Lesson learned of EAFM from pole and line fishery based in Sikka Regency, Nusa Tenggara Timur

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Abstract. Sikka Regency, Nusa Tenggara Timur is one of the key landing places for tuna in Indonesia’s archipelagic waters (IAW), which was selected for pilot scale application of EAFM. This study was aimed to identify some best practices of the EAFM application from pole and line fishery based in Sikka Regency. Pole and line data were collected by the observer and port sampling programs, data from handline fishery collected from other areas within the IAW was also investigated. Furthermore, for broader comparison purposes, trends from purse seine fishery operated in other areas within the IAW were also used. Data from pole and line fishery in Sikka Regency were analyzed to obtain length distribution by gear. Stakeholder consultative meetings were conducted to investigate some key issues and possible improvements for the fishery. Skipjack was the most predominant species caught by pole and line and purse seine (>60%) but mostly immature fish. All yellowfin tuna caught by pole and line and purse seine was immature. It is recommended to reduce small-size yellowfin catch and to maximize the economic benefit to local fishers. In addition, improvement of FAD management implementation, monitoring, and law enforcement are required reflected best practice of EAFM.

Keywords: EAFM, pole and line, tuna fishery

1. Introduction

Ecosystem approach to fisheries management (EAFM) is one of the innovations in managing fisheries that try to balance the ecological and human well-being components through good governance (FAO 2012) which the outcome is beneficial to the community (Fletcher 2010). Several initiatives of EAFM implementation have been done in Indonesia, such as reef fisheries in Raja Ampat and Wakatobi MPA, small pelagic fishery in Flores Timur Regency, reef and mud crab fisheries in Regency of Maluku Tenggara MPA, Teluk Jor in Regency of Lombok Timur (Muawanah et al 2018). In addition, some initiations of EAFM had been conducted for scad fishery in Sulawesi Sea (Puspasari et al 2014) and Bombay duck fishery in Tarakan, North Kalimantan (Prasetyo et al 2014). However, a specific EAFM for tuna fisheries in Indonesia has not been implemented yet.

Skipjack (Katsuwonus pelamis-SKJ) is the most predominant tuna species caught by Indonesian tuna fisheries in the Western and Central Pacific Ocean (WCPO) (Satria et al 2014, Satria et al 2015, Satria
et al 2016, Satria et al 2017, Satria et al 2019), fisheries targeting or catching this species should become one of Indonesia’s concern in term of ensuring its sustainability. SKJ is the main target for pole and line (PL), purse seine (PS) and troll line (TR). Pole and line that locally known as huhate have been used as a fishing gear by Indonesian fishers since long time ago to capture mainly skipjack, but commercially began in 1970s. The pole and line have been developed mainly in the eastern part of Indonesia particularly in the water northern of Papua, Sulawesi, Maluku, Halmahera and Nusa Tenggara Timur. Fishing operation of pole and line is mainly in within five out of eleven Indonesian Fisheries Management Areas (FMAs) that are FMA 713, 714, 715, 716 and 717.

Sikka-Maumere is one of the key landing places for tuna fisheries operating in Indonesia’s archipelagic waters (IAW) within FMA 714 that uses pole and line to target SKJ, but also handline (HL) to target yellowfin tuna (Thunnus albacares-YFT). This site was selected for the Pilot scale application of EAFM. In 2017, data collection through observer and port sampling programs (under the collaborative research project between Center for Fisheries Research and the Western and Central Pacific Fisheries Commission, under the West Pacific and East Asia project) were conducted for pole and line based in Sikka-Maumere. In addition, extensive stakeholder consultations have been conducted in Kupang in relation to the fishery. Some issues were identified during the focus group discussion that involved relevant stakeholders which including a large catch proportion of small YFT and bigeye tuna (T. obesus-BET) by pole and line and handline fisheries, and increase in the use of fish aggregating devices (FADs) have been identified among others.

This study was aimed to identify some best practices of the EAFM application from pole and line fishery in Sikka Regency, Nusa Tenggara Timur (NTT). As the small YFT were also caught by handline in a large proportion, whilst only pole and line data was collected by the observer and port sampling programs, data from handline fishery was collected from and other areas within the IAW were also investigated. Furthermore, for broader comparison purposes, trends from purse seine fishery operated in other areas within the IAW were also used.

2. Materials and methods

Pilot-scale application of EAFM to one site of the tuna fishery in Indonesia was attempted in a pilot site-Sikka Regency, NTT for pole and line fishery, accompanied with provision for extensive stakeholder consultation on all aspects of the process. However, other relevant tuna fisheries, i.e. handline fishery and purse seine were also investigated.

Data were obtained through field visit, by means of port-based sampling (enumerator) and observer programs for pole and line fisheries based in Sikka Regency. Data and information related to the price of the yellowfin tuna by size and quality obtained from interviews with relevant sources in the study area were included in the analysis, to enhance the findings from Sikka Regency pilot study. Summary of data used in the analysis is provided in Table 1.

Data from pole and line fishery in Sikka Regency, meanwhile handline and purse seine from other areas within the IAW were analyzed to obtain length distribution by gear. Stakeholders consultative meeting attended by policymakers, stakeholders, and government agencies were conducted to investigate some key issues and possible improvements for the fishery. Findings from the data analysis combined with the results of the consultative meeting were used to develop some recommendation on potential measures to improve the best practice of tuna fisheries in the IAW.
Table 1. Summary of data used in the study.

| Data Set                        | No. trips/landings | Duration (months) | Gear types | Information recorded                      |
|--------------------------------|--------------------|-------------------|------------|------------------------------------------|
| Observer Program - Sikka        | 17                 | 7 (2017)          | PL         | • Positions in Lat & Lon (per setting)    |
|                                |                    |                   |            | • No. Poles & fishing days               |
| Port Sampling Program - Sikka   | 288                | 8 (2017)          | PL         | • Grid code (per trip)                   |
|                                |                    |                   |            | • No. fishing days                       |
| Port Sampling Program - Bitung  | 3485               | 12 (2017)         | PL, HL & PS| • Grid code (per trip)                   |
|                                |                    |                   |            | • No. fishing days                       |
| MDPI – Labuan Lombok Timur      | 42                 | 12 (2016)         | HL         | • No. days at sea                        |

Note: pole and line (PL), hand line (HL), purse seine (PS) and MDPI (Masyarakat dan Perikanan Indonesia).

3. Results and discussion

3.1. Capture fisheries in Sikka

Marine capture fisheries in Maumere-Sikka comprise of many fisheries included hand line-troll line, bottom longline, pole and line (Marine and Fisheries District Agency of Sikka 2017) (table 2). Fish landing locations in Sikka spread in 5 sites i.e. Alok, Paga, Nangahure, Nangahel, and Wuring.

Table 2. Fishing gears operate by fishers based in Maumere-Sikka 2017 (Marine and Fisheries District Agency of Sikka, 2017).

| Fishing Gear                   | Main Target                                      | Number |
|--------------------------------|--------------------------------------------------|--------|
| Pancing Ulur – Tonda           | Yellowfin tuna, Bigeye tuna                       | 1,923  |
| Rawai Dasar                    | Yellowfin tuna, Bigeye tuna                       | 78     |
| Rawai Hanyut                   | Skipjack tuna                                     | 3      |
| Huhate                         | Yellowfin tuna and Bigeye tuna                    | 67     |
| Jaring Insang Tetap            | Skipjack tuna                                     | 340    |
| Jaring Insang Hanyut           | Demersal fishes and Shrimps                       | 930    |
| Pukat Cincin                   | Large and small pelagic fishes                    | 115    |
| Pukat Pantai                   | Small pelagic fishes                              | 574    |
| Bagan                          | Demersal and small pelagic fishes                 | 69     |
| Babu                           | Anchovies                                        | 179    |
| Jala Tebar                     | Snapper and grouper                               | 60     |
| Panah                          | Reef fishes, snapper and grouper                  | 913    |

Sikka’s pole and line fishery have been started since 1980s (according to the head of Marine and Fisheries District Agency of Sikka 2017). Starting from 1 (one) boat in 1980, then 9 boats in 1983, afterward 19 boats in 1985 and became 48 boats in 1988 (all boats are wooden boat). Partnership project among Directorate-General for Capture Fisheries (DGCF) and a fishing company named Bali Raya Co Ltd. developed 26 boats (material fiberglass) so that total pole and line boat about 74 boats in 1988. Size of wooden boats were 20-30 GT and fiberglass boats ranged 15-20 GT. The capacity of fish hold the wooden boats about 10-12 ton and fiber boats about 6-8 ton). In 2017, the number of active poles and line boats is 67 boats ranged 10 and 35 GT and dominated by size 30-35 GT (Marine and Fisheries District Agency of Sikka 2017).
The fishing ground of pole and line based in Sikka especially in Indonesian FMA 713 (Flores Sea) and some time in Indonesia FMA 714. The pole and line boats operate in around of FADs and free schooling. Figure 1 shows the fishing ground of pole and line based on observer program in 2017.

![Figure 1](image1.png)

**Figure 1.** Fishing positions of pole and line vessels recorded by observers. Red circle refers to associated with FADs and blue triangle refers to un-associated with FADs

### 3.2. Pole and line fishery in Sikka

SKJ was the most dominant species caught by PL (Sikka and Bitung) and PS (Bitung), comprised of 60% of its total catch, followed by YFT (comprised of 13% of PL catch in Sikka, 31% of PL catch in Bitung and 25% of PS catch in Bitung, respectively) and then BET. On the other hand, YFT contributed the highest catch of HL in Lotim and Bitung (79% and 95%, of HL catch, respectively) (figure 2). All YFT samples from PL (based at Sikka and Bitung) and PS (based at Bitung) were less than its Lm (102 cmFL) (Figure 3a, b, and e, respectively). There are different trends between HL based at East Lombok and Bitung. 82% of YFT samples from HL (based at East Lombok) were less than its Lm, whereas YFT samples from HL based at Bitung were mostly large fish (96% of YFT samples) (figure 3c and d, respectively). HL vessels based in East Lombok normally bring 3 types of gear (deep and surface HL, and TR). Deep HL is operated in deeper water column, bigger hook size, whereas surface HL are operated in surface water (between 0-50 m depth) and smaller hook size. TR use similar sizes of hook with surface HL. Surface HL and TR catch small-size YFT, whereas deep HL caught larger sizes of YFT. However, the port sampling data do not separate between surface HL and TR.

![Figure 2](image2.png)

**Figure 2.** Catch composition by gear type and landing site: BET, SKJ, YFT, OTH.
Figure 3. The size distribution of yellowfin tuna (*Thunnus albacares*) by gear type and location. Red and green bars show the fish length < Lm and >= Lm, respectively. HL vessels based in Lotim normally bring 3 types of gear (deep and surface HL, and TR).
The proportion of YFT by gear type was also summarized in figure 5a. Although HL from Bitung caught higher proportion of YFT > Lm (figure 5a), HL from Lotim caught mostly YFT < Lm (figure 3c). This might reflect that HL used by fishers from Bitung is different from those used by fishers from Lotim. Fishers from Bitung might fish deeper than those from Lotim. Based on the port sampling data, almost 100% YFT and ~60% SKJ caught by PS from Bitung were less than its Lm. This suggests that PS vessels give higher fishing pressure on small-sized YFT and SKJ. Spatial distributions of YFT (a) and SKJ (b) catches by size (green and red colors represent size more than Lm and less than Lm, respectively) from PL fishery recorded by observer and port-sampling programs are provided in figure 6.
Figure 5. Catch composition of YFT (above) and SKJ (below) in a relation of its Lm.

Figure 6. Catches of YFT (a) and SKJ (b) by size (green and red colors represent size more than Lm and less than Lm, respectively) from PL fishery recorded by the observer and port-sampling programs.
It has been a common practice for HL and PS vessels to catch tuna associated with FADs and there is an increase in the use of FADs by PL fishery in the IAW. However, there is no information available yet on the number of PL vessels and its efforts associated with FADs. Based on the observer program 2017 on PL vessels based in Sikka, there are differences in the tuna catch composition between PL associated and unassociated with FADs. YFT proportion was higher when fishing associated with FADs (figure 7). However, the observed data used in this study are limited in terms of time and area coverage.

3.3. Public and expert consultation

Several issues have been identified during the Focus Group Discussion (FGD) in Kupang led by DGCF, with wide participation from local government (NTT Provinces and SIKKA District), Local fishers, Pole and line company and Pole and Line Association from 13-15 September 2017, as follows:

a. A large proportion of juvenile or small tunas (YFT, BET)
b. Sustainability of associated fishery for live bait on PL (the burden not only from PL fishery but from the increase of demands for local consumptions).
c. Other fisheries that interact with PL, particularly PS fishery catch more juveniles (in quantity) compared to PL fishery. However, the proportion of SKJ juveniles caught by PL is comparable with that by PS.
d. Increase in the use of FADs.
e. Sampling and study coverages in Sikka were not representative and suggested to expand to other sites. Need to seek possibilities other sources of funding. The success of the pilot study could then be applied to other sites.

Figure 7. Catch composition of PL fishery based in Sikka in relation with FADs utilization.

In addition, during the FGD the local government encouraged that FADs are not deployed in the coastal areas of Sikka (< 12 nm) and its adjacent waters and banned Purse Seine (PS) to be operated in these areas. It was agreed that the proposed management objective is to reduce of number/proportion juvenile or small-sized YFT and BET, while minimizing the impact of SKJ catch and economic impact to fishers, but acknowledge the difficulties to measure the impact of SKJ catch as well as its economic benefit.

The EAFM components consist of five components, i.e. retained species, bycatch species and general ecosystem (ecological elements), and social and economic outcomes, and administration (human elements) (Fletcher 2010). The Focus Group Discussion related to tuna fishery in Sikka which was conducted in Kupang, NTT from 13-15 September 2017 highlighted a large proportion of bycatch species from pole and line fishery, i.e. juveniles catch of YFT and BET. Accordingly, this study was focused on the bycatch species and then linked into human element (i.e. economic aspect).
3.4. Fishermen’s income

The price of YFT in Sikka varied based on its size and quality. Prices of frozen YFT were varied between 15,000 rupiahs/kg (weight < 10 kg) and 40,000 rupiahs/kg (weight > 20 kg) (table 3). The loin product of YFT had higher price, i.e. 80,000 rupiahs/kg (weight > 10 kg). It suggests that the bigger size of YFT being caught, the higher price per kg of the fish (higher income for the fishermen obtained).

To provide an illustration how different size of YFT could influence the fishermen’s income, a simple calculation is provided. Length of YFT was estimated for each size class (10 kg, 15 kg and 20 kg) using the following length-weight relationship (N. Miyabe, NRIFSF in Hampton et al 2006):

\[ W = 2.512 e^{(-5)} \times L^{2.9396} \]  

where \( W \) and \( L \) are weight and length of the fish, respectively. In addition, age was estimated for three size class using length at age relationship (L. Tremblay-Boyer et al 2017) (figure 8). The estimated length and age of YFT are provided in table 4.

Table 3. Price of YFT by size and quality in Sikka (based some interviews with fishing company and fishermen in Sikka).

| Commodity | Size class | Price per kg (rupiahs) |
|-----------|------------|------------------------|
| < 10 kg   | 15,000     |
| 10-15 kg  | 20,000     |
| 15-20 kg  | 25,000     |
| > 20 kg   | 40,000     |
| > 10 kg   | 80,000     |

The WPEA port sampling program conducted in Sikka (from March-December 2017 estimated YFT catch by PL in 2017 to be 45,229 kg (table 5). Based on the length-frequency data recorded by the sampling program, all YFT measured were less than 80 cmFL (figure 3) or less than 10 kg (table 4). The value and potential loss of biomass were estimated using three scenarios: 1) 100% of 2017 YFT catches were immature (less than 10 kg per fish); 2) 100% of 2017 YFT catches were adults or at least 20 kg per fish; and 3) 50% of 2017 YFT catches were immature and 50% of 2017 YFT catches were adults. For the first scenario, the estimated value is 45,225,000 rupiahs. In six months, the fish can grow up to around 20 kg (table 5). The weight of YFT could increase by around 30,150 kg (potential loss is ~67% increase). For the second scenario, the estimated value is 90,440,000 rupiahs and after six months, the YFT catches could increase by 18,088 kg (potential loss is ~40% increase). For the third scenario, the value is estimated to be 82,940,000 rupiahs and after six months, the YFT catches could increase by 27,144 kg (potential loss is ~60% increase).
The first scenario reflects the current situation in PL Sikka fishery, whereas the second scenario is difficult to implement with the current fishing practices in Sikka. The third scenario provides the more applicable option, considering the value is estimated to increase by ~80% relative the first scenario (current situation) and potential biomass increase in six months by ~60% relative to the current catch level. Since tuna are highly migratory species, it is managed by central government through the National Tuna Management Plan (NTMP) in the ministerial decree no. 107/KEPMEN-KP/2015, lessons learned from pole and line fishery based in Sikka Regency, can be applied to other tuna fisheries in Indonesia’s archipelagic waters (IAW). However, an active participatory approach from local government and other stakeholders are preferable considering the complexity of tuna fisheries in the IAW in terms of gear types, fishing strategies, and fishing capacities. In addition, in terms of governance, the capacity among local governments within IAW are varied. Summary of findings from the pole and line fishery in Sikka Regency, combined with PS and HL fisheries from the IAW, is given in table 6. The following potential measures to improve the best practice of tuna fisheries in the IAW are proposed (table 6, figure 9):

a. Reduce catch proportion of small-sized YFT, to be less than 50% of total size distribution by the fishery.

b. Regulate hook type and size (larger size) of PL and HL.

c. Reduce fishing practice of surface HL, encourage for HL to deploy gear deeper than 25 m (deep HL) and limiting other surface fishing methods such as PS and TR.

d. Currently, there is no PS operates from Sikka, therefore it is not recommended to introduce PS in Sikka waters.

e. Encourage free school fishing by PL to minimize interactions with small-sized YFT.

f. No FAD deployment in the coastal area (<12 nm) to reduce catch proportion of small-sized YFT. This measure has low-risk failure and low cost for monitoring.

g. Improvement of FAD management implementation, monitoring, and enforcement.

h. Use other species as bait, e.g. milkfish from aquaculture, or artificial bait.

i. Seasonal utilization of live bait from lift net from September – January (peak season for anchovies) in FMA 714, 715 and 717.
j. Improve the handling process and awareness on the quality of fish that link with better price and food safety.

Table 5. Estimated value and potential increase of biomass by different scenarios (catch proportions of small-sized (< 102 cmFL or < 20 kg per fish) and adult YFT (at least 20 kg per fish)).

| Scenario | Estimated Value (kg) | Estimated Number of fish | Price (Rp) | Impact on Biomass increase (kg - how biomass can grow in six months) |
|----------|----------------------|--------------------------|------------|---------------------------------------------------------------------|
| 1        | 45,229 kg (estimated YFT catch in 2017) | 3,015 | 45,225,000 | Assume: 10 kg/fish (18 months old). In six months, the fish can grow up to around 20 kg. The weight of YFT could increase by around 30,150 kg (potential biomass increase is ~67% increase). |
| 2        | 100% small-sized YFT (less than 10 kg per fish/immature) | 2,261 | 90,440,000 | Assume: 20 kg/adult (24 months old). In six months, the weight of individual YFT could increase up to around 28 kg/adult. After six months, the YFT catch could increase by 18,088 kg (potential biomass increase is ~40% increase). |
| 3        | 50% small-sized + 50% adults YFT | 1508 juv + 1508 adult | 82,940,000 | After six months, the YFT catch could increase by 27,144 kg (potential biomass increase is ~60%). |

Figure 9. Proposed improvements for ecological and human well-being which balanced by good governance for NTMP.
| Findings | Proposed improvements/measures |
|----------|--------------------------------|
| Catch composition by gear | - Reduce small-sized of *YFT* (size < Lm) to be less than 50% |
| *YFT* | - Regulate hook type and size (larger size) of PL and HL |
| PL : < 50% | - Reduce fishing practice of surface HL, encourage for HL to deploy gear deeper than 25 m (deep HL) |
| HL : > 70% | - Do not introduce tuna PS in Sikka |
| PS – Btg : ~25% | |
| *SKJ* | |
| PL : > 60% | |
| HL : < 20% | |
| PS – Btg : ~63% | |
| Size composition | |
| *YFT* < Lm | |
| PL : 100% | - Encourage free school fishing by PL to minimize interactions with small-sized *YFT*. |
| HL – Lotim : 82% | - No FAD deployment in the coastal area (<12 nm) to reduce catch proportion of small-sized *YFT* (< Lm). This measure has low-risk failure and low cost for monitoring. |
| HL – Btg : 4% | - Improvement of FAD management implementation, monitoring, and enforcement. |
| PS : 100% | |
| *SKJ* < Lm | |
| PL : > 50% | |
| HL – Lotim : 83% | |
| PS : 66% | |
| FAD vs non-FAD | |
| Higher *YFT* proportion when PL fishing associated with FAD | |
| Live bait | - Anchovies are the most dominant live bait used by pole and line fishery |
| - Limited availability of live bait for PL fishery, as bait species is also for consumption | - Use other species as bait, e.g. milkfish from aquaculture, or artificial bait |
| Quality of tuna | - Condition of small-sized tuna is easily damaged and contains higher histamine level |
| - Limited chiller chain facilities to maintain the quality of tuna both on-board or at the landing site | - Seasonal utilization of live bait from lift net from September – January (peak season for anchovies) in FMAs 714, 715 and 717. |
| Fishers income | - YFT caught by PL, PS and surface HL (operated with TR) are less than its Lm, such that the price is lower (< 25,000 rupiahs per kg). |
| - YFT caught by deep HL comprised of ~90% are ≥ Lm. | - Reduce the proportion of small-sized tuna (fish with size less than Lm are caught not more than 50% of the overall distribution (in number)). |
| - SKJ caught by PL and PS have a similar proportion between sizes < Lm and >Lm, whereas surface HL caught mostly SKJ < Lm (~80%). | - Improve the handling process and awareness on the quality of fish that link with better price and food safety. |
| - Reduce the proportion of *YFT* < Lm, by regulating hook size (minimum size) of HL, and limiting the use of surface fishing methods (i.e. PS, surface HL, and TR). | |
Acknowledgments

The authors wish to thank for the support of West Pacific East Asia-Sustainable Management (WPEA-SM) Project and parties involved in this study including WPEA-CFR observers (deployed in the pole and line fishery based at Sikka) and enumerators, DGCF, and Non-Government Organizations (especially MDPI) for their active engagement and providing the data. In addition thanks to all participants of the focus group discussion for their expertise and inputs. Main contributors of this paper are Fayakun Satria and Lilis Sadiyah.

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