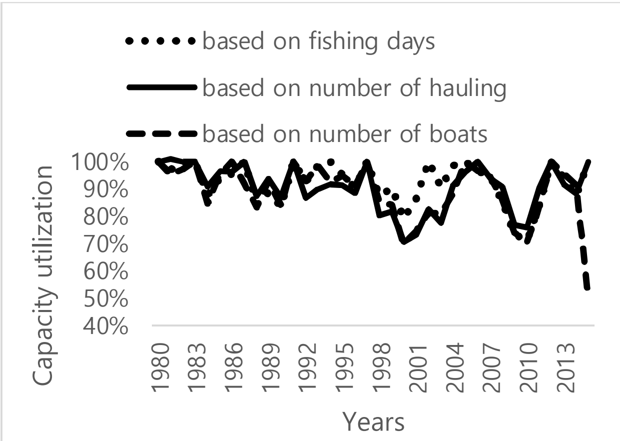

Figure 3. Estimated Capacity utilization of shrimp trawlers from 1980-2014 using fishing days, hauling number, and number of boats.

By using the number of boats as the input measurement unit, the capacity utilization dropped significantly to 70-88 % and 71-86 % respectively, because the lower fishing capacity of Arafura shrimp fishery has been occurred during 1998-2004 and 2009-2011 periods. The lowest capacity utilization has occurred in the year 2000, in which only 70% of the potential capacity had been utilized. This might be related to the fuel price fluctuation as an impact of the Indonesian monetary crisis during that period, which eventually has led to the inefficiency of the fishing capacity. Ideally, the capacity output of Arafura shrimp fishery could reach 1,045 tons of shrimp production in 2000; however, due to the lack of inefficiency, the fishing capacity fell into the lower actual production, which was only 732 tons.

Another measurement input unit based on the number of hauling has also shown similar results. By the number of hauling, lower fishing capacity occurred during the periods of 1998-2003 and 2009-2010. The fishing capacity are 71-83% and 76-77% respectively during the two periods. The lowest capacity utilization occured in 2000 at about 71 %. In other words, compared to the capacity output, the actual production of Arafura shrimp fishery was 732 tons in 2000, at about 71% of total production that could have been 1,037 tons.

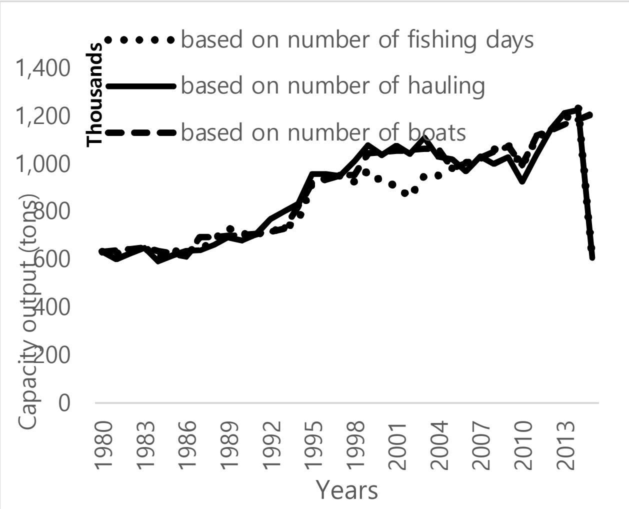

Figure 4. Capacity output of shrimp trawlers from 1980-2014 using number of fishing days, hauling number, and number of boats.

Figure 4 shows the fishing capacity outputs using number of days, hauling, and boats. It shows there is a positive increase in capacity outputs from shrimp trawlers from about 600,000 tons to 1.2 million tons in later years. They reached its peak capacity output in 2012-2013 and dropped significantly afterwards. According to the shrimp trawlers association, many of their vessels did not go fishing after 2015 due to ex-foreign vessel ban in Indonesian Fisheries. These vessels were made overseas and included in the negative list of investment under the Government Regulation No 44 Year 2016.

Purwanto (2017) has stated that in the Arafura Sea, double rigged trawl was the main fishing gear to utilize shrimp fishery resources. Year by year, the fleet development to catch shrimps in the Arafura Sea has increased from 168 units to 526 units during the period of 1986-2000. In 2015, Ministerial Decree No.2/PERMEN-KP has banned the use of Trawls and Seine Nets in all Indonesian waters (Ministry of Marine Affairs and Fisheries, 2015). The regulation has effectively shaped the fleet structure in the Arafura Sea soon after the regulation was implemented by the ministry.

The Trawls has completely stopped their operation in 2016 as the effect of the regulation and shortly been replaced by others fishing gear such as the squid jigging vessels, bottom long lines, and oceanic gill nets. The complete structure of fishing fleets in Arafura Seas now can be seen as in Figure 5.

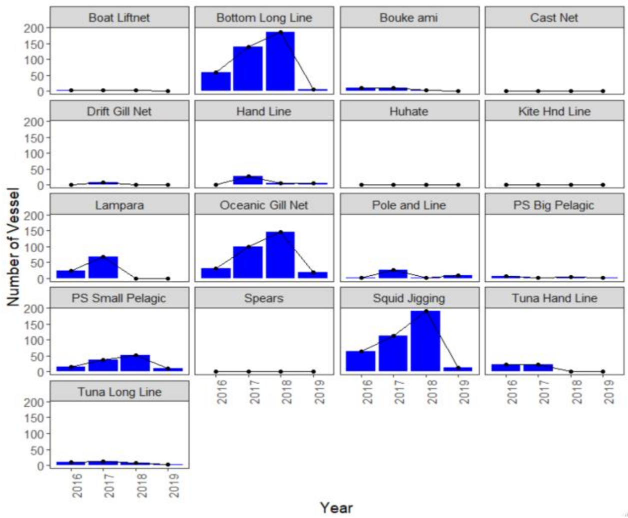

Figure 5. Trend of Fishing Gears in the Arafura Sea in the year 2016 – 2019

5. Discussion

The productive performance of the shrimp trawler fishery in the Aru and Arafura Sea, is the most densely fishing ground of trawlers in Indonesia, this is important in building a strong foundation for implementing appropriate management approaches of sustainable shrimp stocks in Indonesia. Kirkley & Squires (1999) stated that excess capacity of the fishing fleet is the most pressing problem facing the world's fisheries and the sustainable harvesting of resource stocks.

Since the average capacity utilization of the trawl vessels in the Arafura Sea is about 90% based on the number of boats as the technological input, the shrimp trawl fishing in the Arafura Sea might become the most productive fleet among other fishing vessels that operated in all Indonesian waters during the period of 1984 to 2015. For instance, Musyafak, Rosyid & Suherman (2009) reported that capacity utilization of the purse seiners in the Java Sea was only about 80%, while Sutanto (2005) stated that technical efficiency of the mini trawl Cantrang fishing of the Java Sea was ranged from 50% to 80%.

The fishing capacity of Arafura shrimp fishery has increased gradually during the periods of 1980 to 2014 (Figure 4). Its potential production was 632,5 tons per year in 1980, then increased gradually over the period, and increased to 1,208 tonnes in 2015. The estimation of its capacity utilization has shown a fluctuated trend. Although its capacity utilization has fluctuated as shown in Figure 3, the general trend was downward until 2014, which then dropped sharply in 2015.

The issuance of Ministerial Decree No.2/PERMEN-KP/2015 on Prohibition of the use of Trawls and Seine Nets has gradually stopped trawl fishing, which is the main fleet of shrimp fishery in the Arafura Sea. According to this decree, the licenses for trawl and seine net gears that had been issued before the decree, was still valid until the license expires. The main goal of this decree was to reduce the use and practices of destructive fishing gears in Indonesian waters. Currently, the ban on fishing using trawl and trawl nets has been fully implemented because the fishing permit in the last 1 (one) year has expired on January 9, 2016. It is strongly believed that the (shrimp) resources have started to recover.

Furthermore, based on Ministerial Decree No.56 / PERMEN-KP / 2014 concerning Moratorium for Fishing Vessels Built Abroad up to April 30 2015 which was extended to October 31 2015 based on Ministerial Decree No. 10/2015 (Ministry of Marine Affairs and Fisheries, 2014b), fewer vessels are fishing in Indonesia waters. These two consecutive decrees complete a year cycle of license system in Indonesia. Thus, there is no built-overseas vessel that operated in Indonesia waters.

We have observed a sharp decline in capacity utilization from 1998 until 2000. This has happened due to the global economic crisis in the 1998s and a spike on the fuel prices. Fuel prices have risen 58 % in that year (Harunurrasyid, 2013) and the poverty level has increased (Muthalib, Adam, Rastin, Saeong & Suriadi, 2018). This has lowered capacity utilization by up to 71%. Secondly, there had been more and more illegal fishing vessels operating in Indonesia waters in 2000. Campbell (2009) has reported about 85% of all vessels above 50 GT or about 7,000 vessels were operating without a license. This condition has led to a shrimp trawl moratorium in the year 2003-2004 (Endroyono, 2016).

Throughout the history of shrimp extraction from the Aru and Arafura Sea in Indonesia, there had been 2-3 policies by MMAF that have directly impacted the capacity of fishing in the Aru and the Arafura Sea. One of them is the 2002-2003 permit moratorium, which was intended to reduce capacity as long as there was overcapacity in the Aru and Arafura Seas at that time. This policy was specific to this region. Second is the moratorium of foreign-made vessels in 2014. This policy applies to all fishery in Indonesia in the effort of curbing the IUU fishing practices in Indonesia. Some evidences show that many vessels have double flags or there is no certificate of deletion from the country of origin. For example, fishing vessels acquired abroad are required by Indonesian law to file a deletion certificate to change their flag from foreign to Indonesian, but from 2001-2005, 94% of deletion certificates were falsified. Furthermore, in 2003, 70% of Indonesian-flagged vessels with permits to fish in Indonesian waters were foreign-owned vessels (Sodik, 2009). In mid 2019, FMA 718 was fished by about 1,497 vessels larger than 30 GT without trawlers with multi fishing gears ranging in sizes of 57-146 GT. The types of gears were depicted in table 2.

Table 2. The Composition of Fishing Gears and the Total GT in FMA 718

Fishing Gear	Unit	Total GT
Squid Jigging	604	63,182
Oceanic Net	443	43,380
Purse Seine	257	37,538
Bottom Longline	141	10,492
Gill Nets	28	1,603
Drifted Net	10	829
Bouke Ami	9	705
Cast Net	5	663
Total	**1,497**	**158,392**

Source: MMAF, 2019

6. Conclusion

Arafura shrimp fishery performs high technical efficiency, which is indicated by the high utilization value of its catching capacity ranging from 71% to 100% annually from 1980 to 2015. Although the fishing capacity fluctuated on a year-to-year basis, the issuance of ministerial degree on the prohibition of the use of trawls has impacted on the drastic decline in Arafura's trawl production after the regulation was implemented in 2015. This production value (606 tons in 2015) is below the production of the total Arafura's shrimp trawler production in 1980.

Beyond 2015, there is no shrimp trawler-but Arafura sea has different sets of fishing gears dominated by Squid Jigging and oceanic gillnets. In the future, if Indonesia would like to utilize harvest shrimp resources from the Arafura Sea, the potential interaction with the current set of gears should be well considered and its conflict potentials both gear conflicts and social conflicts with local fishers.

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The lead author for this paper is Umi Muawanah as she designed the research question, obtained the data, analyzed the results and drafted the manuscripts. The other three co-authors contribute significantly to the paper in collecting and analyzing the data and provided inputs to the manuscript draft.

References

Af-idati, N., & Lee, S.-G. (2009). Management measures of shrimp trawling fihery in Arafura Sea, Indonesia: a challenge. Journal of Coastal Development, 56-63. Retrieved from https://ejournal.undip.ac.id/index.php/coastdev/article/view/990/839

Ballard, K., & Blomo, V. (1978). Estimating the structure of capacity utilization in the fishing industry. Marine Fisheries Review, 29-34. Retrieved from https://spo.nmfs.noaa.gov/sites/default/files/pdf content/MFR/mfr408/mfr4086.pdf

Bars, M., Sutomo, A., Oosterhuis, S., & Arinardi, O. (1990). Zooplankton abundance in the eastern Banda Sea and northern Arafura Sea during and after the upwelling season, August 1984 and February 1985. Netherlands Journal of Sea Research, 527-543.

Ballard, K., & Roberts, J. (1978). Empirical estimation of the capacity utilization rates of fishing vessels in 10 major Pacific fisheries. Washington, DC: US Department of Commerce, National Marine Fisheries Service.

Campbell, D., Resosudamo, B., & Napitupulu, L. (2009, December). Illegal Fishing in The Arafura Sea: Development, Resources, and the Environment in Eastern Indonesia. Working With Nature Against Poverty, pp. 178-200.

Felthoven, R. G. (2002). Effects of the American Fisheries Act on the harvesting capacity, capacity utilization, and technical efficiency of Pollock Catcher-Processors. Marine Resource Economics, 181-205

G.C.Cadée. (1988). Organic carbon in the upper 100 m and downward flux in the banda sea; monsoonal differences. Netherlands Journal of Sea Research, 109-121. doi:https://doi.org/10.1016/0077-7579(88)90015-4

Endroyono. (2016). Overview of Trawl Fisheries Socio-Economic Condition in Indonesia After the 2nd Trawl Ban. Report. Bogor. Indonesia. Retrieved November 10, 2020, from http://repository.seafdec.or.th/handle/20.500.12067/994

Hargiyatno, I. T., Sumiono, B., & Suharyanto. (2013). Laju Tangkap, Kepadatan Stok Dan Beberapa Aspek Biologi udang jerbung (*Penaeus merguiensis*) di perairan Dolak, Laut Arafura. Bawal Widya Riset Perikanan Tangkap, 123-129.

Hargiyatno, I. T., & Sumiono, B. (2016). Kepadatan stok dan biomassa sumberdaya udang windu (*Penaeus semisulcatus*) dan Dogol (*Metapenaeus endeavouri*) di Sub Area Aru, Laut Arafura. *Jurnal Penelitian Perikanan Indonesia, 18*(1), 17-25.

Harunurrasyid, H. (2013). Pengaruh Perubahan Harga Bahan Bakar Minyak (BBM) Terhadap Tingkat Inflasi di Indonesia. *Jurnal Ekonomi Pembangunan*, *11*(2), 78-90. Retrieved August 8, 2020, from https://ejournal.unsri.ac.id/index.php/jep/article/view/4917

Himpunan Pengusaha Pukat Udang Indonesia (HPPI). 2015. Perkembangan Perikanan dan Sumberdaya Udang Di Laut Arafura [PowerPoint slides]. HPPI.

Hoyo, J. J., Castilla-Espino, D., & Toribio, R. J. (2004). Determination of technical efficiency of fisheries by stochastic frontier models: A case on the Gulf of Cádiz (Spain). ICES Journal of Marine Science, 416-421.

Huffard, C. L., Erdmann, M. V., & Gunawan, T. R. (2012). Geographic priorities for marine biodiversity conservation in Indonesia. Jakarta Pusat: Coral Triangle Initiative on Coral Reefs, Fisheries, and Food Security.

Ministry of Marine Affairs and Fisheries. (2014a). Ministerial decree of MMAF No. 54 : Fishery Management Plan (FMP) for FMA 718 (including Aru dan Arafura Sea). Jakarta, Indonesia. Retrieved May 10, 2020, from http://kkji.kp3k.kkp.go.id/index.php/dokumen/regulasi-hukum/keputusan-menteri/ finish/14-keputusan-menteri/601-kepmen-kp-no-54-tahun-2014.

Ministry of Marine Affairs and Fisheries. (2014b). Ministerial decree of MMAF No. 56: The moratorium of ex-foreign made vessels. Jakarta, Indonesia. Retrieved May 10, 2020, from http://jdih.kkp.go.id/peraturan/56-permen-kp-2014-ttg-moratorium-perizinan-usaha-perikanan-tangkap-di-wppnri.pdf.

Ministry of Marine Affairs and Fisheries. (2015). Ministerial decree of MMAF No. 2: prohibition of use trawl (Pukat Hela) and Seine Nets (Pukat Tarik) in WPP-NRI. Jakarta, Indonesia. Retrieved May 10, 2020, from http://jdih.kkp.go.id/peraturan/3-2-1-rpermen.pdf.

Musyafak, Rosyid, A., & Suherman, A. (2009). Kapasitas penangkapan kapal pukat cincin di pelabuhan perikanan nusantara pekalongan. Saintek Perikanan: *Indonesian Journal of Fisheries Science and Technology, 4*(2), 16-23.

Muthalib, A.A., Adam, P., Rastin, Saeong, Z., & Suriadi L.O. (2018). The fuel influence of fuel prices and unemployment rate towards the poverty level in Indonesia. *International Journal of Energy Rconomics and Policy*, *8*(3), 37-42.

Naamin, N. (1982). Shrimp fishery on the south coast of Java and some problems of its management. In Workshop on Coastal Resources Management in the Cilacap Region, Yogyakarta (Indonesia), 20-24 Aug 1980. LIPI.

Naamin, N. (1984). Dinamika populasi udang jerbung (Penaeus merguiensis de Man) di perairan Arafura dan alternatif pengelolaannya. Unpublished Doctoral Dissertation]. IPB University.

Okamoto, H., Miyabe, N., & Matsumoto, T. (2001). General linear mixed model analysis for standardization of Taiwanese longline CPUE for bigeye tuna in the Atlantic Ocean. IOTC Proceeding, 1892-1915.

Pascoe, S., Coglan, L., Punt, A. E., & Dichmont, C. M. (2012). Impacts of vessel capacity reduction programmes on efficiency in fisheries: the case of Australia's multispecies northern prawn fishery. *Journal of Agricultural Economics, 63*(2), 425-443.

Purwanto. (2017). The biological optimal level of the arafura shrimp fishery. *Indonesian Fisheries Research Journal*, *16*(2), 79-89.

Purwanto. (2012). Performance of a fishery harvesting different minimumshrimp sizes in the arafura sea. *Indonesian Fisheries Research Journal, 18*(2), 79-89.

Sadhotomo, B., Rahardjo, P. & Wedjadmiko. (2003). Pengkajian kelimpahan dan distribusi sumberdaya demersal dan udang di perairan Laut Arafura. Prosiding Forum Pengkajian Stok Ikan Laut 2003. Pusat Riset Perikanan Tangkap, Departemen Kelautan dan Perikanan, Jakarta.

S.M. Evans, & R.I. Wahju. (1996). The shrimp fishery of the Arafura Sea (eastern Indonesia). *Fisheries Research*, 365-371. doi:https://doi.org/10.1016/0165-7836(95)00448-3

Sodik, D. M. (2009). Analysis of IUU fishing in Indonesia and the Indonesian legal framework reform for monitoring, control and surveillance of fishing vessels. *The International Journal of Marine and Coastal Law, 24*(1), 67-100.

Sularso, A. (2005). The shrimp fisheries management options of the Arafura Sea. [Published Doctoral Dissertation]. IPB University, Indonesia. Retrieved May 10, 2020, from http://repository.ipb.ac.id/handle/123456789/41006

Suman, A., & Satria, F. (2014). Opsi Pengelolaan Sumberdaya Udang Di Laut Arafura (WPP 718). *Jurnal Kebijakan Perikanan Indonesia*, *6*(2), 97-104.

Suman, A., Ernawati, T., & Pane, A. R. P. (2017). The population dynamic of banana prawn (Penaeus merguiensis de Man) in Tanah Laut waters, South Kalimantan. *Indonesian Fisheries Research Journal, 23*(1), 17-22.

Sumiono, B. (2012). Status sumberdaya perikanan udang penaeid dan alternatif pengelolaannya di Indonesia. *Jurnal Kebijakan Perikanan Indonesia*, *4*(1), 27-34.

Sutanto, H. A. (2005). Analisis Efisiensi Alat Tangkap Perikanan Gillnet dan Cantrang (Studi di Kabupaten Pemalang Jawa Tengah), Jawa Tengah, Indonesia. [Published Doctoral Dissertation]. Universitas Diponegoro. Retrieved August 8, 2020, from https://www.researchgate.net/publication/277769851_analisis efisiensi alat tangkap perikanan gillnet dan_cantrang_Studi_di_Kabupaten_Pemalang_Jawa_Tengah.

Squires, D., & Kirkley, J. (1999). Skipper skill and panel data in fishing industries. *Can. J. Fish. Aquatic Sci., 56*, 2011-2018.

Tijssen, S. B., Mulder, M., & Wetsteyn, F. J. (1990). Production and consumption rates of oxygen, and vertical oxygen structure in the upper 300 m in the eastern Banda Sea during and after the upwelling season, August 1984 and February/March 1985. *Netherlands Journal of Sea Research*, *25*(4), 485-499.

Vestergaard, N., Squires, D., & Kirkley, J. (2002). Measuring capacity and capacity utilization in fisheries: the case of Danish Gill-net fleet. *Fisheries Research, 1445*, 1-12.

Wetsteyn, F. J., Ilahude, A. G., & Baars, M. A. (1990). Nutrient distribution in the upper 300 m of the eastern Banda Sea and northern Arafura Sea during and after the upwelling season, August 1984 and February 1985. *Netherlands Journal of Sea Research*, *25*(4), 449-464.

Wijopriono, Wiadnyana, N. N., Dharmadi, & Suman, A. (2019). Implementasi penutupan area dan musim penangkapan untuk pengelolaan perikanan udang di laut Arafura. *Jurnal Kebijakan Perikanan Indonesia*, *11*(1), 11-21.

Wyrtki, K. (1961). Scientific Results of Marine Investigations of the South China Sea and the Gulf of Thailand 1959-1961 Physical Oceanography of the Southeast Asian Waters. NAGA report, 2, 195. Retrieved May 10, 2020, from https://escholarship.org /content/ qt49n9x3t4/ qt49n9x3t4.pdf.