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Production Shock Dynamics: A Comprehensive Assessment of *Scomberoides* sp., *Megalaspis* sp., and *Decapterus* sp. Fisheries in the Sunda Strait, Indonesia

Boimin[*1,2], **Zulfa Huriah**[1] **Karila Dyastari**[1], **Mohamad Iqbal Fajari**[1]

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ABSTRACT

Over the past decade, many fisheries have experienced declining yields—often described as production shocks—driven by factors such as excessive fishing pressure, climate variability, and policy misalignment. These policy-induced effects can heighten risks to fish stocks and influence local food system resilience. This study investigates these dynamics in the Sunda Strait, Indonesia, using 2019 data on production, fishing effort, and interviews with fishers operating out of Lempasing Landing Port, Lampung. Analytical approaches included assessing catch-per-unit-effort (CPUE) trends as a proxy for productivity, estimating maximum sustainable yield (MSY), and modelling effort-change scenarios for three small pelagic taxa: *Decapterus*, *Scomberoides*, and *Megalaspis* spp. Results from 2010–2019 reveal a decline in both production and fishing activity for all three species. Annual reductions in fishing effort were substantial: *Decapterus* declined by 27.3%, *Scomberoides* by 18.8%, and *Megalaspis* by 14.32%. Despite falling catches, CPUE increased, largely due to reduced effort. Fox model analyses indicate that stock status for all three species remains within underfished conditions, implying relatively abundant stocks or diminished fishing pressure. The simultaneous occurrence of declining production under an underfishing scenario suggests a production shock driven by reduced fishing capacity or diminished stock availability. External disruptions—particularly natural disasters and unsuitable policies—can further intensify production shock risks.

Keywords: Production Shock, Small-Scale Fisheries, Productivity, Food Security, Fisheries Policy, Sunda Strait.

INTRODUCTION

The enforcement of the Ministry of Maritime Affairs and Fisheries Regulation No. 56/2014—concerning the moratorium on fishing licenses for foreign-built vessels operating within Indonesia's fisheries management areas—requires a careful assessment of its overall effectiveness. The policy was designed to enhance national fisheries performance across both industrial and small-scale sectors. However, several cascading effects have emerged, including vessel deconstruction, reduced fishing effort, declining productivity, production shocks, and concerns regarding stock sustainability in relation to shifts occurring in both large- and small-scale fishing operations (Syafitrianto and Makmun, 2017).

National fisheries statistics from the Ministry of Marine Affairs and Fisheries (MMAF) indicate that between 2015 and 2016, fishing effort (measured as the number of active vessels) declined across nearly all Fisheries Management Areas (FMAs). The reductions varied by region: 0.96% in Sumatra, 49.91% in Java, 19.18% in Bali–Nusa Tenggara, and 6.09% in Maluku–Papua. On a national scale, fishing effort had fallen by 4.31% by 2016 (KKP, 2018).

At the local level, particularly in the Sunda Strait, the implementation of Regulation No. 56/2014 has been associated with reduced production, diminished productivity, and shifts in stock sustainability, especially in small-scale fisheries. This underscores the need to evaluate the relationship between fishing effort and production for key small pelagic species such as double-spotted queenfish (*Scomberoides* sp.), torpedo scads (*Megalaspis* sp.), and mackerel scads (*Decapterus* sp.). These species are commonly harvested using bottom gillnets, handlines, pelagic danish seines (payang), and purse seines (Telussa, 2016).

The relatively low production of these three species is influenced by several factors, including limited fisher skills and knowledge related to gear

*Corresponding author:
✉ boimin@apps.ipb.ac.id
[1)]Centre for Coastal and Marine Resources Studies (CCMRS) IPB University, Indonesia
[2)]Awardee LPDP PK-18 at the University of Massachusetts Amherst, the U.S.A

use, insufficient access to information on productive fishing grounds, and decreasing fishing effort (Tanjov et al., 2016). Additional drivers of production shocks include vulnerability to environmental variability and climate change (Gephart et al., 2017). Climate-related changes can alter fish structure, function, and distribution patterns (Sumaila et al., 2011), as well as the availability of plankton—the primary food source of small pelagic fish. Key oceanographic variables such as sea surface temperature and chlorophyll-a concentration can indirectly shape stock status (Nontji, 2008).

To better understand production shocks and policy impacts at the local level, this study evaluates production trends, productivity changes, and stock potential (estimated via MSY) for three pelagic species in the Sunda Strait. The findings provide an important reference for assessing policy implications and informing adaptive fisheries resource management strategies.

MATERIAL AND METHOD

Time and Location

The enforcement of the Ministry of Maritime Affairs and Fisheries Regulation No. 56/2014—concerning the moratorium on fishing licenses for foreign-built vessels operating within Indonesia's fisheries management areas—requires a careful assessment of its overall effectiveness. The policy was designed to enhance national fisheries performance across both industrial and small-scale sectors. However, several cascading effects have emerged, including vessel deconstruction, reduced fishing effort, declining productivity, production shocks, and concerns regarding stock sustainability in relation to shifts occurring in both large- and small-scale fishing operations (Syafitrianto and Makmun, 2017).

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The relatively low production of these three species is influenced by several factors, including limited fisher skills and knowledge related to gear use, insufficient access to information on productive fishing grounds, and decreasing fishing effort (Tanjov et al., 2016). Additional drivers of production shocks include vulnerability to environmental variability and climate change (Gephart et al., 2017). Climate-related changes can alter fish structure, function, and distribution patterns (Sumaila et al., 2011), as well as the availability of plankton—the primary food source of small pelagic fish. Key oceanographic variables such as sea surface temperature and chlorophyll-a concentration can indirectly shape stock status (Nontji, 2008).

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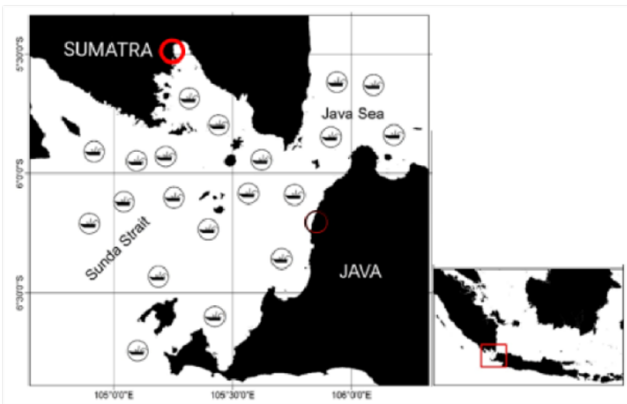

Figure 1. Research area in the Sunda Strait and Lempasing Landing Port

The Sunda Strait forms part of Fisheries Management Area–Indonesian Republic (FMA-IR) 571 within the Indian Ocean. Small-scale fisheries in this region target a diverse assemblage of pelagic species using multiple gear types and vessel classes, reflecting the multispecies and multigear nature characteristic of tropical fisheries (FAO, 2014; Yonvitner, 2019).

Data Collection

Data were sourced from the Lempasing Landing Port located along the coast of Lampung Province. Recorded datasets included annual catch volumes and fleet numbers obtained from local fisheries agency archives spanning 2010–2019. From the total annual landings, three small pelagic species were selected for analysis: double-spotted queenfish (*Scomberoides* sp.), torpedo scads (*Megalaspis* sp.), and mackerel scads (*Decapterus* sp.)—all of which are consistently landed at Lempasing.

Production Trend Analysis

Annual production patterns for *Scomberoides*, *Megalaspis*, and *Decapterus* were analyzed using descriptive statistical methods (Walpole, 1992). Trends in production and fishing effort were visualized using bar charts and prediction models. Changes in fishing effort were examined following Steel and Torrie (1986), enabling the identification of effort "deconstruction" trends for each species. Positive correlations between effort and production were interpreted as evidence of beneficial policy outcomes influencing local fisheries performance.

Maximum Sustainable Yield (MSY)

The stock sustainability of the three species was estimated using surplus production models developed by Schaefer and Fox (Venema, 1999). Because small-scale fisheries in the Sunda Strait employ various fishing gears—bottom gillnets, handlines, pelagic danish seines (payang), and purse seines—each with differing fishing power, it was necessary to standardize fishing effort (Azkia et al., 2015). Standardization followed two key steps: calculating catch per unit effort (CPUE) and determining the Fishing Power Index (FPI).

MSY was estimated using the Fox surplus production model based on simple linear regression between catch and standardized effort for each species. From this model, the optimum fishing effort (fMSY) and total allowable catch (TAC)—approximately 80% of MSY—were calculated. The influence of Regulation No. 56/2014 was assessed by examining changes in fishing effort and productivity. More broadly, the analysis reflects global patterns in which production shocks arise due to multiple interacting pressures.

RESULT AND DISCUSSION

Result

Production

Fisheries Management Area (FMA) 571, which includes the Sunda Strait, is recognized as one of Indonesia's important regions for small pelagic fish production (Nurkhairani et al. 2018). Among the numerous species found here, three taxa consistently contribute to the landings: mackerel scads (*Decapterus* spp.), double-spotted queenfish (*Scomberoides* spp.), and torpedo scads (*Megalaspis* spp.). Trends in the production of these dominant pelagic species are displayed in Figure 2.

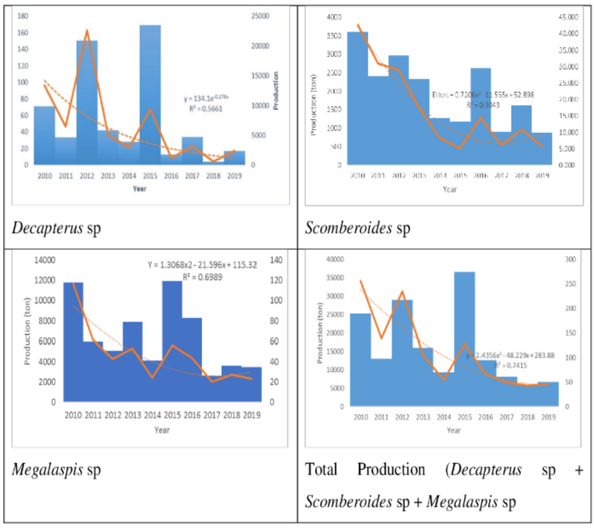

Figure 2. Production and fishing effort of *Decapterus* (A), *Scomberoides* (B), *Megalaspis* (C), and combined production (D) recorded in the Sunda Strait.

The average annual production of *Decapterus* spp. from 2010 to 2019 was 7,818.9 ± 8,017.6 kg, with a mean fishing effort of 48.4 ± 49.3 units. Over this period, *Decapterus* production grew by 107.62%, accompanied by a 64.27% increase in fishing gear usage. However, following the 2016 ban on foreign fishing vessels, production dropped sharply by 92.52%, with a simultaneous 87.41% decrease in effort. A similar decline occurred again in 2018, with production falling by 87.19% and effort by 80.09%. Overall, *Decapterus* fishing effort showed an annual decline of 27.3% from 2010–2019. In contrast, Purwinda et al. (2020) reported that *Decapterus* production in eastern Indonesia fluctuated, with a notable increase in productivity in 2019.

The average annual production of *Scomberoides* spp. during 2010–2019 was 1,979 ± 940 kg, while average fishing effort was 141.04 ± 45.88 units. Over the decade, production increased marginally by 0.91%, whereas gear usage declined by –1.07%. A substantial reduction in both production and effort occurred in 2017, falling by 65.87% and 57.21%, respectively. A second major decline took place in 2019, with production decreasing by 45.14% and fishing effort by 46.13%. Polynomial modelling suggests an annual decline in effort of approximately 18.8%. Declining catches of this genus are consistent with increased fishing mortality observed in Pakistani waters (Panhwar et al. 2014).

The average production of *Megalaspis* spp. from 2010–2019 was 6,479 ± 3,391 kg, with an average effort of 46.9 ± 28.8 units. Production grew by only 7.85% over the decade, while fishing gear usage decreased by –3.62%. Significant drops in production occurred in 2016 (–49.66%) and 2017 (–37.73%). Mean annual effort declined by 14.32%. Womar et al. (2016) reported that biological reference points derived from statistics in Pakistani waters indicate that *Megalaspis* stocks there are overfished and insufficient to support MSY.

Across the three species, the combined average annual production during 2010–2019 was 16,276.5 ± 10,497.74 kg, and mean fishing effort was 112.4 ± 78.4 units. Overall production of the three taxa increased by 18.42%, although a steady decline has occurred since 2016, with total effort decreasing by 2.42%. Polynomial modelling indicates that fishing effort declined by roughly 14.32% per year. Although the Sunda Strait supports high biodiversity, total landings have continuously decreased (Yonvitner et al. 2019).

Productivity

Productivity—measured as catch per unit effort (CPUE)—was calculated for each species. Overall productivity remained positive and showed an increasing trend across the three taxa. Average annual productivity increased by 10.75% for *Decapterus*, 7.65% for *Scomberoides*, and 5.39% for *Megalaspis*. The combined trend of productivity change, averaging 7.85% annually, is illustrated in Figure 3.

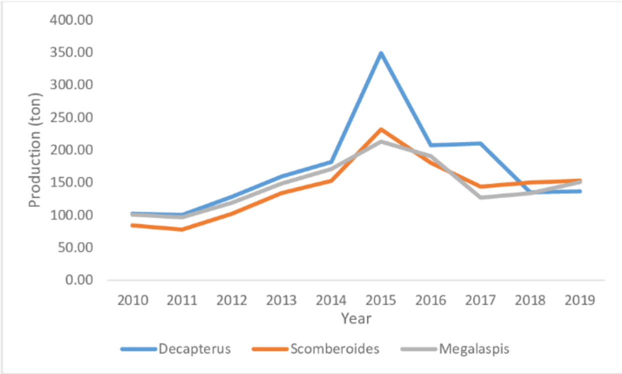

Figure 3. Produktivity of *Decapterus* sp, *Scomberoides* sp, dan *Megalaspis* sp species from 2010-2019.

Productivity estimates for purse seine, danish seine, mini purse seine, and mini trawl in Labuan during 2018 were approximately 72.56 tons per year (Yonvitner et al. 2020a), which is considered relatively low. The productivity increase recorded in 2015 corresponds to a notable reduction in fishing effort. After 2015, productivity declined again and stabilized at a relatively low level in 2018–2019. Additional studies by Yonvitner et al. (2020b) show that gears such as *sero*, shrimp longlines, and traps yield the lowest productivity (below 1 ton per year). Regulating these fishing gears is expected to improve overall productivity in the Sunda Strait.

Stock Security

Stock security refers to the condition in which actual production remains below the maximum sustainable yield (MSY) threshold. To determine stock status, MSY analyses were conducted for the three dominant small pelagic taxa caught in the Sunda Strait—*Scomberoides* spp., *Megalaspis* spp., and *Decapterus* spp.—based on monthly landings from 2010–2019. The estimated MSY values are illustrated in Figure 4.

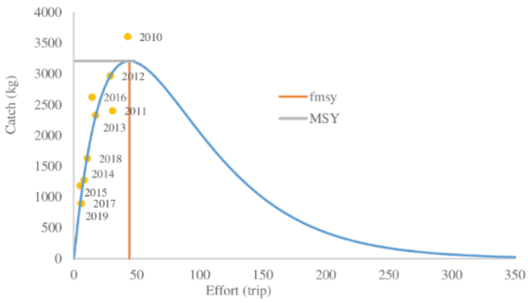

Figure 4. Maximum sustainable potential of double-spotted queenfish (*Scomberoides* spp.) in the Sunda Strait.

Using the Fox surplus production model, the MSY for *Scomberoides* spp. was estimated at 3.21 tons per year, with an optimal fishing effort (fMSY) of 44 trips per year. Actual catch and effort in 2019 were far below these thresholds at 0.89 tons and six trips (Figure 5).

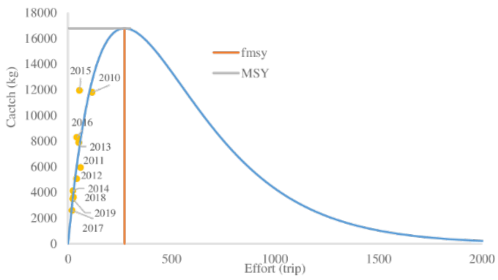

Figure 5. Maximum sustainable potential of torpedo scads (Megalaspis sp.) in the Sunda Strait

For *Megalaspis* spp., the Fox model estimated an MSY of 16.80 tons per year and an fMSY of 273 trips. Actual 2019 landings and effort were substantially lower at 3.49 tons and 23 trips (Figure 6).

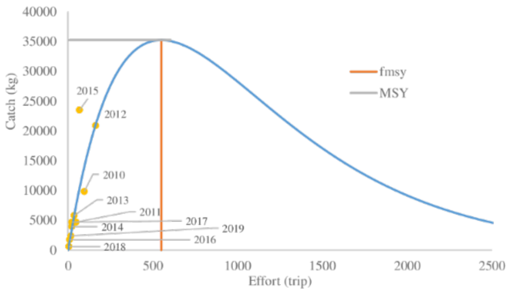

Figure 6. Maximum sustainable potential of mackerel scads (Decapterus sp.) in the Sunda Strait

The MSY for *Decapterus* spp. was estimated at 35.25 tons per year, with an optimal effort of 550 trips annually. Actual 2019 figures—2.38 tons and 17 trips—were well below these reference points. Prihatiningsih (2006) noted that *Decapterus* populations in the eastern Indonesian seas showed signs of overfishing between 1997–2004.

Although the three species are caught throughout the year, their landings remain relatively low, partly because they are not the primary target species at PPP Lempasing. Nonetheless, these taxa are representative of the broader small pelagic fish community landed in the port.

All three species are captured using the same types of fishing gear—bottom gillnets, handlines, pelagic danish seines, and purse seines—which vary in efficiency and operational characteristics. Therefore, effort standardization was required before conducting MSY analyses.

Based on standardized effort, MSY and fMSY estimates for the three species are consistently higher than actual 2019 catches and efforts, indicating that all species remain underfished. Their low exploitation levels reflect their secondary status in the fishery, as well as limited fisher knowledge regarding environmental factors such as sea surface temperature and chlorophyll-a concentrations, which influence catchability. Meanwhile, several other pelagic species in the Sunda Strait exhibit declining stock conditions or signs of overfishing, such as savala hairtail (Agustina et al. 2015), spotted sardinella (*Amblygaster firm*; Kartini et al. 2017), and ponyfish (*Leiognathus equulus*; Permatachani et al. 2016).

Discussion

Shocks to small-scale fisheries in the Sunda Strait can arise from several factors, including intensive exploitation or overfishing, natural disasters that disrupt fish availability—most notably the Anak Krakatau eruption—as well as policy and political dynamics. Analysis of production data for the three evaluated fish species indicates a simultaneous decline in both fishing effort and landings. Reductions in production may stem from decreased fishing activity, or conversely, increased effort that yields diminishing returns. Although earlier data suggested a temporary uptick in catches, overall productivity remained very low.

The landslide and subsequent tsunami triggered by Anak Krakatau led to a sudden halt in fishing operations. No fishing took place for over one month due to widespread trauma among fishers following the disaster. This short-term production shock persisted only temporarily, with signs of recovery visible in subsequent months, as illustrated in Figure 7.

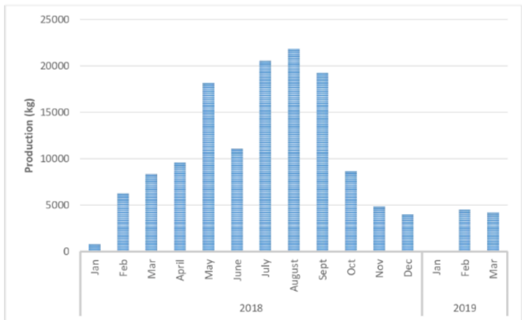

Figure 7. Production decline after the tsunami was recorded in Labuan Landing Fishing Port (as Part of the Sunda Strait landing port)

Comparing pre- and post-tsunami conditions—particularly for January to March—highlights the severity of the disruption. In January 2019, fish landings dropped to zero due to the absence of fishing activity. By February and March 2019, total landings reached only 40.9% and 37.7%, respectively, of the 2018 monthly averages. When assessed as the proportional impact on fishing output, production in January fell by 100%, followed by 27.3% in February and 50% in March relative to the same months in 2018. This pattern is expected, as more than half of Labuan's fishers remained psychologically affected by the tsunami, and community recovery in fisheries is closely tied to livelihood continuity and fish-related enterprises (Lyons et al., 2019). Similarly, Scholtens and Oueghlissi (2020) report that earthquakes and comparable disasters significantly depress market returns for fishing enterprises, with an estimated decline of 48.27%.

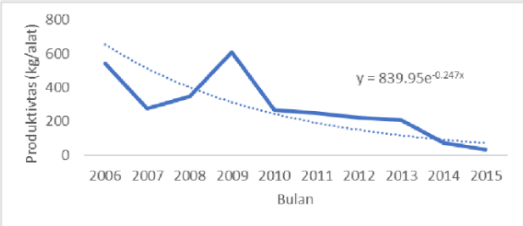

Figure 8. The trend of total productivity decline in Pandeglang since 2006-2015

The enforcement of Ministerial Decree No. 56/2014 further influenced national fishing capacity. At the national scale, tuna fisheries were most heavily affected, but reductions in effort were evident across multiple Fisheries Management Areas (WPP). In Pandeglang, catches declined consistently from 2006 to 2015, with an average annual decrease of 24.7%, and indications of overfishing in Java Sea small pelagic stocks (Purwanto et al., 2014). These patterns correspond with broader global seafood trends, where production increased by approximately 27% from 1994–2012 (Gephart and Pace, 2015). The long-term decline in productivity from 2006–2015 is presented in Figure 8 (above).

Policy restrictions on the use of imported fishing vessels have also contributed to reduced landings. Such disruptions influence not only stock sustainability but also local and global food supply chains (Gephart et al., 2016). This reduction may compromise the availability of protein and household food sufficiency, thereby affecting food security. Given that production shocks continue to occur and remain a source of vulnerability (Yonvitner et al., 2020), proactive mitigation strategies are essential to ensure both sustainable stocks and adequate food supply for communities. To address this, we conducted an integrated evaluation of national production trends spanning aquaculture (Cottrell et al., 2019), mariculture, and brackishwater aquaculture.

CONCLUSION

Over the past decade, the production and fishing effort for double-spotted queenfish (*Scomberoides* sp.), torpedo scads (*Megalaspis* sp.), and mackerel scads (*Decapterus* sp.) in the Sunda Strait have shown a consistent decline. Despite this reduction, overall productivity has remained stable with a slight upward trend. This modest increase in productivity may reflect reduced fishing effort or a gradual recovery of fish stocks. The relatively low catch levels compared to the sustainable potential (MSY) indicate that effort has not kept pace with stock abundance. Nevertheless, the broader decrease in total production reflects pressures—or production shocks—arising from excessive fishing effort, the impacts of the tsunami, and the consequences of vessel deconstruction policies. To safeguard stock sustainability and maintain food security, expanded investment in aquaculture and mariculture is essential, as these sectors are increasingly central to meeting national demand for fish-based protein.

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