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Characteristics of tuna fisheries associated with Indonesian anchored FADs in waters of the West Pacific and the Indonesian archipelago

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Abstract

With the primary aim of addressing information gaps on the scale and operations of Indonesia's FAD based tuna fisheries, to aid improved fisheries management, an Indonesia - Australia research collaboration conducted a study during Nov 2013 – Dec 2015 at four key fishing ports in eastern Indonesia and western Indonesia. The full outputs from this study, involving an enumeration program with skipper interviews, biological sampling and direct observations are to be published as final report and subsequent papers. Presented here are preliminary results from research at two ports in eastern Indonesia - Kendari (SE Sulawesi) and Sorong (West Papua). All tuna FADs in Indonesian waters are anchored and are of 3 main float types: steel pontoon (*ponton*), bamboo with bungalow (*rakit*), and polystyrene block (*gabus*). Subsurface attractors are biodegradable materials and most commonly palm branches (nipa and coconut), and do not include netting materials. Tuna fisheries based in Kendari and Sorong include the fishing gears hand-line/troll-line (HL/TR), pole and line (PL), and purse seine (PS) and fishing areas include the Indonesian Fishing Management Areas 713, 714, 715, 716, and 717. Estimating the total number of FADs in these FMAs is difficult because of the current lack of effective systems of FAD registration and monitoring, and also because of the desire of fishing companies and vessel skippers to keep FAD position information confidential. Estimates range from several hundred to several thousand FADs. From 484 fishing trips surveyed, the average number of fishing days in trips of PL and HL/TL vessels in Kendari was 3 days and 7 days respectively, and 6 days for PL vessels in Sorong. Vessels visited up to 7 FADs in a single trip and the level of success in fishing events on FADs within a fishing trip (FAD Success Rate; FSR) varied across the fleets. In Kendari, HL/TR and PL vessels had a FSR of 64.9% and 65.9% respectively. The FSR of PL vessels in Sorong was 84.9%. The average catch rates (per trip) of HL/TL vessels in Kendari in 2013, 2014, and 2015 were 1077 kg, 1273 kg and 980 kg respectively. PL vessels in Kendari had average trip catch rates of 1593 kg (in 2013), 2490 kg (in 2014), and 4260 kg (in 2015). The average catch landings by PL vessels in Sorong in 2013, 2014, and 2015 were 6515 kg, 11,633 kg, and 13,569 kg per vessel per trip respectively. The estimated catch rate range for PS vessels based in Sorong during 14 months (Nov 2013-Dec 2014) was between 7,700 – 12,932 tonnes/set/vessel. Catch compositions included 18 species for HL/TL, 9 species for PL, and 7 species for PS. Skipjack tuna (SKJ) were the dominant species, 73% by volume, in catches of PL in Kendari and PS vessels in Sorong - 76% and 81% of total catch respectively - but only made up 41% of HL/TL landings and 38% of PL landings in Kendari. Yellowfin tuna (YFT) made up the largest proportion (47%) of HL/TL catches in Kendari, compared to SKJ (41%). A large proportion of the SKJ, YFT and bigeye tuna (BET) landed from the FAD-based fisheries at both ports were juvenile fish, below reported Lengths at Maturity (L*m*) for those species.

Introduction

Utilization of floating objects (logs, seaweed, etc.) as known attractors of fish has been a feature of artisanal, coastal fishing in the waters of the Western and Central Pacific Ocean (WCPO) for hundreds of years (Kakuma 2000, Morales-Nin *et al.* 2000, Reuter, 1938; Nasution *et al.*, 1986). The early 1980s (Tuasamu, 1985) marked the beginnings of fishers deploying floating Fish Aggregating Devices (FADs) in deepwater in eastern Indonesia waters to attract and catch tunas. Anchored FADs in waters as deep as 2000 – 3000 m have since become a dominant practice for tuna fishing in Indonesia's archipelagic waters. Gershman *et al.* (2015) estimated that the number of anchored and drifting tuna FADs in marine waters globally to be ± 120,680, and of these, as many as 29,700 FADs in the WCPO. Western and Central Pacific Fisheries Commission (WCPFC)

made a similar estimate of total FAD numbers in 2014 for purse-seine vessels operating in the WCPO (Hurry 2014), but qualified with the statement that this estimate excluded the numbers of FADs in Indonesian and Philippine waters, as these were unknown.

Indonesia's FAD-based tuna fishing in the WCPFC Statistical Area occurs primarily in the nation's Fishing Management Areas (FMAs) 713, 714, 715, 716, and 717 (Figure 1). Since 2004, the Government of Indonesia has issued various FAD related fisheries regulations: PER.30/MEN/2004; PER.08/MEN/2011 and PERMEN No. 26/PERMEN-KP/2014, and the relevant plans: National FAD Management Plan for 2015-2017 (DGCF 2014) and National Tuna Management Plan (MMAF 2015).

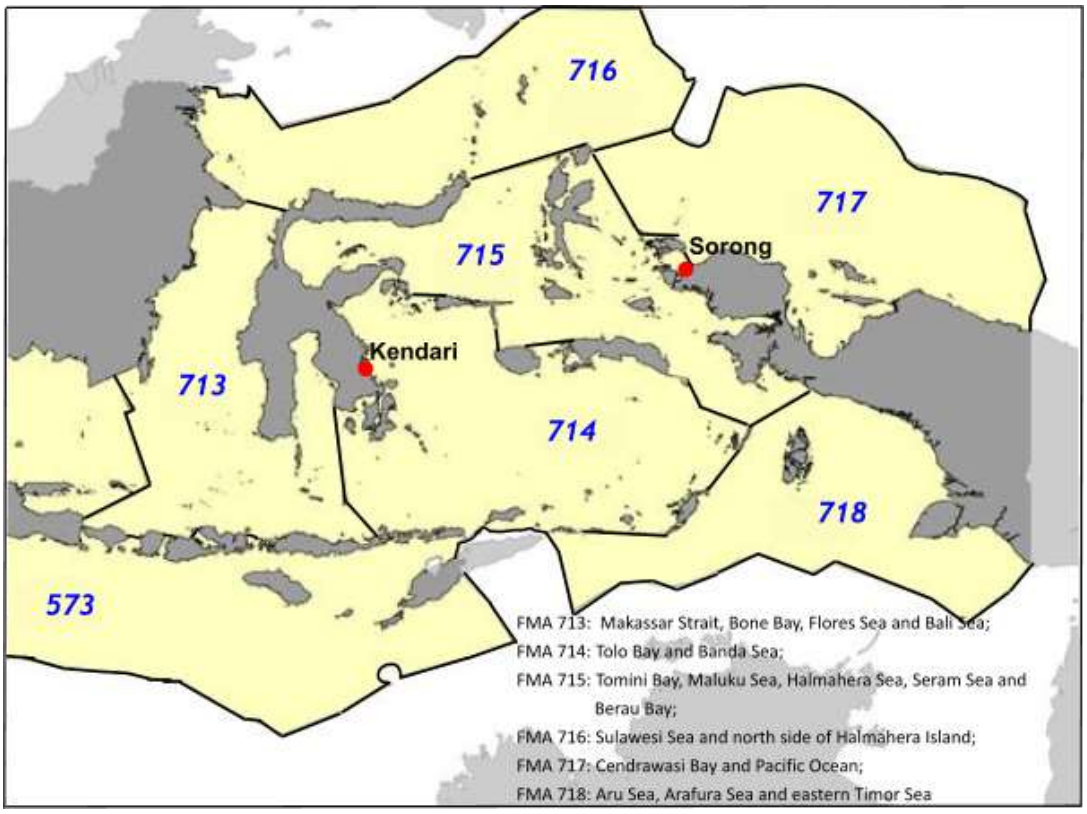

Figure 1. Indonesian Fisheries Management Areas 713-718 (modified from Wilayah Pengelolaan Perikanan, KOMNAS KAJISKAN 2010)

Effective fisheries regulations for management of FADs requires quality data and information on the Indonesian fisheries including: numbers and locations of FADs, types of FAD ownership, types of fishing gears deployed on the FADS and vessel operations, catch rates, and catch compositions for each gear type, by species and size of fish (target tunas and bycatch species). Until now, implementation of FAD regulations has proved difficult, largely due to the lack of such information. To address the information gaps, in 2012 Indonesia's Agency for Marine and Fisheries Research and Development joined with CSIRO Australia in a four year research collaboration[1] that includes a FAD fisheries study. This paper provides preliminary results from this study (ongoing to end of 2016), with particular reference to waters of FMAs 713-717.

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Materials and Methods

The results presented are outputs from an enumeration program at two key tuna landing ports in eastern Indonesia - Kendari (SE Sulawesi) and Sorong (West Papua), where hand-line/troll-line (HL/TL), pole and line (PL) and purse-seine (PS) fleets operate on FADs in FMAs 713 – 715, and FMAs 715 – 717 respectively. Data and information were obtained through daily enumeration (2 enumerators in each port), including interviews with skippers at earliest opportunity after their vessels 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 bycatch 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*.

Results

1. Technical aspects of Indonesian anchored FADs

Drifting FADs are not used in the Indonesian tuna fisheries, even by purse-seine vessels; only anchored FADs are used. 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. Itano *et al.* (2004) also provided information on design of anchored and drifting FADs in the WCPO, including anchored FADs in Indonesia. In common with anchored tuna FADs employed by fisheries of other countries, the Indonesian FADs have four key components: the surface float, the mainline to seafloor, a subsurface attractor, and the anchor (Figure 2).

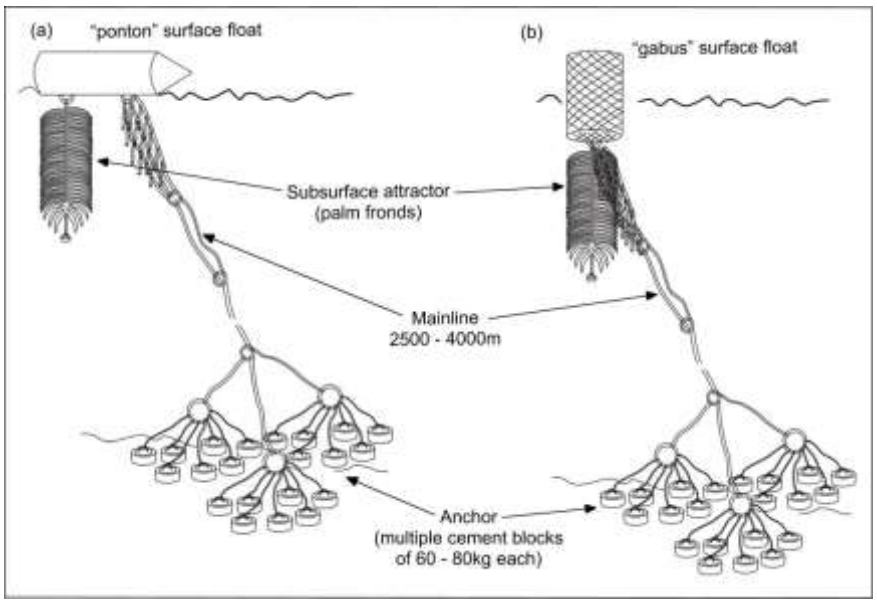

Figure 2. Typical FAD construction for (a) *ponton* type FAD and (b) *gabus* type FAD.

The FAD surface floats are of three main types (Figure 3):

1. steel cylinder of 2 – 3 m length and approximately 0.8 m diameter, with generally one end is conical. These are called pontoon type or *"ponton"*, and were, until recent years, the most common type of FAD float in western and southern Indonesia
2. bamboo raft, the most sophisticated version having a bungalow ("*rakit*") in which the fishers and/or caretakers of the FAD reside, for weeks or even months. Fresh supplies of food and water, and other

necessities for the persons staying at the FAD are brought by fishing vessels or carrier vessels. FADs with *rakit* are found in eastern Indonesia, but to date, have not extended to western Indonesia;

3. 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 FAD surface floats are not equipped with navigation aids (no radio signal emitters or radar reflectors), but in some cases have an attached superstructure to make the FAD more visible.

Figure 3. Various types of anchored FAD floats in Indonesia (a) steel *ponton*, (b) styrene foam *gabus*, and (c) bamboo raft with *rakit* (photos: Proctor)

The FAD mainline, of up to 4000m in length for FAD deployment in water depth of 2000 – 3000m (but sometimes as deep as 6000m), is most commonly a 2.5 – 4.0 cm diameter synthetic rope (Figure 4), sometimes with wire core, but other types of synthetic rope of lesser diameter and less cost are also not uncommon, particularly with *gabus* FADs. The subsurface attractors are most commonly branches of nipa palm (*Nypa fruticans*) or coconut palm (*Cocos nucifera),* which are usually attached as a hanging cluster to the underside of the surface float. Attractors made of plastic strips (synthetic *raffia*) have also been encountered on FADs during this study, but current regulations prohibit the use of non-biodegradable materials. Nets and netting-like materials are not used as subsurface attractors on the FADs, and therefore Indonesian tuna FADs pose minimal risk of entanglement of turtles or other marine fauna.

FAD anchors are most commonly comprised of 60 - 80kg concrete blocks or cylinders (Figure 4), with embedded ropes or motorcycle tyres as attachment points in each block, and 25 – 40 blocks linked together to form an anchor of total weight 2 – 3 tonnes (Figures 2 and 4).

Figure 4. Examples of components for Indonesian anchored FADs: (a) coils of rope used for FAD mainline, (b) 60-80 kg cement weights which are linked together to form the FAD anchor, and (c) coconut palm branches attached to mainline as subsurface attractor (Photos: Proctor).

2. Total number and positions of FADs

Achieving an estimate of the total number of anchored tuna FADs in Indonesia's FMAs 713 – 717 proved difficult. Although current fisheries laws require the registration of FADs and owners of FADs to supply positional and vessel use information for each FAD installed to Directorate General of Capture Fisheries in Jakarta, these laws have not been effectively implemented and adhered to. In general, National, Provincial, Regency and District offices of Department of Marine Affairs and Fisheries (DKP) were unable to provide information of numbers and locations of FADs. Port Authorities are primarily concerned with monitoring vessel traffic into and out of ports, and vessel activity in their ports, and do not, in general, maintain records of FAD locations. Some fishing companies, vessel 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. The information obtained by this study's enumeration program, combined with that from other sources, suggests the total number of FADs in FMAs 713 – 717 is at least in order of many hundreds and may extend to thousands. Figure 5 and Figure 6 show the positional information for FADs in FMAs 714, 715 and 717 based on an earlier survey by CFRD in 2012 (Hargiyatno pers. comm.) and on enumeration done for this study. An assessment of all the positional information obtained through the current study is in progress.

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. 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 vessel 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).

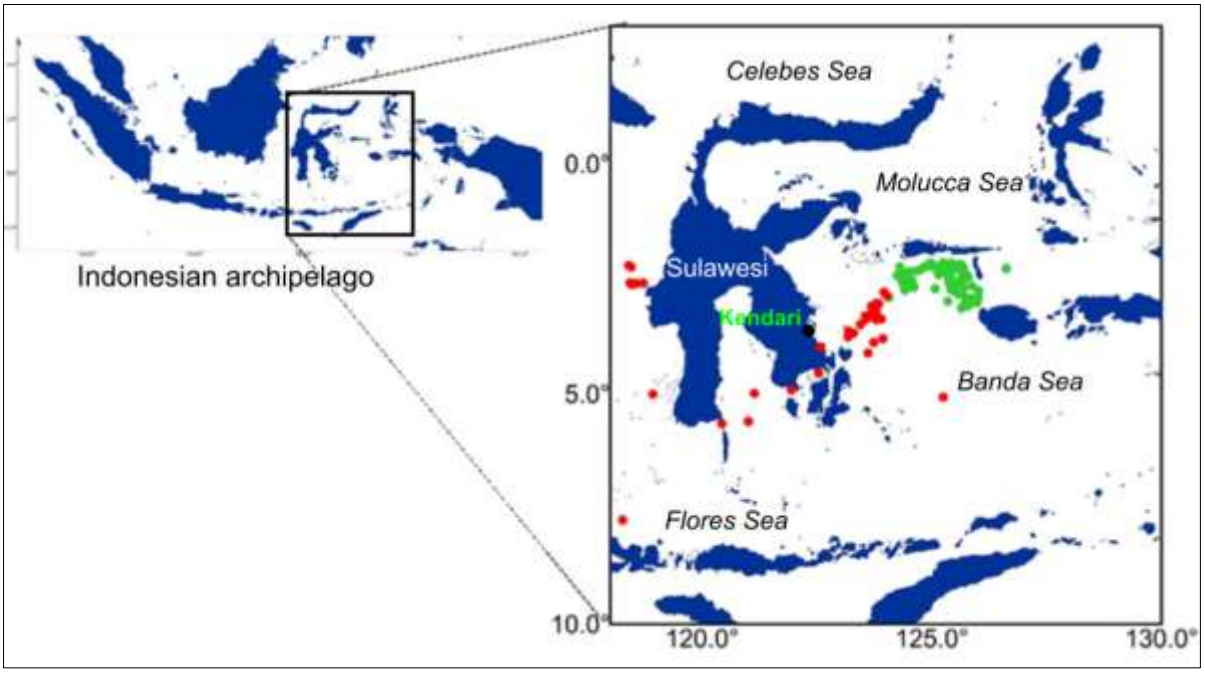

Figure 5. FAD positions in FMA 714 as determined from GPS coordinates obtained in survey in 2012 (i.e. not from enumeration in the current study). Green symbols indicate FADs used by PS vessels and red symbols indicate FADs used by HL/TL vessels from PPS Kendari and PPP Sodohoa (Kendari) respectively.

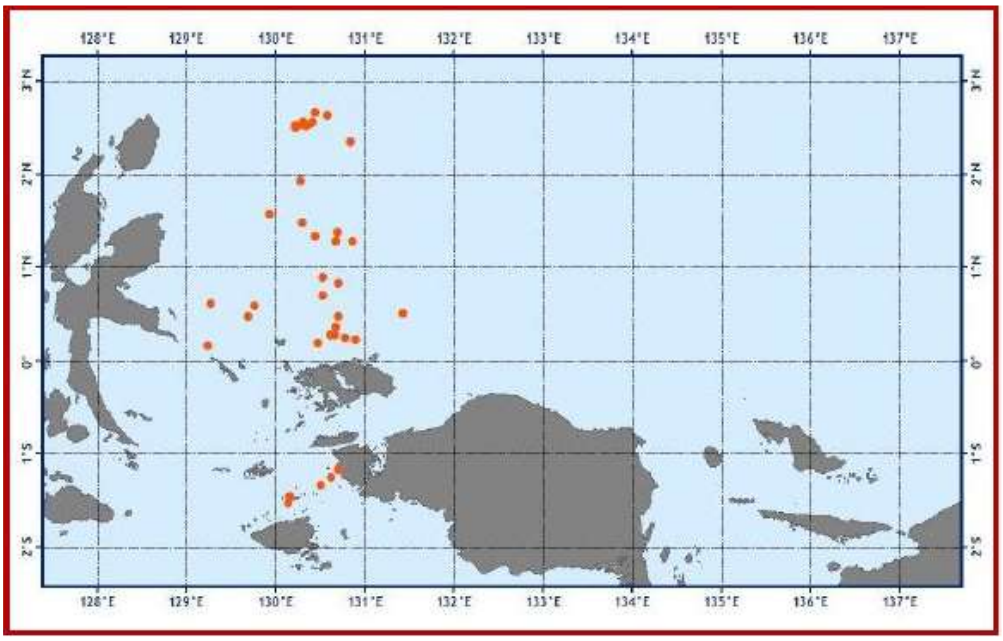

Figure 6. FAD positions in FMAs 715 and 717, from information collected during enumeration in Sorong in 2013 and 2014. These FADs are used by PL and PS vessels.

3. Tuna fisheries associated with FADs

Tuna fisheries that operate in association with FADs in Indonesia include the gear types purse seine, pole and line, hand-line, troll-line, and surface fishing using kites and lures. Two types of purse seine fleet size operate in the waters of FMA 713 – 717: smaller vessels of <30 GT which are called “mini-purse-seine” (Figure 7a) of

local name "*pajeko*", and larger purse seine vessels ("*kapal pukat cincin*") of > 30 GT (Figure 7b). Pole and line vessels operating around FADs are also of two main types: small size vessels of <20 GT, commonly called '*funae*' (Figure 7c) and larger vessels of > 20 GT, commonly called "*huhate*" (Figure 7d). The numbers of *funae* vessels are not increasing, but still operate in several areas in northern Sulawesi (e.g. Belang and Pulau Gangga). Hand-line fishing, troll-line fishing and kite fishing are generally done by a single vessel type i.e. multi-gear vessels, which switch between gears depending on season, prevailing seas conditions and catch success. These vessels, commonly wooden-hull vessels of size 6 – 10 GT (Figure 7e), have different local names across regions, including "*penongkol*" in northern and south-eastern Sulawesi, and "*sekoci*" in Bali and east Java. These hand-line/troll-line vessels and their fishing methods originated from southern Sulawesi (Bugis fishermen) and have spread to many other areas of the Indonesian archipelago.

Figure 7. Examples of Indonesian vessel types that fish on FADs: (a) Mini purse-seine (*pajeko*), < 30 GT, at PPP Sodohoa; (b) larger purse-seine (*pukat cincin*), > 30 GT, at PPS Kendari; (c) small pole and line (*funae*) in Belang, North Sulawesi; (d) pole and line, >50 GT, in Sorong; (e) hand-line/troll-line (*penongkol*) at PPP Sodohoa; and (f) hand-line/troll-line 'mother-ship' carrying several small catcher boats (*sampan*) in Kendari (Photos: Proctor).

Another type of tuna hand-line vessel that have operated widely in the eastern Indonesian waters, and particularly in northern Sulawesi, are *'pump boats*', which operate as a 'mother-vessel' servicing several small catcher boats (*sampan*) which are carried on board during travel. Some Indonesian HL/TL vessels, primarily in southern Sulawesi (e.g. in Bone) and SE Sulawesi (Kendari) have adopted this style of fishing, routinely

carrying as many a 6 – 8 of the *sampan*, from which both large (up to 100 kg yellowfin tuna) and small tunas are caught (Figure 7f).

4. Operational aspects of the fisheries using FADs

Catch success rate

The majority of the enumeration at Kendari and Sorong fishing ports focused on hand-line/troll-line (HL/TL) and pole and line (PL) vessel activity. Table 1 summarises some of the fishing trip characteristics; results from 372 trips surveyed for HL/TL vessels and 112 trips surveyed for PL vessels. Interviews with skippers in Kendari revealed that on average, HL/TL vessels visited 12 FADs during fishing trips of average length 7 fishing days (excludes days travelling to and from fishing grounds, and any days lost to bad weather or gear issues etc.) and, on average, 8 of the FAD visits were successful with respect to fish catch. The success rate (successful FAD visits expressed as a % of total number of FADs visited) of the HL/TL fleet in Kendari was around 65%. The success rate of the Kendari PL fleet was similar at around 66%, for fishing trips of average length 2 - 3 fishing days. The success rate PL vessels based in Sorong was significantly higher at around 85% (Table 1), for trips of average length 6 fishing days.

Table 1. Summary of trip length (fishing days) and FAD visit success, for HL/TL and PL vessels in Kendari and Sorong, based on information collected by this study during 2013 – 2014.

Location	Gear Type	No. Vessel Trips	Average Number of Fishing (Days)	Average Number of FADs Visited	Average Number of FADs With Success	FADs Success Rate (%)
Kendari	HL	372	7.2	12.1	7.5	64.9
Kendari	PL	21	2.4	2.1	1	65.9
Sorong	PL	91	5.8	4.5	3.9	84.9

During the surveys in Kendari and Sorong, skippers of PL vessels often expressed frustration that FADs were found to "empty of fish" after sets by PS vessels. 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.

Catch rates

Results of enumeration at landing place PPP Sodohoa (on northern side of Kendari Bay), where the HL/TL (*penongkol*) vessels unload catch, showed the average catch rates (based on total catch - all species) of HL/TL vessels in 2013 (Oct – Dec only), 2014, and 2015 were 1077 kg, 1273kg, and 980 kg per vessel per trip respectively (Table 2). Average catch rates by day per HL/TL vessel (based on total catch/no. fishing days for fishing trips with available catch data) in 2013 (76 trips), 2014 (144 trips) and 2015 (163 trips) were 155 kg, 157 kg, and 169 kg per vessel/day. The primary fishing areas for HL/TL vessels based at PPP Sodohoa in Kendari are on FADs in the waters around Manui Island, approximately 36 nm from Sodohoa.

Figure 8 illustrates the general operations of the PL fleet based in Kendari (at the main fishing port, PPS Kendari), both for catcher vessels and carrier vessels. The vessels use the island group Kepulauan Umbele (approximately 58 nm north from Kendari) as the base for fishing activity.

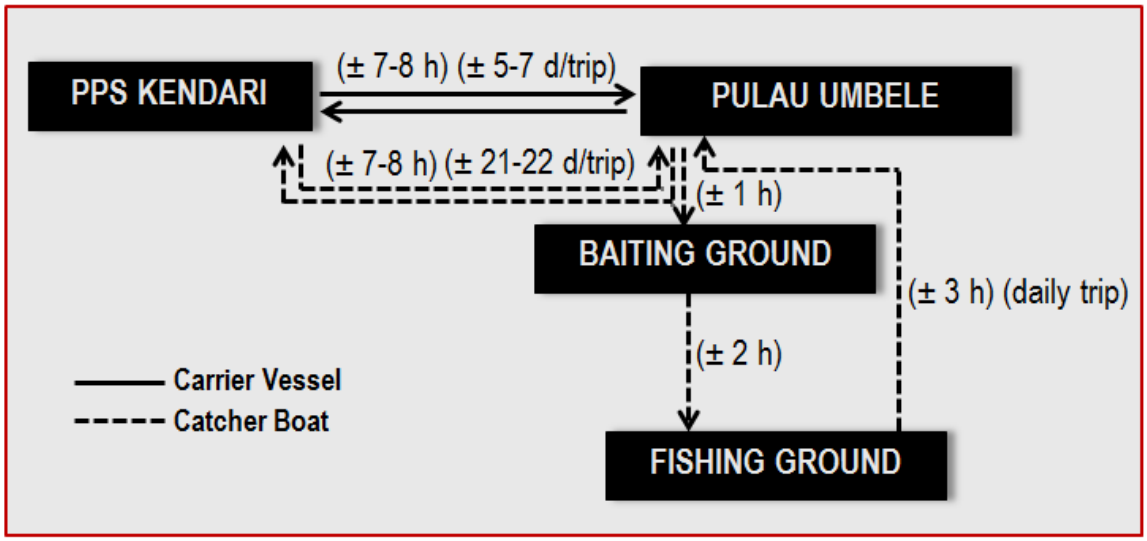

Figure 8. An illustration summarising PL fleet operations out of fishing port PPS Kendari.

Port sampling activities were also conducted on carrier vessels that collect catch from one or more catcher vessels (CV) and unload in PPS Kendari. At time of writing, analysis to delineate the catches of individual catcher vessels collected and carried by the CV was incomplete. Determining total trip catch for many of the PL vessels is difficult, in situations where some of the trip catch has been collected by a CV(s), and the PL vessel returns to port with only the catch from its most recent fishing days (i.e. post CV collection). Hence, the total landings reported in Table 3, as landings of PL vessels surveyed in PPS Kendari, may not represent the total trip catch.

Table 2. Catch landings of HL/TL vessels (*penongkol*) surveyed at PPP Sodohoa di Kendari during Oct 2013 - Dec2015.

Gear Type	Year	Month	No. of Trips	Total Catch (kg)	Catch / Trip (kg)
HL/TL	2013	10	26	30,042	1,155
		11	23	23,815	1,035
		12	27	28,082	1,040
	Average			**27,313**	**1,077**
	2014	1	20	20,400	1,020
		2	18	20,724	1,151
		3	19	24,500	1,289
		4	8	9,500	1,188
		5	6	9,500	1,583
		6	9	12,800	1,422
		7	9	11,792	1,310
		8	10	13,200	1,320
		9	11	12,650	1,150
		10	10	22,750	2,275
		11	11	10,080	916
		12	13	8,449	650
	Average			**14,695**	**1,273**
	2015	1	12	11,290	941
		2	8	5,500	688
		3	14	13,825	988
		4	15	13,560	904
		5	15	14,925	995
		6	15	16,905	1,127
		7	7	8,600	1,229
		8	13	13,250	1,019
		9	14	16,435	1,174
		10	16	15,560	973
		11	15	14,610	974
		12	19	14,251	750
	Average			**13,226**	**980**

Results of enumeration for PL vessels at PPS Kendari (on sothern side of Kendari Bay) showed the average catch rates (based on total catch - all species) in 2013 (7 trips surveyed), 2014 (15 trips surveyed), and 2015 (3 trips surveyed) were 1593 kg, 2490 kg, and 4260 kg per vessel per trip respectively (Table 3).

Table 3. Catch landings of PL vessels (*huhate*) surveyed at PPS Kendari during Oct 2013 – Dec 2015.

Gear Type	Year	Month	No. of Trips	Total Catch (kg)	Catch/Trip (kg)
PL	2013	10	2	2,006	1,003
		11	4	8,100	2,025
		12	1	1,750	1,750
	Average			**3,952**	**1,593**
	2014	1	3	5,500	1,833
		2	1	2,045	2,045
		3	5	16,912	3,382
		4	2	7,650	3,825
		9	4	5,450	1,363
	Average			**7,511**	**2,490**
	2015	8	1	4,100	4,100
		9	1	2,980	2,980
		10	1	5,700	5,700
	Average			**4,260**	**4,260**

Enumeration in Sorong during the same period (Oct 2013 - Dec2015) showed that, on average, the length of PL vessel trips was 10 days (max 27 days), with an average of 6 actual fishing days . On average, 4 days were required to travel to and from the fishing areas, searching for bait, and or for other non-fishing activity including repairs of the vessel's engine. The average catch landings (based on total catch - all species) by PL vessels in Sorong in 2013 (9 landings surveyed), 2014 (59 landings surveyed), and 2015 (24 landings surveyed) were 6515 kg, 11,633 kg, and 13,569 kg per vessel per trip respectively. (Table 4). Average catch per actual fishing day for these vessels in 2014 and 2015 was 1,994 kg, and 2262 kg respectively.

Table 4. Catch landings of PL vessels (*huhate*) surveyed at Sorong during Oct 2013 – Dec 2015.

Gear Type	Date_Year	Date_Month	No_Of_Trips	Total_Catch (kg)	Catch/Trip (kg)
PL	2013	11	7	44,005	6,286
		12	2	13,486	6,743
	Average			**28,746**	**6,515**
	2014	1	6	36,289	6,048
		2	7	33,283	4,755
		3	7	56,233	8,033
		4	9	52,574	5,842
		7	1	8,712	8,712
		9	7	144,651	20,664
		10	9	193,058	21,451
		11	10	124,358	12,436
		12	3	50,264	16,755
	Average			**77,714**	**11,633**
	2015	1	4	70,169	17,542
		2	5	79,858	15,972
		3	8	97,266	12,158
		4	7	60,218	8,603
	Average			**76,878**	**13,569**

In general, purse seine (PS) vessels based in Fishing Port of Sorong operate in a group which consists of a PS catcher vessel, 3 to 4 carrier vessels, and 3 to 4 light boats. The pattern of fishing operations of the group is as follows: the catcher vessels have fishing trips of more than 6 months; catches are transferred directly to CVs because the catcher vessels 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 Sorong by a CV is most often the result of 3 to 4 sets by the catcher vessel. The enumeration of CVs showed that in 2013 and 2014 the average volume of fish landed by an individual CV in Sorong was 38,794 tonnes and 30,803 tonnes respectively, with the highest landing being 54,597 tonnes (Table 5). If these landings result from catches from 3 - 4 sets of the PS net, the estimates of average catch/set was 9 – 12 tonnes in 2013 and 8 – 10 tonnes in 2014.

Table 5. Landings (by volume) by carrier vessels surveyed in Sorong during Nov 2013 – Nov 2014.

Gear_Type	Date_Year	Date_Month	No_Of_Trips	Total_Catch (kg)	Catch/Trip (kg)
CV	2013	11	3	116,572	38,857
		12	2	77,460	38,730
	Average			**97,016**	**38,794**
	2014	1	4	101,502	25,376
		2	3	163,792	54,597
		3	1	19,389	19,389
		4	3	87,644	29,215
		9	4	111,983	27,996
		11	1	28,242	28,242
	Average			**85,425**	**30,803**

5. Biological aspects of the tuna fisheries operating on FADs

Catch composition

The results from enumeration in Sodohoa (Kendari) showed that, in the landings surveyed, at least 18 species of fish were caught by the HL/TL fleet. Yellowfin tuna (YFT), *Thunnus albacares*, was a dominant component, comprising 47.6% by volume of the surveyed catch over the study period. Skipjack tuna (SKJ), *Katsuwonus pelamis*, were also a major component at 41.0%, with bigeye tuna (BET), *T. obesus*, at 5.4% (Table 6). Billfish (marlins, sailfish, spearfish etc.) only made up 0.06%, by volume, of the catch.

Table 6 :Composition of catch by species by volume (kg) from HL/TL vessels surveyed at PPP Sodohoa in Kendari during Oct 2013 – Dec 2015.

Indonesian Name	Common Name	Scientific Name	2013	2014	2015	Total (kg)	%
Madidihang	Yellowfin	*Thunnus albacares*	42,131	77,881	78,525	198,537	47.611
Cakalang	Skipjack tuna	*Katsuwonus pelamis*	31,954	74,405	64,805	171,164	41.047
Matabesar	Bigeye	*Thunnus obesus*	2,862	10,463	9,346	22,671	5.437
Tongkol banyar	Frigate tuna	*Auxis thazard*	2,221	9,080		11,301	2.710
Setuhuk Hitam	Black Marlin	*Makaira indica*	1,568	2,352	2,170	6,090	1.460
Tongkol, Kawa-kawa	Eastern little tuna, Kawa kawa	*Euthynnus affinis*		600	1,620	2,220	0.532
Tongkol	Tongkol	*Auxis spp.*		900	910	1,810	0.434
Lemadang	Common dolphinfish	*Coryphaena hippurus*	656	236	100	992	0.238
Hiu macan	Tiger shark	*Galeocerdo cuvier*			700	700	0.168
Cucut, Hiu	Various sharks nei			120	535	655	0.157
Billfish (setuhuk dll.)	Marlins, sailfish, spearfish etc. nei	*Istiophoridae*	163	100		263	0.063
Setuhuk Biru	Blue Marlin	*Makaira nigricans*	233			233	0.056
Mungsing (Bali)	Silky shark	*Carcharhinus falciformis*		130	0	130	0.031
Layang	Scads nei	*Decapterus spp*	80			80	0.019
Cucut selendang	Blue shark	*Prionace glauca*	65			65	0.016
Setuhuk Loreng	Striped Marlin	*Tetrapturus audax*		65		65	0.016
Tenggiri	Narrow-barred Spanish mackerel	*Scomberomorus commerson*	6	8		14	0.003
Alu-alu	Barracuda	*Sphyraena spp*		5		5	0.001
Total						**416,995**	**100**

The catches of PL vessels landed that were surveyed in PPS Kendari were dominated by skipjack tuna (73.2% by volume), and yellowfin tuna (26.7%) (Table 7). Bigeye tuna were recorded at overall at only 0.1% of the landings. This level of bigeye tuna occurrence is surprisingly low and is a result being treated with caution at this stage in the data assessment. It may be partly or wholly explained by inexperience of the enumerators in discerning YFT and BET at small size.

Table 7. Composition of catch by species by volume from PL vessels surveyed at PPS Kendari during Oct 2013 – Dec 2015.

Indonesian Name	Common Name	Scientific Name	2013	2014	2015	Total (kg)	%
Cakalang	Skipjack tuna	*Katsuwonus pelamis*	8,250	27,960	9,300	45,510	73.2
Madidihang	Yellowfin	*Thunnus albacares*	3,530	9,597	3,480	16,607	26.7
Matabesar	Bigeye	*Thunnus obesus*	76			76	0.1
Total						**62,193**	**100**

Among the 9 species in the catches of PL vessels surveyed in Sorong, skipjack tuna made up 75.6% by volume, yellowfin tuna 19.6%, and bigeye tuna only 3.50% (Table 8). Purse seine catches landed by CV in Sorong included 7 species, dominated by skipjack tuna at 81.0% by volume, and yellowfin tuna 14.1% (Table 9). Bigeye tuna were recorded at only 2.1% by volume.

Table 8. Composition of catch by species by volume from PL vessels surveyed at Sorong during 2013 – 2015.

Indonesian Name	Common Name	Scientific Name	2013	2014	2015	Total (kg)	%
Cakalang	Skipjack tuna	*Katsuwonus pelamis*	38,810	481,746	284,536	805,092	75.64
Madidihang	Yellowfin	*Thunnus albacares*	11,410	173,826	22,975	208,211	19.56
Matabesar	Bigeye	*Thunnus obesus*	5,070	32,201		37,271	3.50
YFT/BET?	Indistinguishable Yellowfin or Bigeye			6,227		6,227	0.59
Tongkol banyar	Frigate tuna	*Auxis thazard*	940	2,096		3,036	0.29
Tongkol, Kawa-kawa	Eastern little tuna, Kawakawa	*Euthynnus affinis*	1,261	1,314		2,575	0.24
Sunglir	Rainbow runner	*Elagatis bipinnulata*		825		825	0.08
Kasper	Ray's bream, Pomfret	*Brama spp*		711		711	0.07
Lemadang	Common dolphinfish	*Coryphaena hippurus*		476		476	0.04
Total						**1,064,424**	**100**

Table 9. Composition of catch by species by volume from CV vessels surveyed at Sorong during Oct 2013 – Dec 2015.

Indonesian Name	Common Name	Scientific Name	2013	2014	2015 (kg)	Total
Cakalang	Skipjack tuna	*Katsuwonus pelamis*	154,080	418,549	572,629	81.0
Madidihang	Yellowfin	*Thunnus albacares*	31,571	68,115	99,686	14.1
Matabesar	Bigeye	*Thunnus obesus*	4,881	9,962	14,843	2.1
Tongkol banyar	Frigate tuna	*Auxis thazard*	2,755	6,739	9,494	1.3
Tongkol, Kawa-kawa	Eastern little tuna, Kawakawa	*Euthynnus affinis*	311	5,700	6,011	0.9
Sunglir	Rainbow runner	*Elagatis bipinnulata*	273	1,913	2,186	0.3
Lemadang	Common dolphinfish	*Coryphaena hippurus*	161	1,574	1,735	0.2
Total					**706,584**	**100**

Overall, the proportion of sharks and billfish, as bycatch species, in the landings of HL/TL and PL vessels in Kendari and Sorong was extremely low, with sharks and billfish aggregated being highest in HL/TL landings at Sodohoa, but only at 1.9% by volume. No sharks or marlins were recorded in landings of PL vessels in Kendari and in Sorong and nor in the landings of PS vessels (landed by CV) in Sorong. This latter result contrasts markedly with the significant amounts of shark (in particular silky sharks, *Carcharhinus falciformis*) reported by Nicol et al. (2009) as bycatch in the PNG purse-seine fishery. Further assessment of the surveyed landings from carrier vessels in Sorong is in progress to determine if bycatch species were 'missed' by the enumeration. At present, the results of the enumeration in this study suggest that, overall, the tuna fisheries associated with FADs in FMAs 713-717 have relatively low levels of bycatch.

Fish size

Table 10 details the length (FL) of SKJ, YFT, and BET measured from subsamples of catch landings from HL/TL and PL vessels in Kendari and PL vessels in Sorong. At time of writing, assessment of subsampling of

PS landings at both locations was still in progress. The average size of most of YFT and BET, caught by both these gear types, were below the reported Lengths of Maturity (L*m*); 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/TL vessels in Kendari were also below their reported L*m* of 40 – 42 cm FL (Tandog-Edralin *et al.* 1990).

Table 10. Length (cm FL) of SKJ, YFT, and BET caught by HL/TL and PL vessels based in Kendari and Sorong, surveyed during Oct 2013 – Dec 2015. n = number of fish measured.

Location	Gear Type	Species	Year	Min Length	Max Length	Avg Length	n
Kendari	HL/TL	SKJ	2013	21	41	31.5	456
			2014	20	48	32.3	1,235
			2015	24	41	32.6	543
		YFT	2013	29	41	34.0	418
			2014	22	41	34.5	1,240
			2015	22	45	33.7	830
		BET	2013	25	42	37.8	28
			2014	31	46	40.1	150
			2015	32	48	39.8	93
	PL	SKJ	2013	30	46	37.3	65
			2014	30	87	42.2	855
			2015	26	73	49.9	58
		YFT	2013	34	47	40.8	32
			2014	30	82	41.0	514
			2015	29	82	50.0	29
		BET	2013	48	52	49.7	3
			2014	31	57	46.2	30
			2015	58	63	60.5	2
Sorong	PL	SKJ	2013	15	65	36.5	435
			2014	15	83	38.7	2,388
			2015	25	59	43.9	205
		YFT	2013	15	66	42.7	151
			2014	15	65	43.6	528
			2015	29	59	43.1	35
		BET	2013	27	65	48.0	70
			2014	18	85	46.5	221
			2015	25	58	44.5	15

The use of FADs, as attraction devices for tuna, have a negative effect on the environment. There has been considerable earlier research on this matter e.g. Bromhead *et al.* (2000), Sokimi (2008), Ménard *et al.* (2000), Freon and Dagorn (2000). Among the important outcomes from these studies was that the operation of the purse seine fishing around FADs results in large catches of juvenile YFT and juvenile BET, and an associated high

risk of overfishing. The preliminary results from this study in eastern Indonesian archipelagic waters have shown catches of HL/TL and PL also include a high percentage of immature fish in the YFT and BET caught.

The data and information presented from this study are preliminary, prior to more complete assessment and reporting in a forthcoming project Final Report and subsequent papers. The study includes an assessment of bio- and socio-economic aspects of the FAD-based fisheries.

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