

OVERFISHING OF THE ANCHOVY FISHERIES IN KRUENG RAYA BAY-ACEH, INDONESIA

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ABSTRACT

Anchovy fisheries in Indonesia faces a declining state in the next decade. This research investigates some factors contributing to a reduction of anchovy resources. It was carried out in Krueng Raya Bay-Aceh from September to October 2012. Survey and interviews were implemented to explore the state of anchovy. Primary and secondary data was analyzed using descriptive, simple regression and stock classification. Anchovy production showed a decreasing trend before tsunami, it sharply plummeted to 171 tons in 2005 after the tsunami, and it fluctuated in range 126- 279 tons in the period 2006-2012. Simple regression analysis resulted to different models of MSY either before or after the tsunami in 2004 which were shown as $y = 0.8696 - 0.00008x$ and $y = 0.1138 - 0.00002x$, respectively. Average recent catch in MSY showed 53.9% (less abundant) before the tsunami and 5.5% (depletion) after that. These conditions was led by increasing effort, un-friendly, destructive fishing gears, and degradation of coral reef and mangrove. Such an overfishing was accelerated by anthropogenic factors and compounded by the tsunami factor. The tsunami impact on anchovy fishery overpressure may be lesser than the combined effects of destructive fishing and anthropogenic factors.

Keywords: Anchovy fisheries, factors contributing, maximum sustainable yield, overfishing

INTRODUCTION

Anchovy production was fluctuation because of increasing demand for human consumption and bait fish in Indonesia. It decreased during the period 2001-2007 (average growth -1.1%) and increased again in the period 2008-2011 (average growth 4.4%), with an average annual growth reaching 1.4% [1]. However, over the past 14 years production has shown a decline trend in several anchovy fisheries centers, including in Aceh Province. In this region, anchovy production declined to 5,516 tons (2004) from 7,062 tons (2001), being a -21.9% decrease. It gradually dropped from 2005 to 2010, with an average decline of -3.4% [2].

There were several factors contributing to anchovy production decrease in Aceh Province. The most decisive factor is the rapid increase of lift net boats. The number of these boats increased from 593 units in 1994 to 607 units in 2004. After the 2004 tsunami, lift net boats dramatically dropped to 194 units, but again increased gradually to 224 units in 2012. Another factor was environmental degradation that affected anchovy resources. Nowadays, overfishing, mangrove and coral reef destruction, and waste pollution, have become worse and they would expectedly impact on anchovy fisheries in the next decade. Moreover, the tsunami indirectly influenced the declining of anchovy production during 2005-2012.

Overfishing of anchovy resources has also occurred in Krueng Raya Bay. Unfortunately, there is no scientific report on anchovy stock for this semi close ecosystem in relation to anchovy fisheries management. Our study in 2012 found that anchovy production showed a sharp decrease from 2,072 tons in 1999 to 1,050 tons in 2004 and dramatically declined further to 171 tons an aftermath of the tsunami [3]. Anchovy production showed fluctuation in the period 2005-2009. It was less than its pre-tsunami production that reached 126.57 tons in 2012. On the contrary, the number of lift net boats increased from 8 units in 2005 to 31 units in 2009. In-depth interviews with the Panglima Laot Lhok (sea commander, hereinafter called PLL) in 2012 indicated that both coral reef and mangrove ecosystem degradation were decisive factors in reducing anchovy catch before and after the 2004 tsunami. However, not many researches paid attention on what natural disasters can directly and indirectly do to the anchovy fisheries.

Past data were not appropriate to fully account for the anchovies' state. Scientific data are also limited to reveal whether anchovy fisheries are subjected to either overfishing or depletion in Krueng Raya Bay. Therefore, this study aims to explore some crucial factors contributing to overfishing of anchovy resources in Krueng Raya Bay. The specific objectives of this research are to examine the maximum sustainable yield (MSY) of anchovy before and after the tsunami; and, to examine the state of anchovy stock categories.

The research site was conducted in Krueng Raya Bay which is located on the edge of Malacca Strait and North Sea waters (Fig. 1). Intensive data collection was conducted in four villages (desas), i.e., Ruyung, Meunasah Keudee, Meunasah Kulam and Meunasah Mon. Secondary, in particular about the production of anchovy, number of lift net boats, and coral reef condition, were obtained from APMAF. Production of anchovy and the number of lift net boat series data in period 1999-2012 were analyzed to assess MSY and production trend. Other secondary data, such as fisheries and ecosystem data, were sourced from available reports. Data was analyzed using surplus production model (SPM), descriptive statistics, comparative and fish stock classification.

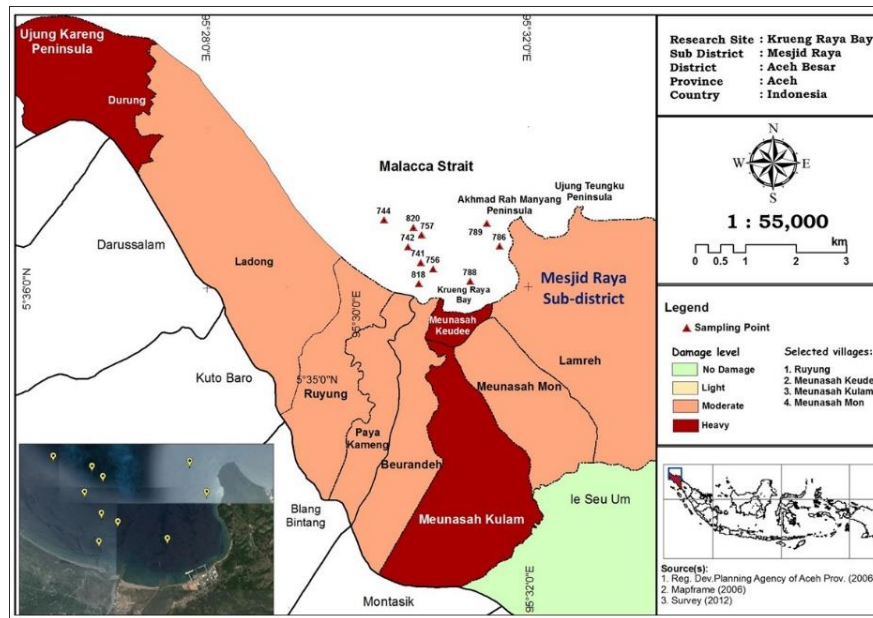


Fig. 1: Study site at Krueng Raya Bay, Aceh -Indonesia (Data from Regional Development Planning Agency of Aceh Province [4]; BRR NAD-Nias [5] Field Survey, 2012)

PRODUCTION TREND AND FISHING OPERATION

Before the tsunami, anchovy production showed a decreasing trend (Fig. 2). Anchovy catch dropped to 1,050 tons in 2004 and it sharply plummeted to 171 tons in 2005 after the tsunami. Eventually, it fluctuated between 126 and 279 tons in the period 2006-2012. Fig. 2 also point out that actual production has been less than the result of production surplus model recommendation. During the field survey on September-October 2012, anchovy catch was very low in the east monsoon season. With the operation of 7-29 units of lift net boats, anchovy production was 7.8 tons. Average catch per unit effort (CPUE) reached 13.5 kg/day or total catch of 100-425 kg/day.

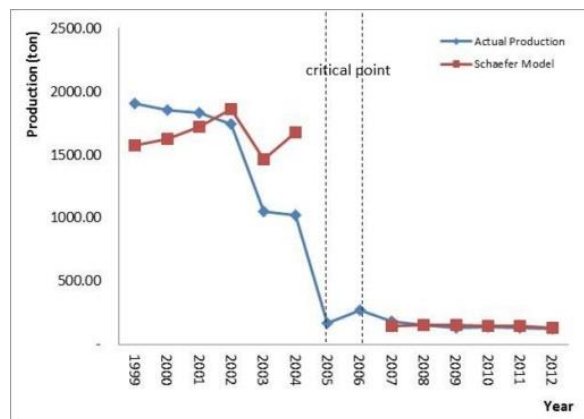


Fig. 2: Comparison of actual production of anchovy and surplus model recommendation during 1999-2012 (Data from MAFOAP [2]; Data Analysis, 2013)

A lift net boat operated from 18 to 22 days each month for a total of six months per year. It operate only in the coastal water zone and catch various small pelagic fishes including anchovy throughout the year. Fishing operation starts at 0430H and finishes the following morning at 0700H. Various pelagic fish species were caught and total volume of catch differs between west (October-March) and east monsoon season (April-September). This research found that 23% and 15% of anchovy size were distributed within intervals of 84.4-88.4 mm and 88.5-92.5 mm during the period September-October 2012, respectively. The mean of total length value was 84 ± 0.02 mm; thus, it can be classified as adult stage.

MAXIMUM SUSTAINABLE YIELD (MSY) AND THE STATE OF ANCHOVY STOCK

Anchovy production is significantly correlated with effort as indicated in the data for the period 1999-2012. When the effort reached 9,344 trips in 1999, anchovy catch was 1,905.58 tons. Afterward, catch volume fluctuated and fell sharply in 2003. This fact indicated that the critical point of anchovy fisheries occurred after the 2004 tsunami. Production dropped extremely down to 166.94 tons in 2005 using 432 trips. Even though the fishing effort was three times than that in 2005, anchovy production only went up almost twice in 2006. Simultaneously, the total effort gradually increased during the recovery process, but anchovy catch continued to show constant decline.

Data revealed that CPUE in both the period 1999-2004 and 2007-2012 tend to decrease with increasing efforts (Fig. 3). Correlation between CPUE as a dependent variable (y) and effort as an independent variable (x) was computed using SRA. According to SRA, we can propose two distinguishable models of anchovy MSY in Krueng Raya Bay. Model 1 represented the period before

the tsunami with equation $y = 0.8696 - 0.00008x$ and Model 2 addressed the period 2007-2012 with equation $y = 0.1138 - 0.00002x$. Both models recommended the MSY of anchovy fisheries and the optimum effort to be spent in a managed area of Krueng Raya Bay. To sustain the anchovy fisheries for each period, models 1 and 2 also performed the optimum number of 43 units and 23 units of lift net boats, respectively.

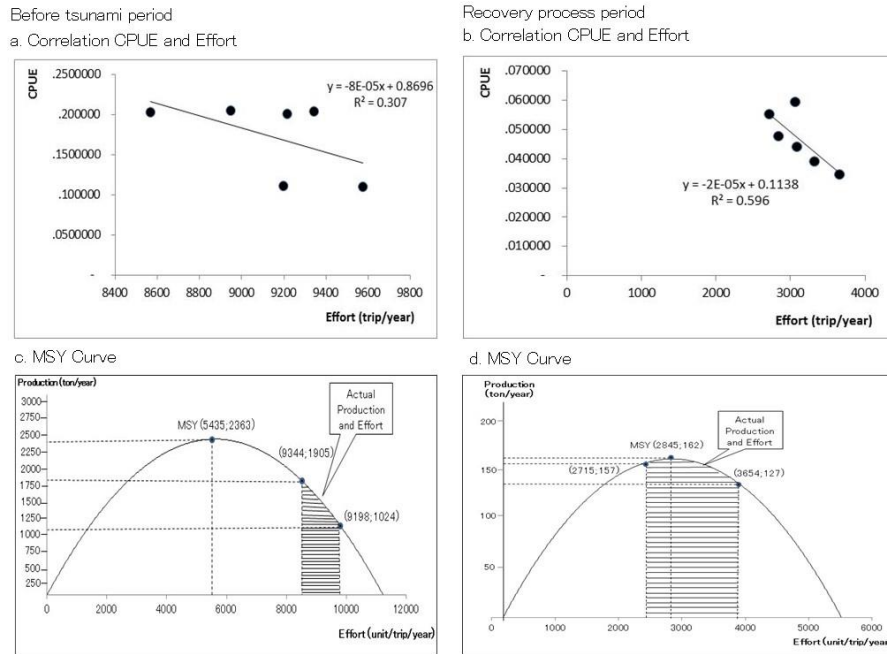


Fig. 3: CPUE-effort correlation (a-b) and MSY curve (c-d) of anchovy in the period 1999-2012 (Data from MAFOAP [2]; Data Analysis, 2013)

Later on, anchovy's MSY curve can be directed using both constant (a) and coefficient (b) estimators (Fig. 3). This research revealed that MSY in the period before tsunami (1999-2004) and recovery process (2008-2012) were 2,363.138 tons/year and 161.881 tons/year, respectively. Meanwhile, actual productions in the same period were in range of 1,024.18-1,905.58 ton and 126.57-156.79, respectively. According to Fig. 3, actual production was less than anchovy's MSY, but the actual effort had already been over the optimum efforts as this model suggested for both periods. Interestingly the findings in this research were: (1) the fishery's MSY in the period of recovery process was 20 times less before the tsunami; (2) the recent average catch in MSY was 53.9% of MSY and it can be classified to the less abundant stock in before tsunami; and (3) the recent average catch in MSY went down to 5.5% of MSY, it means the stock faced imminent depletion.

OVERFISHING OF ANCHOVY FISHERIES IN THE PERIOD 1999-2004

Overfishing of anchovy fisheries was shown by actual effort more than the optimum effort and actual production less than the MSY (see Fig. 3c). Indeed, anchovy stock could be considered into less abundant state, which is shown by the recent average catch in MSY (53.9%). There were several major factors that caused overfishing of anchovy fisheries prior to the tsunami disaster. Firstly, the number of lift net boats definitely increased in the 1980s and the 1990s. In the earlier stage of anchovy fisheries development in the 1970s, only 2 lift net boats had been put into operation for fishing

anchovy, according to PLL . The number of lift net boats rapidly increased to 70 units in the 1980s, and reached 89 units in the 1990s. PLL mentioned that the number of fishing boats was 91 units just before the disaster in 2004.

Secondly, since the 1990s, equipment and materials used for fishing have become rapidly sophisticated with a sharp rise of productivity. In the earlier stage of development, the lift net boats used simple kerosene lamps in the 1970s and the 1980s; finally, they operated fluorescent lamps (capacity 10 watts) since the 1990s to attract phytoplankton and small schooling fish, including anchovy. Motorization of pull boats equipped with outboard engine was a decisive factor to increase catch effort. In the last two decades, generators were equipped on board as power plant for light fishing to increase productivity. Each lift net boat was equipped with 25-40 white fluorescent lamps and one green lamp.

Thirdly, the mesh size of the lift net fishing gear is becoming smaller. Fishermen used the mesh size 0.95 cm on the bottom side, 1.27 cm in the middle side, and 2.54 cm on the top side to construct a set of lift net fishing gear with wide 18 m X 18 m and depth of around 15 - 20 m. This fishing net is not selective, targeting juvenile stage of anchovy (fishermen knew such fish as small anchovy or “Teri Medan”), and catching all kind of small pelagic fish. In fact, the design of lift net also harvested the small size of anchovy (10-15 mm) during east and west monsoon seasons. As a consequence, stock of anchovy faced pressured condition and declined year after year, because it has no chance to reach sexual maturity stage. There is no special record the interval length of first stage maturity for *S. commersonii*. However, Luther [6] reported that minimum size of *S. commersonii* at first maturity is 110 mm in the southwest coast of India. Andamari et al., [7] mentioned that the maturity stage of *S. commersonii* was identified in average length 109.9 ± 0.5 mm in Bima Bay.

Fourthly, anchovy is harvested throughout the year in both west and east monsoons. It might cause a decline of stock to support reproduction system of anchovy. In case of tropical anchovy, spawning season may have occurred throughout the year and reproductive seasons are often linked to the monsoon season [8].

OVERFISHING OF ANCHOVY FISHERIES IN THE PERIOD 2005-2012

Overfishing of anchovy fisheries continued during the period 2005-2012. Because the actual production and fishing efforts were more than MSY and optimum efforts in the same period, means anchovy fisheries was in overcapacity condition. Lift net fisheries was in overcapacity at around 16.7% by using the effort of 3,325 trips in 2011. Thus, the number of lift net boats had to be reduced by 23 units for sustainable anchovy fisheries. Otherwise, anchovy resources sustainability would be threatened and depleted due to the recent average catch in MSY (5.5% of MSY).

Besides the factors mentioned above, there are many other factors as to why anchovy fisheries showed depletion. Firstly, coral reef and mangrove ecosystem degradation might have contributed to anchovy depletion. According to the Center for Oceanography-Indonesia Research Institute [9], coral reefs in the western part of Indonesia are in poor condition (35.7%), including the reef in this study area. As an aftermath of the tsunami, the area, length and average living cover of the coral reef ecosystem were 196.4 ha, 13 km and 10%, respectively [10]; and the live cover of hard coral was 36.9 % [11]. Therefore, the coral reef ecosystem was in poor condition based on the classification developed by McAllister [12].

Commonly, coral reef damage in the study area has been caused by increasing intensity of line boat activities, anthropogenic factors, and tsunami impact. Increasing number of line boats to 31.3% before the tsunami might have contributed to the destruction of coral reef ecosystems because these boats captured reef fish as a target species. These boats also frequently dropped anchors on reefs that can cause severe damage to coral reef ecosystems.

Anthropogenic factors have simultaneously occurred toward contributing to anchovy depletion after the tsunami. Nowadays, potassium cyanide that can kill coral polyps, symbiotic algae, and other small organisms necessary for healthy reefs has been used to catch ornamental reef fish by some fishermen in the study area. Explosives, land-based pollution, destructive fishing, oil spills, sand mining and untreated human sewage might have exerted much stress towards coral reef degradation. Indeed, mangrove conversion, deforestation, agriculture, shipping and harbor construction have destroyed the coral reef ecosystem indirectly.

The tsunami also affected the mangrove ecosystems in Krueng Raya Bay. It is estimated that 77.1 ha of mangrove ecosystem is distributed along a 15.27 km stretch within the Aron Meudawa-Ujung Teungku Peninsula zone. The percentage cover of mangrove trees had remained at around 5% and it can be classified as under the severely damaged category according to the Ministry of Environment Classification [13]. In the 1980s, the mangrove area was estimated at around 300 ha in Krueng Raya Bay. The mangrove ecosystem has been converted into brackish water shrimp ponds, which might be a major factor for the ecosystem degradation in this area. As a comparison, Wibisono and Suryadiputra [14] reported that 26,823 ha mangrove ecosystem in Aceh Besar District was affected by the huge tsunami disaster. However, the tsunami's effect was less than the other anthropogenic impacts on the mangroves which are harvested for charcoal, housing and fire wood.

Secondly, rapid human population growth in Krueng Raya Bay after the tsunami disaster has urged fishing communities to depend more on fisheries resources (in particular anchovy) than before the 2004 tsunami. Before the disaster, around 69% of the population in this region had been dependent on capture fisheries and 31% on other livelihoods such as agriculture and livestock. After the tsunami disaster, those who were engaged in capture fishery and relied on it for their income increased to 78%. Lotze et al., [15] stated that rapid human population growth caused an increasing demand, commercialization of resources, technology development, unselective and destructive fishing gears that caused a sharply upward trend on fish resources depletion. They added that human activities have impacted to more than 90% of important species depletion; and 60% sea grass and wetlands habitat destroyed, water quality degradation, and accelerated species invasion.

CONCLUSION

Increasing utilization and dependency of anchovy resources caused the decline of anchovy fisheries which is increasingly unable to support fisheries livelihood after the 2004 tsunami. As a consequence, anchovy fisheries was over exploited during the period 1999-2004 and became deplete in the period 2005-2012.

There are several factors that contributed to overfishing anchovy fisheries prior to the tsunami. Increasing effort, non-selective mesh size, unlimited use of lighting, harvesting throughout the monsoon season were direct factors contributing to anchovy overfishing. Anthropogenic factors definitely caused the degradation of coral reef and mangrove ecosystem and these factors could be indirect factors on the decline of anchovy fisheries prior to the tsunami.

Anchovy fisheries faced overfishing condition due to the actual production of anchovy and average recent catch in MSY. This anchovy fisheries depletion can lead to at least six scenarios, as follow: (1) anchovy resources suffered under extreme pressure during the critical years (2005-2006), (2) the direct factor continued contributing on anchovy resource declining during recovery process, (3) the destructive fishing operations threaten the coral reef ecosystem, (4) the anthropogenic factors lead to coral and mangrove ecosystem degradation, (5) tsunami impact compounds the degradation of coastal ecosystem; and (6) the population increase caused the increase of anthropogenic factors and dependency on anchovy resources. However, it is clear that the tsunami impact on anchovy resources depletion may be lesser than the combined effects of destructive fishing and anthropogenic factors.

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