Information gap on FADs management meassures implementation in Indonesian Indian Ocean waters.

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Abstract

Deep-water anchored Fish Aggregating Devices (aFADs), in waters as deep as 2000–5000m, have been a common feature of Indonesia's tuna fisheries since the early 1980s. Presently, the use of FADs has become the dominant practice in tuna fishing in Indonesian Indian Ocean. FADs management measures for the tuna fisheries have not been successfully implemented, mainly due to the information gap including characteristic of tuna fisheries associated FADs. In addressing information gaps to enable improved management, Indonesia and Australia have conducted a joint study as part of a 5 year ACIAR project (FIS/2009/059), including an enumeration program at four key tuna landing ports: Padang (West Sumatera) and Palabuhanratu (West Java). Preliminary findings to date include: (1) FADs in Indonesian Indian Ocean are of two main types include steel pontoon and polystyrene block. Subsurface attractors are most commonly natural materials include nipa and coconut palm branches, (2) Fishing gears include hand-line/troll-line (HL/TR), and purse seine (PS), (3) The proportions of the two main target tunas, skipjack tuna, *Katsuwonus pelamis* (SKJ), yellowfin tuna, *Thunnus albacares*, SKJ comprised 30-43% of HL/TL landings of HL/TL boats in Palabuhanratu, (4) Fishing success (as measured by % of FAD visits that yielded catch success) ranged from as low as 35% for HL/TL in Padang to 86% for HL/TL in Palabuhanratu, (5) A large proportion of the SKJ, YFT and bigeye tuna, *T. obesus*, landed by the FAD-based boats, were juvenile fish, below reported *lengths at maturity* (L_m) for those species, raising obvious concerns for sustainability of the fisheries.

Introduction

The early 1980s (Tuasamu, 1985) marked the beginnings of fishers deploying floating fish aggregating devices (FADs) in deep-water in eastern Indonesia waters to attract and catch tunas. In 1984 a pole & line company namely Usaha Mina Co. Ltd. started deploying eight *anchor fish aggregating devices* (aFADs) in north of Sorong waters (Pers. Comm. with Mr. Z. Abiddin, a former fishing operational director of Usaha Mina Co. Ltd., 2015). Since then the use of aFADs in waters as deep as 2000 – 5000 m become a dominant practice for tuna fishing in eastern Indonesia's archipelagic waters. The result of the data reconstruction on the Research Institute for Marine Fisheries (RIMF)'s research document 1980 - 1990s showed that RIMF has conducted a research with deploying an aFAD to increasing the catch of purse seine in Indian Ocean particularly in Prigi Bay-East Java in 1986. With similar address, RIMF deploying two FADs in Cempi Bay (Indian Ocean)-Nusa Tenggara Barat Province in 1992. In the same year, RIFM also deploying each two FADs in Binuangen cape waters-West Java, Semangka Bay-Lampung-Sumatera and Pesisir Selatan waters-West Sumatera as well which was dedicated for hand line-troll line fisheries. Since beginning 2000s, FADs developed rapidly in Indian Ocean of Indonesia including in Pacitan waters-East Java (Nuraini *et al.,* 2014). Presently, the use of FADs has become the dominant practice in tuna fishing in Indonesian Indian Ocean.

Since 2004, the Ministry of Marine Affairs and Fisheries (MMAF) Republic Indonesia has issued various regulations related to FAD including Ministerial Decree Number 30/2004; Ministerial Decree Number 08/2011); Ministerial Decree Number 08/2011), and the relevant plans including National FAD Management Plan for 2015-2017 (DGCF 2014) and National Tuna Management Plan (MMAF 2015). FADs management measures for the tuna fisheries have not been successfully implemented, mainly due to the information gap including characteristic of tuna fisheries associated FADs. To address the information gaps, in 2013-2016 Indonesia's Agency for Marine and Fisheries Research and Development (AMFRD) joined with Commonwealth Scientific and Industrial Research Organization (CSIRO) Australia in a four year research collaboration that includes a FAD fisheries study. This paper provide preliminary result such as identifying the character aFAD fisheries in the Indonesian Indian Ocean which have not sufficiently available to support the implementation of management measure required.

Materials and Methods

The results presented are outputs from an enumeration program at two key tuna landing ports in western Indonesia – Pelabuhanratu (West Java) and Padang (West Sumatera). Tuna fisheries based at Padang include the fishing gears hand line / troll-line (HL/TR) and purse seine (PS), and fishing areas include the waters of the Indian Ocean Indonesia, namely in Indonesia Fishing Management (FMA) 572. Tuna fisheries based at Pelabuharatu include the gear hand-line/troll-line (HL/TR), and fishing areas include the waters of the Indian Ocean Indonesia, namely in FMA 572 (Figure 1). Data and information were obtained through daily enumeration (2 enumerators in each port), including interviews with skippers at earliest opportunity after their boats unload catch, and also by direct observations, information sourced from local port authorities, fisheries offices, fishing companies and fishing association representatives. Biological sampling (length measurements of individual fish; tunas and by-catch species) were done on a subsample of the catch at time of catch unloading or at point of auction/sale. Data were first recorded onto hard-copy Landings and Biological Samplings forms and later entered into a project specific database (Oracle/Apex), FAD Fisheries Database.

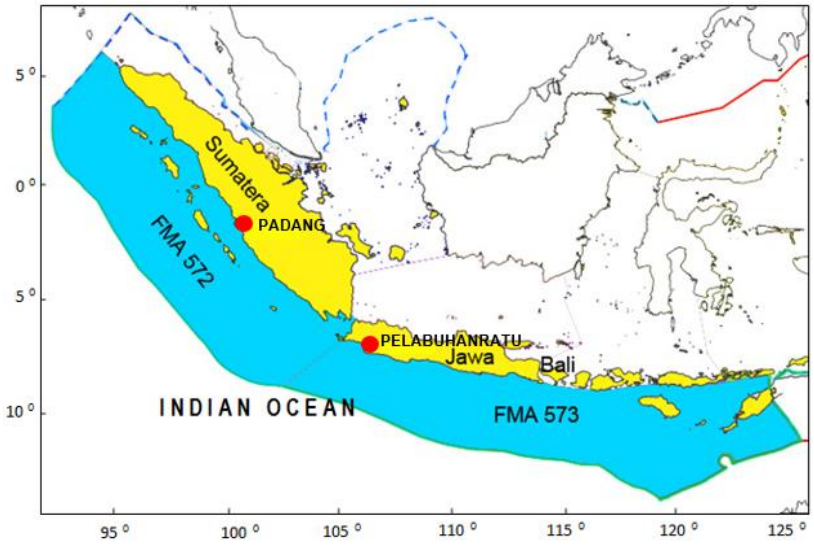

Figure 1. Indonesian Fisheries Management Areas 572 and 573 (modified from Wilayah Pengelolaan Perikanan, KOMNAS KAJISKAN 2010).

Results

1. Technical aspects of Indonesian aFADs

Only anchored FADs (aFAds) are used in the Indonesian tuna fisheries and developments in Indonesian FAD construction, including region specific designs, were first detailed by Subani and Barus (1989). Monintja (1993) described ten different types of FAD from Indonesia and more than 20 types of FAD from around the world. The Indonesian aFADs have four key components include the surface float (bamboo raft, steel ponton or polystyrene block), the mainline to seafloor (polypropylene rope), a subsurface attractor (nipa or coconut leaf), and the anchor (Figure 2). aFADs with rakit are found in eastern Indonesia, but to date, have not extended to western Indonesia. Pontoon is steel cylinder of 2 – 3 m length and approximately 0.8 m diameter, with generally one end is conical, this most common type of FAD float in western and southern Indonesia. Polystyrene block is a large cylinders or blocks of styrene foam, encased in cloth and often bound by rope and used-motorcycle tyres, and strengthened by a wooden frame. These are commonly called “gabus” type FAD. This type of FAD has replaced ponton as the most common FAD type, due to its lower cost. In general, the Indonesian aFAD surface floats are not equipped with navigation aids such as radio signal emitters or radar reflectors, but in some cases have an attached superstructure such as flag to make the FAD more visible.

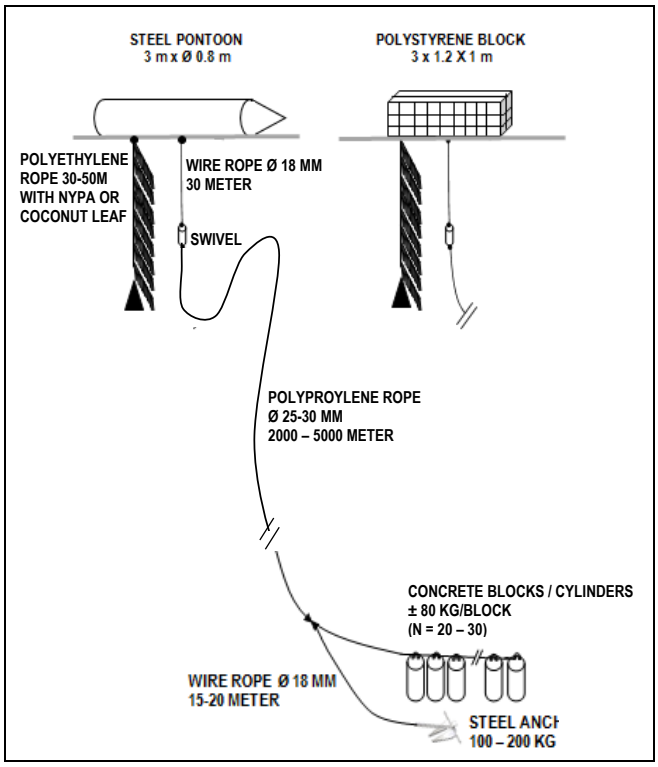

Figure 2. Common construction of anchored FADs employ by fisher based at Pelabuhanratu and Padang (drawn by Widodo, 2015).

2. Total number and positions of FADs

Achieving an estimate of the total number and position of tuna aFADs in Indonesia's FMAs 572 – and 573 proved difficult. The current lack of effective systems of FAD registration, monitoring, and also the desire of fishing companies and boat skippers to keep FAD position information confidential have being generated that issue. Some fishing companies, boat owners and skippers interviewed for this study did provide positional information for their FADs, whereas others were reluctant to do so for want of keeping their fishing locations confidential. Figure 3 show the positional information for FADs in FMAs 572 and 573 based on enumeration done for this study. Among the current Indonesian fisheries regulations for FADs is the requirement that FADs be a minimum of 10 nm apart. There is strong evidence to suggest that this requirement is not being adhered to, with FADs in many cases being significantly less than 10 nm apart (Figure 4). Achieving effective enforcement of this regulation is undoubtedly one of the biggest challenges faced by Indonesia's management agencies, and requires improved communication to fishing companies, fishing boat owners, and fishers about the proven benefits that are likely to come from a reduction in density of FADs in any given area (Cayré 1991; Marsac and Cayré 1998).

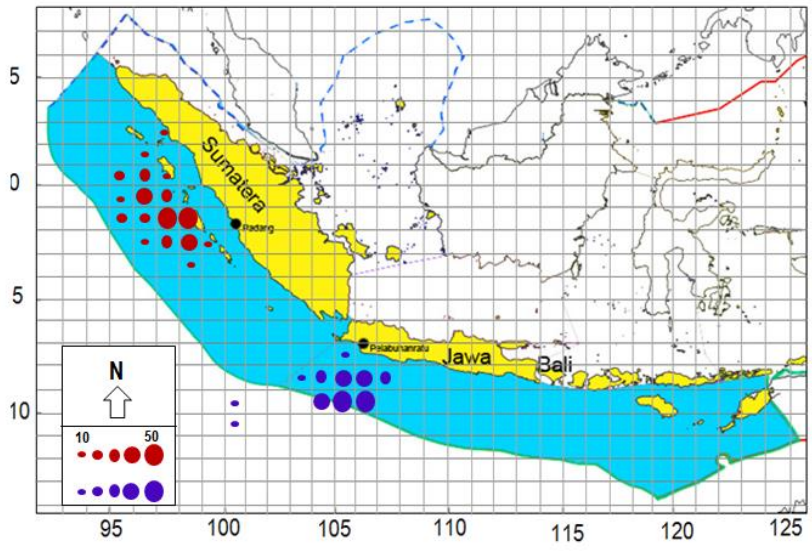

Figure 3. Estimation FAD number and positions in FMAs 572 and 573, from information collected during enumeration in Padang in 2013 and Palbuhanratu in 2014.

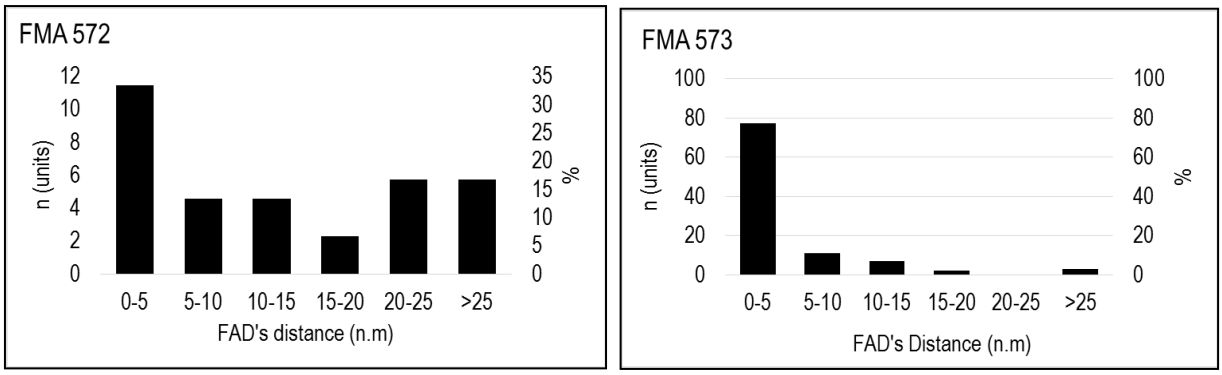

Figure 4. Distance between aFADs in FMA 572 and 573.

3. Tuna fisheries associated with FADs

Fishers based at Pelabuhanratu use multi-gear boats which are called '*kapal tonda*' to catch tuna in around FAD. The *kapal tondas* normally operate gears hand-line fishing (HL), troll-line fishing (TR) and kite fishing (KT) which switch between gears depending on season, prevailing seas conditions and catch success. These boats, commonly wooden-hull boats of size 6 – 10 GT. The *kapal tonda* and their fishing methods originated from southern Sulawesi (Bugis fishermen). Fishers based at Padang use TR and purse seine boats to catch tuna in around FAD. The puse seine boats devided in two types are catcher boat and carrier boat. Both TR and purse seine boats are commonly wooden-hull. Size of the TR boats ranged 10 – 20 GT, and the size of purse boats ranged 30 – 150 GT.

4. Operational aspects of the fisheries using FADs

4.1. Catch success rate

The success rate here success rate is defined as successful FAD visits expressed as a % of total number of FADs visited. From Table 1 indiacates that success rate of HL-TR boats based at Muara Padang was 34.5% and the PS boats absed at Bungus Fishing Port was 48.3%. Whilst HL-TR boats based at Pelabuhanratu Fishing Port was significantly higher at about 87.7%. It is interesting to note that success rate of TR/HL based at Muara Padang shows a much lower level of success rate compared to the TR/HL based at Pelabuhanratu. Allegedly it was caused by the result of there being more FADs in the Padang region at perhaps higher FAD density (see Figure 4), and/or result of there is competition with PS boats which are similar fishing ground. Widodo, *et al*. (2016) noted that skippers of PL boats based at Kendari and Sorong (FMAs 713-717) often expressed frustration that FADs were found to "empty of fish" after sets by PS boats. In FMAs 713-717, the PS, PL, and HL/TL fleets have significant overlaps in their fishing areas. Information provided by the PL skippers indicated that it normally takes at least 1 – 2 weeks before fish numbers at the FADs 'recover' after a PS set.

Table 1. Summary of trip length (fishing days) and FAD visit success, for HL/TR and PS boats in Padang and Pelabuhanratu based on information collected by this study during 2013 – 2016.

Location	Gear Type	No. Boat Trips	Ave. No. Fishing (Days)	Ave. No. of FADs Visited	Ave. No. of FADs with Success	FADs Success Rate (%)	Ave. Catch
Padang (FMA 572)	HL-TR	133	12.6	12.9	4.0	34.5	1,026.8 (kg/trip)
Padang (FMA 572)	PS	5	35.5	8.8	3.3	48.3	3,723.2 (kg/set)
Pelabuhanratu (FMA 573)	HL-TR	976	7.6	1.3	1.0	87.7	566.1 (kg/trip)

4.2. Catc Rate

Results of enumeration at landing place Muara Padang (Padang) where the TR boats unload catch, showed the average catch rates (based on total catch - all species) of TR boats per trip in 2013 (Oct – Dec only), 2014, and 2015 (Jan – April only) were 750.0 kg, 913.9 kg, and 1,111.5 kg per boat per trip respectively (Table 2). In general number day per trip was 12-16 days, with an average of 10 day actual fishing days per trip. Average catch rates by day per TR boat (based on total catch/number of actual fishing days for fishing trips with available catch data) in 2013 (1 trips), 2014 (59 trips) and 2015 (73 trips) were 150 kg, 91 kg, and 111 kg per boat/actual fishing day respectively. The fishing areas for HL-TR boats based at Padang spreads in the offshore around Mentawai Island waters, approximately 70-300 nm from Padang (Figure 3).

Very limited data and information of PS boats found during enumeration. In general, purse PS boats based at Bungus Fishing Port operate in a group which consists of a PS catcher boat, 3 to 4 PS carrier boats, and 3 to 4 light boats. The pattern of fishing operations of the group is as follows: the PS catcher boats have fishing trips of more than 6 months; catches are transferred directly to PS carrier boats because the catcher boats generally do not have fish-holds of sufficient size to hold the catch; one setting of the net over 1 day/1 night is normal. The amount of fish that is transported to Bungus Fishing Port by a PS carrier

boats is most often the result of 3 to 4 sets by the catcher boat. The enumeration of PS carrier boats in Bungus Fishing Port showed that from 5 carrier boats surveyed during 2013 (3 boats) and 2014 (2 boats) were unloaded catches between 1530 and 43500 kg tuna respectively landed by an individual PS carrier boats (Table 3). If these landings result from catches from 3 - 4 sets of the PS net, the estimates of average catch/set was 4291.7 – 5722.2 kg in 2013 and 3191.3 – 4255.0 kg (ave. 3723.2 kg/set) in 2014.

Results of enumeration at landing place Pelabuhanratu Fishing Port-PPNP (Pelabuhanratu) where the TR boats unload catch, showed the average catch rates (based on total catch - all species) of TR boats per trip in 2013 (Oct – Dec only), 2014, 2015 and 2016 (Jan – August only) were 486.3 kg, 516.7 kg, 680.1 kg and 655.5 kg per boat per trip respectively (Table 4). In general number day per trip was 5-8 days, with an average of 6 day actual fishing days per trip. Average catch rates by day per TR boat (based on total catch/number of actual fishing days for fishing trips with available catch data) in 2013 (165 trips), 2014 (548 trips), 2015 (263 trips) and 2016 (115) were 81.1 kg, 86.1 kg, 113.4 kg and 109.3 kg per boat/actual fishing day respectively (Table 4). The fishing areas for TR boats based at Padang spreads in the Indonesian EEZ waters approximately 20-200 nm from Pelabubuhanratu, and some of FADs located in high seas about 350 nm from Pelabuhanratu (Figure 3).

Table 2. Catch landings of TR boats sampled at Muara Padang (Padang) during October 2013 – April 2015.

Boat	Year	Month	No. of boats sampled	Total Catch (kg)	Catch / vessel / Trip (kg/vessel/Trip)
HL-TL	2013	10	1	1500	1500
	2013	11	0	0	0
	2013	12	0	0	0
	Total	3	1	1500	Ave. 1500
	2014	1	0	0	0
	2014	2	13	8843	680
	2014	3	16	16585	1037
	2014	4	0	0	0
	2014	5	3	4000	1333
	2014	6	1	1330	1330
	2014	7	0	0	0
	2014	8	0	0	0
	2014	9	1	250	250
	2014	10	1	15	15
	2014	11	22	20600	936
	2014	12	2	2300	1150
	Total	12	59	53923	Ave. 914
	2015	1	22	23950	1089
	2015	2	22	24870	1131
	2015	3	26	29320	1128
	2015	4	3	3000	1000
	Total	4	73	81140	Ave. 1112

Table 3. Catch landings of PS carries boats sampled at Bungus Fishing Port (Padang) during during October-December 2013 and January and May 2014 (Jan and May).

Boat	Year	Month	No. of boats sampled	Total Catch (kg)	Catch / vessel / Trip (kg/vessel/Trip)
PS	2013	10	1	43500	43500
	2013	11	1	5500	5500
	2013	12	1	2500	2500
	Total	3	3	51500	Ave. 17167
	2014	1	1	24000	24000
	2014	5	1	1530	1530
	Total	2	2	25530	Ave. 12765

Table 4. Catch landings of TR boats sampled at Pelabuhanratu Fishing Port-PPNP (Pelabuhanratu) during October 2013 – August 2016.

Boat	Year	Month	No. of boats sampled	Total Catch (KG)	Catch / Boat / Trip (kg/Boat/Trip)
HL-TR	2013	10	54	36517	676.2
	2013	11	78	32321	414.4
	2013	12	33	11402	345.5
Total		3	165	80240	Ave. 486.3
	2014	1	36	12991	360.9
	2014	2	37	15213	411.2
	2014	3	40	21275	531.9
	2014	4	47	33602	714.9
	2014	5	49	22980	469.0
	2014	6	46	21033	457.2
	2014	7	46	25880	562.6
	2014	8	39	17236	441.9
	2014	9	55	38259	695.6
	2014	10	67	32139	479.7
	2014	11	41	16348	398.7
	2014	12	45	26210	582.4
Total		12	548	283166	Ave. 516.7
	2015	1	15	6446	429.7
	2015	2	14	6651	475.1
	2015	3	25	15042	601.7
	2015	4	23	12504	543.7
	2015	5	29	18088	623.7
	2015	6	25	12066	482.6
	2015	7	17	11495	676.2
	2015	8	29	26729	921.7
	2015	9	35	35693	1019.8
	2015	10	26	18645	717.1
	2015	11	16	10391	649.4
	2015	12	9	5108	567.6
Total		12	263	178858	Ave. 680.1
	2016	1	12	6308	525.7
	2016	2	7	3676	525.1
	2016	3	16	11166	697.9
	2016	4	17	13136	772.7
	2016	5	18	14280	793.3
	2016	6	16	10669	666.8
	2016	7	14	7248	517.7
	2016	8	15	8898	593.2
Total		8	115	75381	Ave. 655.5

5. Biological aspects of the tuna fisheries operating on FADs

5.1. Catch Composition

The results from enumeration in Muara Padang (Padang) showed that, in the landings surveyed, at least 10 species of fish were caught by the TR boats. The highest percentage taken by skipjack tuna (*Katsuwonus pelamis*) about 34.7% by volume of the surveyed catch over the study period. Yellowfin tuna

(*Thunnus albacares*) and bigeye tuna (*Thunnus obesus*) about 24.7% and 13.1% respectively. Black marlin (Makaira indica) and various sharks (*Carcharhinus spp.*) only made up 0.1% and 0.01% by volume respectively, of the catch (Table 5). Composition of catch of PS boats based at Bungus Fishing Port (Padang) consist of at least 5 species which was skipjack (*Katsuwonus pelamis*) taken first place with percentage 29.9% (Table 6). The results from enumeration in Pelabuhanratu Fishing Port show that at least 9 species of fish were caught by the TR/HL boats, small yellowfin and skipjack make up a large proportion of the catch. Common dolphin fish and striped marlin are key bycatch species. For many of the months, particularly during 2014, YFT made up the largest proportion of the catch; these data include both large and small fish, so obviously, the YFT proportions (volumes) are larger than if we were looking at just the small fish catch (Table 7).

Table 5. Composition of catch by species by volume from HL-TR boats surveyed at Muara Padang (Padang) during October 2013 – April 2015.

Fish Species			Number (KG)				%
Local Name	Common Name	Scietific Name	Y. 2013	Y. 2014	Y.2015	Total	
Cakalang	Skipjack Tuna	*Katsuwonus pelamis*	600	17945	28800	47345	34.7
Tuna Madidihang	Yellowfin Tuna	*Thunnus albacares*	800	13115	19800	33715	24.7
Tuna Matabesar	Bigeye Tuna	*Thunnus obesus*	0	8203	9650	17853	13.1
Madidihang/Matabesar*)	Indistinguishable yellowfin or bigeye*)	*T.albacres or T. obesus* *)	0	3490	7400	10890	8.0
Tongkol Lisong	Bullet Tuna	*Auxis rochei*	0	1000	5450	6450	4.7
Tongkol Krai	Frigate Tuna	*A. thazard*	100	3400	0	3500	2.6
Tongkol Komo	Kawa-kawa	*Euthynnus affinis*	0	850	1900	2750	2.0
Lemadang/Mahimahi	Common dolphin fish	*Coryphaena hippurus*	0	4362	5770	10132	7.4
Sunglir	Rainbow runner	*Elagatis bipinnulata*	0	1481	2370	3851	2.8
Setuhuk Hitam	Black Marlin	*Makaira indica*	0	70	0	70	0.1
Cucut	Various Shark	*Carcharhinus spp*	0	7	0	7	0.01
Total			1500	53923	81140	136563	177,3

Note *) juvenile stage

Table 6. Composition of catch by species by volume (kg) from PS boats surveyed at Bungus Fishing Port in Padang during Oct 2013 – May 2014.

Fish Species			Number (KG)			
Local Name	Common Name	Scietific Name	Y. 2013	Y. 2014	Total	%
Cakalang	Skipjack Tuna	*Katsuwonus pelamis*	15500	7520	23020	29.9
Tuna Madidihang	Yellowfin Tuna	*Thunnus albacares*	10500	4510	15010	19.5
Tuna Matabesar	Bigeye Tuna	*Thunnus obesus*	1500	2000	3500	4.5
Tongkol Lisong-Krai (mix)	Bullet-Frigate Tuna	*Auxis rochei - A. thazard*	13000	8000	21000	27.3
Layang	Scads	*Decapterus spp.*	11000	3500	14500	18.8
Total			51500	25530	77030	100.0

Table 7. Composition of catch by species by volume from TR boats surveyed at Pelabuhanratu Fishing Port-PPNP (Pelabuhanratu) during October 2013 – December 2015.

Fish Species			Number (KG)				%
Local Name	Common Name	Scietific Name	Y. 2013	Y. 2014	Y.2015	Total	
Tuna Madidihang	Yellowfin Tuna	*Thunnus albacares*	50975	151675	63994	266644	49.2
Cakalang	Skipjack Tuna	*Katsuwonus pelamis*	16824	84451	76877	178152	32.9
Tuna Matabesar	Bigeye Tuna	*Thunnus obesus*	5159	14971	13588	33718	6.2
Tuna Albakora	Albacore Tuna	*Thunnus alalunga*	0	252	0	252	0.0
Tuna Sirip Biru Selatan	Southern Bluefin Tuna	*Thunnus maccoyii*	0	0	49	49	0.0
Setuhuk Loreng	Strped Marlin	*Kajikia audax*	5011	24212	20945	50168	9.3
Lemadang/Mahimahi	Common dolphin fish	*Coryphaena hippurus*	1621	6940	3149	11710	2.2
Barakuda	Barracuda	*Sphyraena barracuda*	106	0	0	106	0.0
Sunglir	*Rainbow runner*	*Elagatis bipinnulata*	24	0	0	24	0.0
Ikan Lainnya	Other fish	-	520	665	256	1441	0.3
Total			80240	283166	178858	542264	100.0

5.2. Fish size

The result of enumeration in Muara Padang (Padang), Bungus Fishing Port (Padang) and Pelabuhanratu Fishing Port (Pelabuhanratu) as well show that the average size of most of YFT and BET, caught by HL-TR and PS , were below the reported *lengths of first maturity* (Lm); YFT - 103 cm FL (Mardlijah and Patria 2012) and BET - 102 – 105 cm FL (Schaefer et al. 2005). The majority of SKJ landed by HL-TR boats in Muara Padang (Padang) were also below their reported Lm of 40 – 42 cm FL (Tandog-Edralin et al. 1990). But unlike the average size SKJ caught PS based at Bungus Fishing Port (Padang) and HL-TR based at Pelabuhanratu (Pelabuhanratu) were mature fish (Table 8).

Table 8. Length (cm FL) of SKJ, YFT, and BET caught by HL/TL and PS boats based in Padang and Pelabuhanratu, surveyed during Oct 2013 – Dec 2015.

Location	Gear Type	Species	Year	Min Length (cmFL)	Max Length (cmFL)	Avg Length (cmFL)	n
Padang	TR/HL	SKJ	2013	24	60	37.9	288
			2014	16	58	35.0	887
			2015	26	47	35.9	1023
		YFT	2013	26	52	40.6	250
			2014	16	90	37.2	884
			2015	25	45	36.4	971
		BET	2013	27	52	40.8	258
			2014	22	49	37.2	649
			2015	27	44	35.9	764
	PS	SKJ	2013	26	50	38.6	32
			2014	70	90	79.2	18
		YFT	2013	27	50	38.5	44
		BET	2013	30	50	39.2	33
	CV	SKJ	2013	30	42	37.1	73
			2014	30	49	41.3	60
		YFT	2013	34	43	39.5	27
			2014	31	48	40.9	40
Palabuhanratu	TR/HL	SKJ	2013	29	58	42.5	292
			2014	20	88	41.3	1337
			2015	23	63	42.1	1520
		YFT	2013	28	56	39.1	520
			2014	21	72	40.7	1451
			2015	26	66	42.3	1383
		BET	2013	30	53	41.1	226
			2014	26	66	44.6	424
			2015	26	57	43.2	595

n = number of fish measured.

Conclusion

FADs management measures for the tuna fisheries in Indonesian FMA 572 and 573 have not been successfully implemented, mainly due to the information gap including characteristic of tuna fisheries associated FADs. Preliminary result on identifying the character aFAD fisheries in the Indonesian FMA 572 and 573 has concluded (1) distance of aFADs in many cases being significantly less than 10 nm apart (2) SKJ was dominant species of HL-TR and PS's, (3) a large proportion of the SKJ, YFT and BET landed from the aFAD-based fisheries at both location Padang and Pelabuhanratu were juvenile fish.

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