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**CATCH INFORMATION FROM THE FAD-BASED DOMESTIC TUNA PURSE SEINE
FISHERY IN PAPUA NEW GUINEA**

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Abstract

Catches from Associated sets in the Papua New Guinea (PNG) Fad-based purse-seine fishery, shows that skipjack is the main target species (62% by weight and 75% by number) of the catch. Yellowfin (35% by weight and 23% by number) is the next and then bigeye (3% by weight and 2% by number). Bycatch accounts for less than 1% by both weight and number (0.44% by weight and 0.48% by number), with Rainbow Runner being the main species. Comparison of mean lengths between Anchored Fish Aggregating Devices (AFADs) and Free Floating Objects (FFO) caught fish, by species, show no significant difference in the tuna species, but showed, differences in two bycatch species (Rainbow runner and Silky sharks). Comparison of means at the lower and upper quartile levels showed significant differences for most of the species including the tunas. Sex ratio was variable by species by set types, indicating that sex ratio may not necessarily be uniform by set association.

Introduction

The usage of Fish Aggregating Devices (FAD) in Papua New Guinea (PNG) domestic tuna fishery plays a vital role in the overall tuna industry. Most of the investment onshore is dependant on catch from purse-seine vessels catching tuna associated with FADs. Studies on the impacts of FADs, are now showing that although FADs are very economical in the overall operations of fishing vessels, they may ecologically be disastrous in the long term.

This report presents some information on the species composition, population structure and sex ratios of tunas and bycatch species of FAD associated sets from the PNG based purse-seine vessels that fish on FADs. The data covers years 1999. This was the period when, the PNG Fad based purse-seine fishery was just establishing in a big way.

Study site

Sampling was carried out on FAD and FFO sets mainly within the Bismarck Sea (fig. 1)

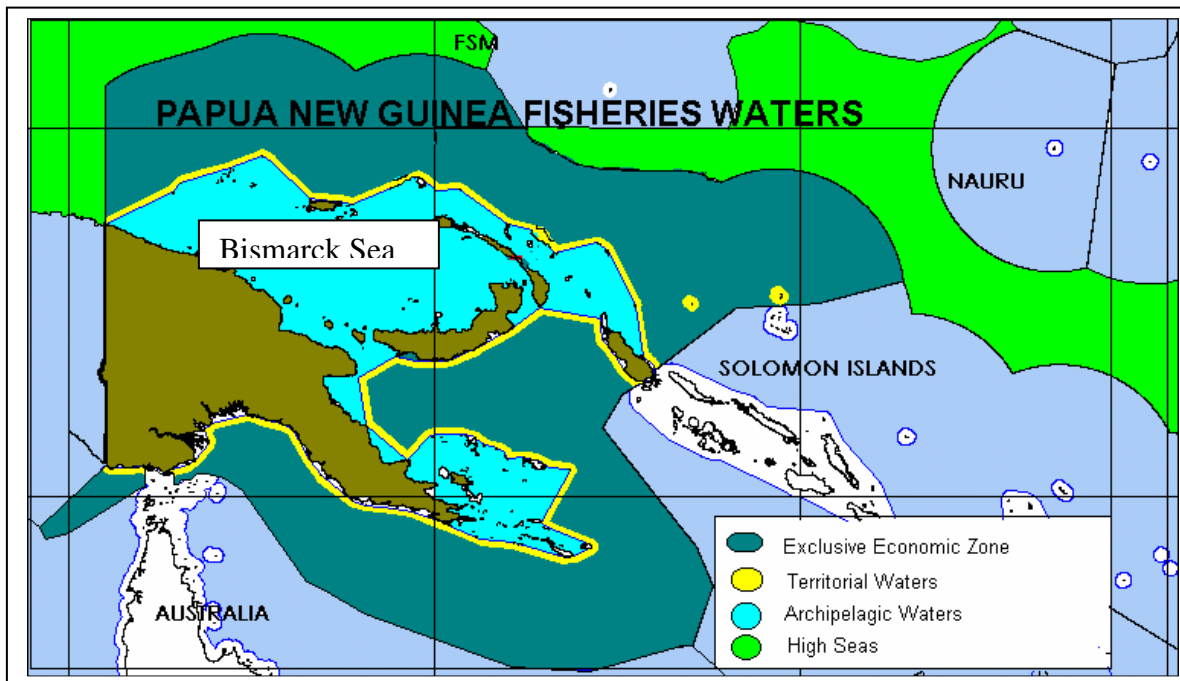


Figure 1. The sampling area, showing the Bismarck Sea

Materials & Methods

Six (6) purse-seine vessels, licensed to fish in the Papua New Guinea Fisheries waters (EEZ and Archipelagic waters) were used during the period of this study. Twelve samplers were engaged, two per vessel, per trip for three, one month long trips in 1999. The trip periods were March-April, July-August and November-December. The trips were organised in a manner that they started at about the same time and ended at about the same time. Samples were taken from associated sets both Anchored Fish Aggregating Devices (AFADs) and

Free Floating Objects (FFO), which were outside 12 nautical miles from land, island or any declared reef within the Bismarck Sea

Comparison of samples means for species from AFAD and FFO was tested using student t-test and the Hypothesis tested at 95% confidence limit. Chi squared test was used to test the deviation in sex ratio from the expected 1:1 male to female ratio. Only those observations that were identified as male or female were used in the sex ratio analysis.

Sampling

Species Composition

Sample brails were chosen at random using random number sampling. The contents of the chosen brails were poured on deck and all the fish counted and identified. Twenty (25) skipjack and twenty (25) yellowfin plus twenty (25) bigeye if enough bigeye were caught were selected at random. These were weighted and the average weight by species determined. The average weight was then multiplied by the number of individuals to estimate the weight of the brail by species. The average weight of bycatch species was also determined per species. The estimated average was then multiplied by the number of individuals to determine the total weight by species.

Size Structure

Twenty (25) skipjack and twenty (25) yellowfin plus twenty (25) bigeye were selected at random. Fork length measurements of these fish were taken. All bycatch were grouped by species and Length measurement of the individuals was taken.

Sex ratio

Twenty (25) skipjack, twenty (25) yellowfin and twenty (25) bigeye were selected at random from the sample brail. Five individuals from each species were selected, ranging from the smallest to the biggest individual. These were then gutted and their sex determined.

Results

Species Composition.

Skipjack tuna is the most common tuna species in associated sets, accounting for 62% (62.07%) by weight and 75% (74.86%) by number of fish (table 1). The second most common species is yellowfin tuna accounting for 35% (34.73%) by weight and 23% (23.10%) by number. Bigeye is the least common of the tuna species, and the third most common in the associated sets, accounting for 3 % (2.76%) by weight and 2% (1.58 %) by number of fish. The remaining 0.44 % by weight was bycatch which is 0.46% by number. Rainbow runner, was the most common bycatch accounting for 0.19% by both weight and number of fish

Table 1. Species composition from both AFAD and FFO sets (combined data).

Species	No. fish	Weight (kg)	% by no. fish	% by weight
Skipjack (<i>Katsuwonus pelamis</i>)	66,658	168,763.30	74.86	62.07
Yellowfin (<i>Thunnus albacares</i>)	20,574	94,427.90	23.10	34.73
Bigeye (<i>Thunnus obesus</i>)	1,385	7,516.20	1.58	2.76
Rainbow runner (<i>Elagatis bippinulata</i>)	167	513.30	0.19	0.19
Mackerel scad (<i>Decapterus macarellus</i>)	134	66.20	0.15	0.02
Trigger fishes	56	28.50	0.06	0.01
Sharks	28	227.80	0.03	0.08
Dolphinfish (<i>Coryphaena hippurus</i>)	29	95.40	0.03	0.04
Sting ray	2	100.00	0.00	0.04
Sword fish	1	119.00	0.00	0.04
Wahoo (<i>Acanthocybium solandri</i>)	1	4.00	0.00	0.00
Pilot fish (<i>Naucrates ductor</i>)	1	1.50	0.00	0.00
Golden Trevally (<i>Gnathanodon speciosus</i>)	3	10.30	0.00	0.00
Others	15	19.90	0.02	0.01

Table2. Species composition by set type

Species	ANCHORED FAD SETS (AFADs)				FREE FLOATING OBJECT SETS (FFO)			
	No. fish	Wgt (kg)	% by no. fish	% by wgt	No. fish	Wgt (kg)	% by no fish	% by wgt
Skipjack (<i>Katsuwonus pelamis</i>)	41,486	96,580.5	75.9 1	60.6	25,17 2	72,182.80	73.17	64.14
Yellowfin (<i>Thunnus albacares</i>)	12,137	57,722	22.2 1	36.22	8,437	36,705.50	24.52	32.62
Bigeye (<i>Thunnus obesus</i>)	877	4,553.30	1.6	2.86	508	2,962.90	1.48	2.63
Rainbow runner (<i>Elagatis bippinulata</i>)	62	200.20	0.11	0.13	105	313.10	0.31	0.28
Mackerel scad (<i>Decapterus macarellus</i>)	38	11.50	0.07	0.01	96	54.70	0.28	0.05
Trigger fishes	0	0.00	0.00	0.00	56	28.50	0.16	0.03
Sharks	12	77.50	0.02	0.05	16	150.30	0.05	0.13
Dolphinfish (<i>Coryphaena hippurus</i>)	24	73.60	0.04	0.05	5	21.80	0.01	0.02
Sting ray	0	0.00	0.00	0.00	2	100.00	0.01	0.09
Sword fish (<i>Xiphias gladius</i>)	1	119.00	0.00	0.07	0	0.00	0	0
Wahoo (<i>Acanthocybium solandri</i>)	1	4.00	0.00	0.00	0	0.00	0	0
Pilot fish (<i>Naucrates ductor</i>)	1	1.50	0.00	0.00	0	0.00	0	0
Golden Trevally (<i>Gnathanodon speciosus</i>)	3	10.30	0.01	0.01	0	0.00	0	0
Others	10	8.20	0.02	0.01	5	11.70	0.01	0.01

Size structure***Target Species******Skipjack***

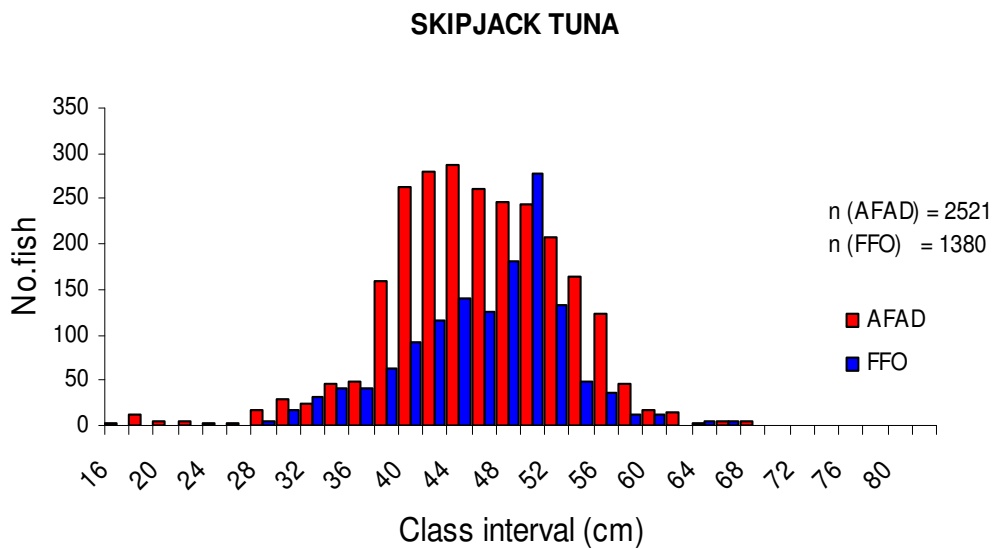
Skipjack size structure (figure 2 top) shows a single mode distribution by both set types. The modal classes are 44.1-46cm and 50.1-52cm for AFAD and FFO respectively. Table 3, shows the values for the mean, standard deviation, minimum and maximum size and the number of samples. Comparison of the mean lengths between samples from AFAD and FFO showed a non significant difference ($t_{cal} = 0.91$, $t_{tab} = 1.96$) for the means of the overall AFAD versus FFO sample and means of the lower quartile ($t_{cal} = 0.45$, $t_{tab} = 1.96$), but showed a significant difference ($t_{cal} = 6.19$, $t_{tab} = 1.96$) in the mean lengths of the sample of the upper quartiles (Table 5).

Yellowfin tuna

Yellowfin histogram shows a bi-modal distribution with peaks around 46-48 cm and 64-66 cm. larger fish also showing around 94-96cm and 106-108cm (figure2, middle). Comparison of the mean sizes showed a non significant difference between the overall AFAD versus FFO samples ($t_{cal} = 1.48$, $t_{tab} = 1.96$), no significant difference ($t_{cal} = 0.31$, $t_{tab} = 1.96$) between the mean sizes of the lower quartiles, but showed a significant difference ($t_{cal} = 3.33$, $t_{tab} = 1.96$) in mean lengths of the upper quartiles (table 5).

Bigeye tuna

Bigeye tuna size structure histogram is as shown in figure 2. Sizes range from 28cm to 103cm for catch associated with AFADs and 30cm to 97cm for catch associated with FFO. There is no significant difference ($t_{cal} = 0.041$, $t_{tab} = 1.96$) in the mean sizes between the AFAD and FFO associated catch. However, comparison of the mean sizes of the lower and upper quartiles show significant differences (lower quartile; $t_{cal} = 2.25$, $t_{tab} = 1.96$, upper quartile; $t_{cal} = 5.91$, $t_{tab} = 1.96$) in the mean sizes between these two set associations (table5).



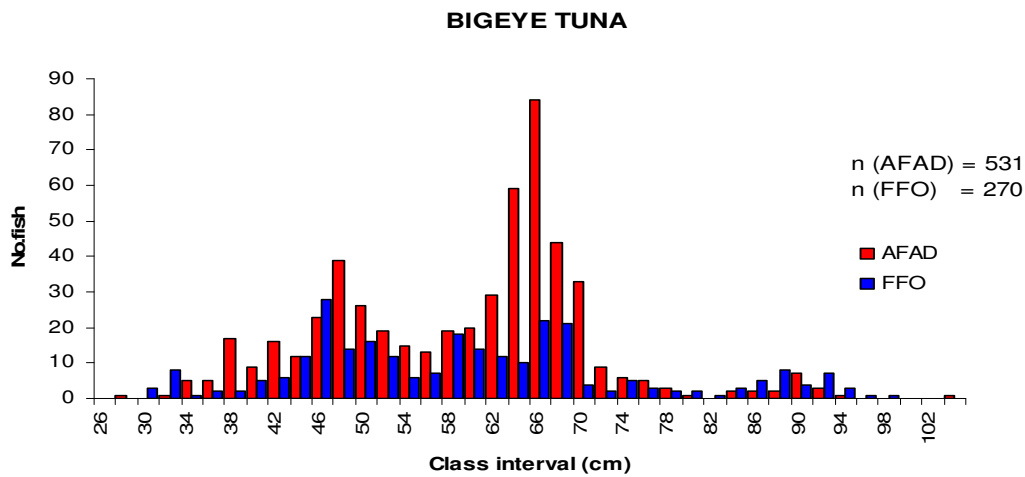
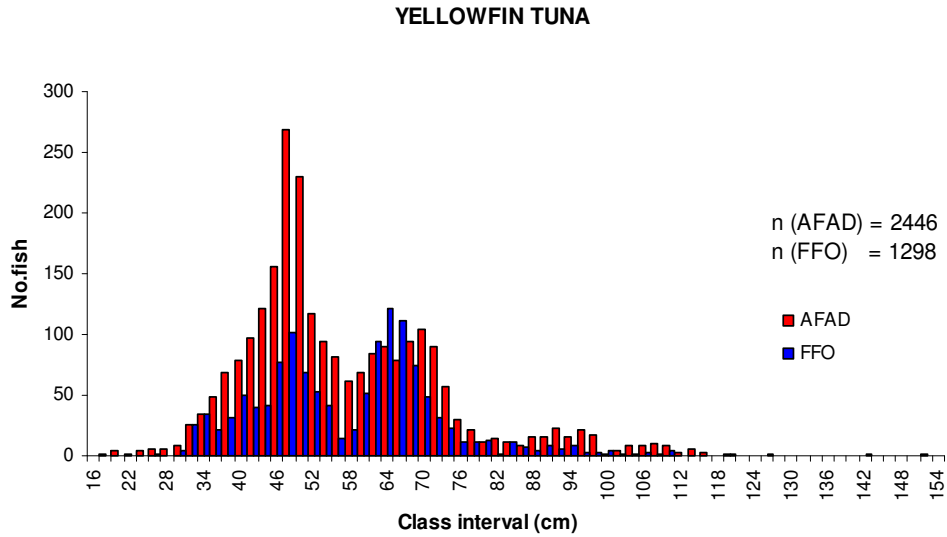


Figure 2; Size structure of the tuna species by set types, skipjack (top), yellowfin (middle) and Bigeye (bottom).

Table 3: Descriptive statistics of the three tuna species by sets associations

	SKIPJACK		YELLOWFIN		BIGEYE	
	AFAD	FFO	AFAD	FFO	AFAD	FFO
Mean	47.13	47.34	56.47	57.28	58.84	58.88
Standard Deviation	7.14	6.49	16.45	15.02	11.89	15.38
Minimum	18.00	28.00	18.00	25.50	28.00	30.00
Maximum	83.00	68.00	152.00	142.00	103.00	97.00
No. samples	2521.00	1380.00	2446.00	1298.00	531.00	270.00

Table 4: Lower and Upper Quartiles of the tuna species from AFADs and FFO sets

SPECIES	AFAD		FFO	
	Lower Quartile	Upper Quartile	Lower quartile	Upper Quartile
Skipjack	42.10 cm	50.87 cm	42.49 cm	50.69 cm
Yellowfin	44.72 cm	65.02 cm	44.99 cm	64.74 cm
Bigeye	48.23 cm	64.89 cm	46.55 cm	70.55 cm

Table 5. Results of t-test calculations (test at 5% CL, df=degrees of freedom)

SPECIES	Overall			Lower Quartile			Upper Quartile		
	t _{cal}	df	t _{tab}	t _{cal}	df	t _{tab}	t _{cal}	df	t _{tab}
Skipjack	0.91	3899	1.96	0.45	977	1.96*	6.19	975	1.96*
Yellowfin	1.48	3745	1.96	0.31	933	1.96	3.33	935	1.96*
Bigeye	0.04	799	1.96	2.25	199	1.96*	5.91	199	1.96*

* = significant at 5% CL, Ho=rejected, Ho: $\mu_{AFAD} = \mu_{FFO}$.

Bycatch species

Rainbow Runners

The size frequency histogram of Rainbow Runner, (figure 3a) shows two distinct modes at length 36-38cm and 68 to 70 cm size classes. The modal class by both set types is 66cm-68cm. Sample size range is 18cm-93cm for FFO and 29cm to 100cm for AFAD. Inter-quartile values for Rainbow runner is as shown in table 7. Comparison of mean size in fork-length between AFAD and FFO samples show a significant difference (t_{cal} = 5.20, t_{tab} = 1.96) for the overall observations, a significant difference in the lower quartiles means (t_{cal} = 10.82, t_{tab} = 1.96) but a non significant difference in the upper quartile means (t_{cal} = 0.77, t_{tab} = 1.96). This is also shown in table 8.

Mackerel Scad

The size distribution histogram for Mackerel scad shows a single mode distribution (figure 3b). The size range is from 16.5cm fork-length to 43 cm fork-length. Comparison of the mean lengths of AFAD and FFO sets show no significant difference (t_{cal} = 0.94, t_{tab} = 1.96). Comparison of means in the lower quartiles and also in the upper quartiles show a significant difference (lower quartile; t_{cal} = 4.11, t_{tab} = 2.01 and upper quartile; t_{cal} = 2.86, t_{tab} = 2.01)

Dolphinfish

Size frequency histogram for Dolphin fish (figure 3c), show modes, with the middle size class almost absent. Mean comparison of the two set types, no significant difference (t_{cal} = 0.15, t_{tab} = 2.00). Lower and upper quartile mean comparisons also show no significant difference (lower quartile; t_{cal} = 0.322, t_{tab} = 2.16 and upper quartile; t_{cal} = 1.302, t_{tab} = 2.14).

Silky Sharks

Size frequency histogram of silky shark is shown in figure 3d. The means of AFAD and FFO compared, show a significant difference (t_{cal} = 4.78, t_{tab} = 1.99). Comparison of means in the lower and upper quartile of the set types also shown significant difference (lower

quartile; $t_{cal} = 2.56$, $t_{tab} = 2.01$ and upper quartile; $t_{cal} = 19.3$, $t_{tab} = 2.06$) The histogram shows that smaller silky sharks are associated with FFO and the bigger ones with AFADs.

Oceanic White Tip sharks

The size frequency histogram of Oceanic white tip shark is as shown in figure 3e. There is no difference in the means of those caught from AFADs and those caught from FFO ($t_{cal} = 1.06$, $t_{tab} = 2.01$).

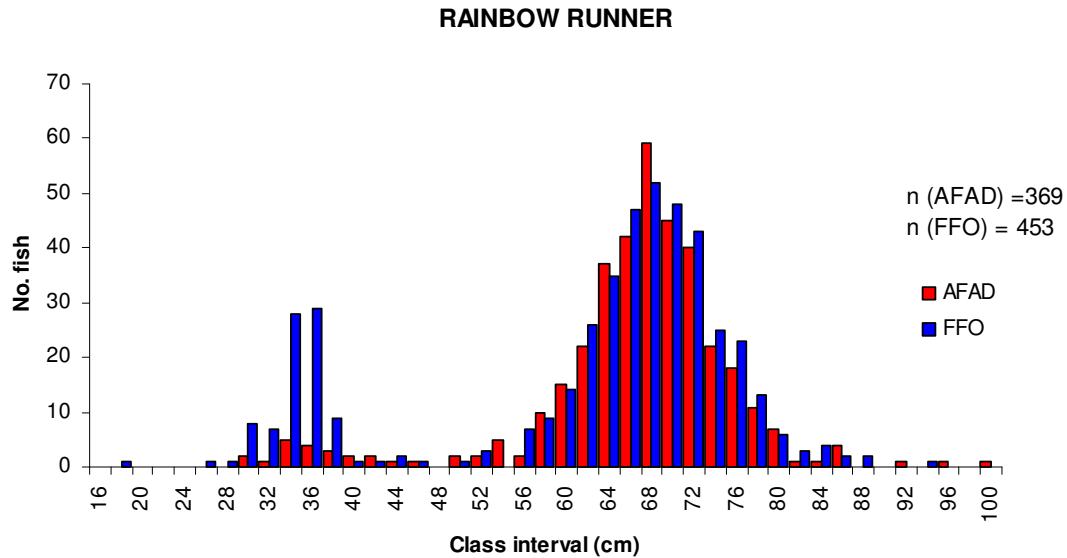


Figure3 a. Rainbow runner (*Elagatis bipinnulata*)

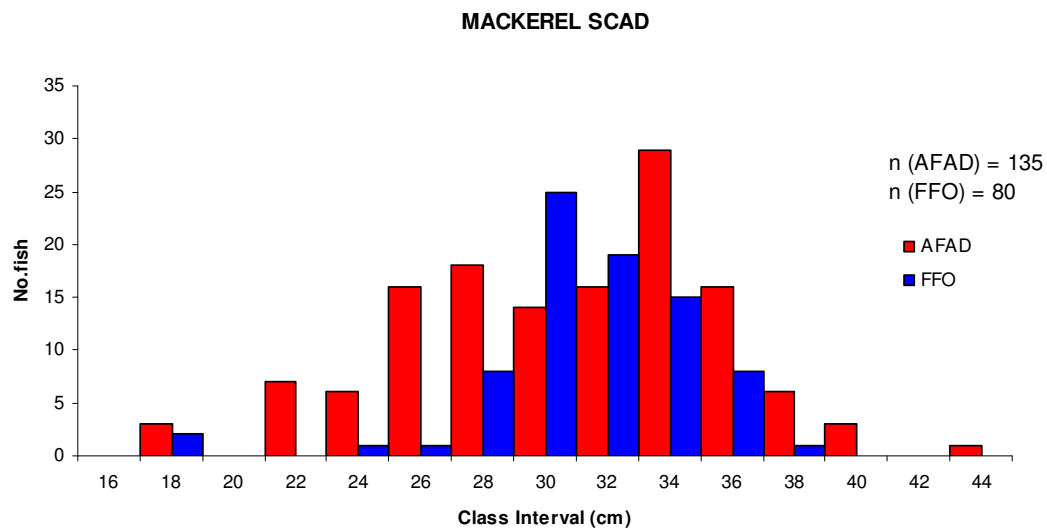


Figure 3b. Mackerel scad (*Decapterus macarellus*)

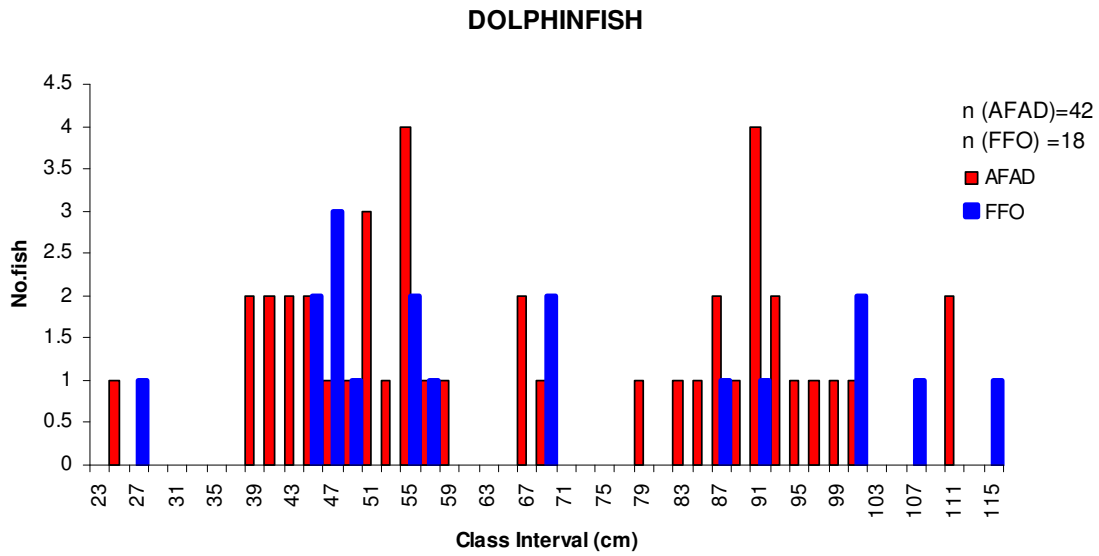


Figure3c. Dolphinfish (*Coryphaena hippurus*)

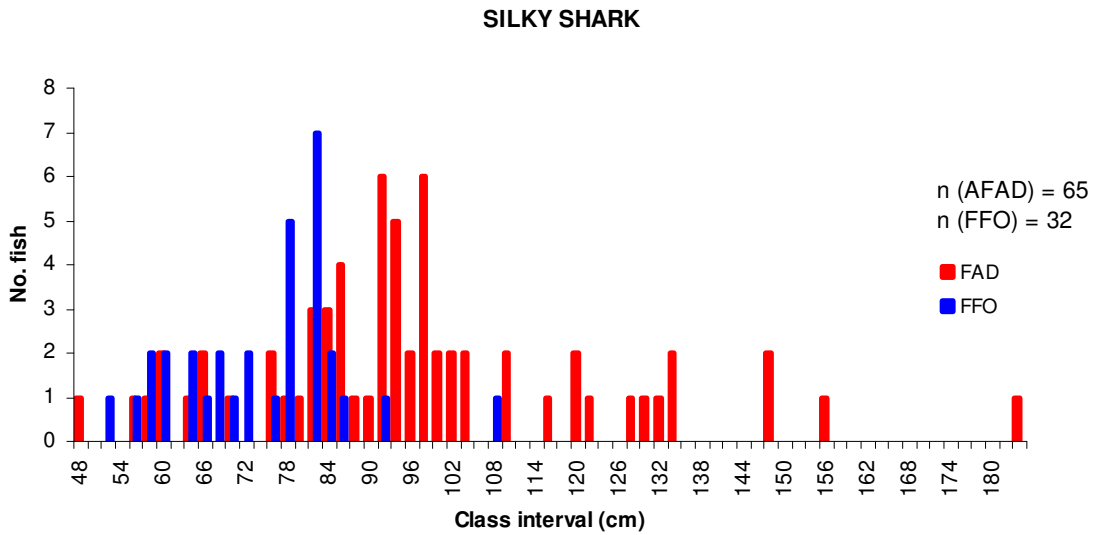


Figure3d. Silky shark (*Carcharinus falciform*)

OCEANIC WHITE TIP SHARK

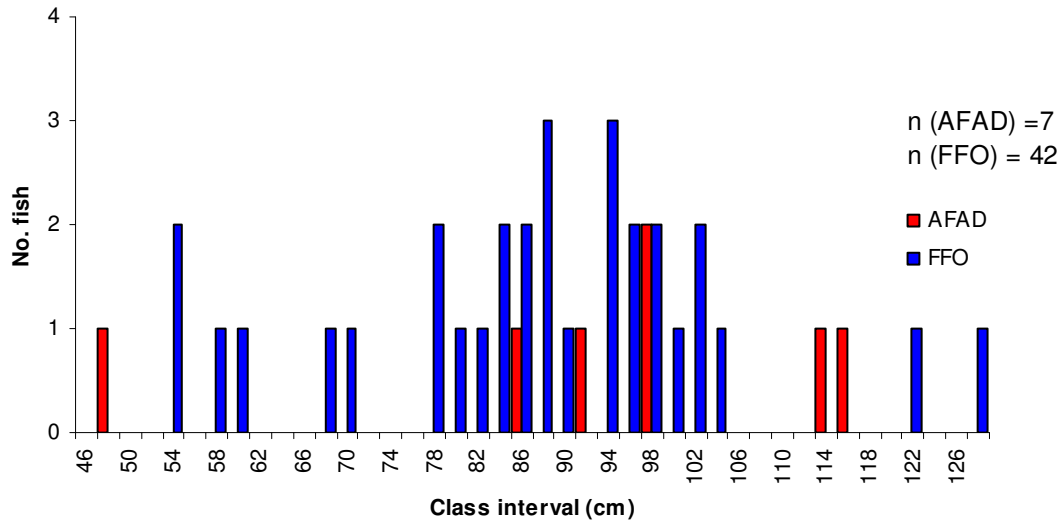


Figure 3e. Oceanic white tip shark (*Carcharinus longimanus*)

Figure 3 (a-e); Size structure of the most common bycatch species by set types.

Table 6: Descriptive statistics of the most common bycatch species by sets associations

	Rainbow runner		Mackerel scad		Dolphinfish		Silky sharks		Oceanic white tip sharks	
	AFAD	FFO	AFAD	FFO	AFAD	FFO	AFAD	FFO	AFAD	FFO
Mean	66.08	61.41	30.12	30.70	67.97	66.97	96.12	73.86	92.57	85.21
Standard Deviation	9.78	14.78	5.12	3.31	23.32	26.11	25.15	12.08	22.74	16.04
Minimum	29.50	18.00	16.50	18.00	23.60	27.00	48.00	51.00	47.00	53.00
Maximum	100.00	93.00	43.00	38.00	110.00	115.00	184.00	108.00	115.00	128.00
No. samples	369	453	135	80	42	18	65	32	7	42

Table 7: Lower and Upper Quartiles of the most common Bycatch species from AFADs and FFO sets

SPECIES	AFAD		FFO	
	Lower Quartile	Upper Quartile	Lower quartile	Upper Quartile
Rainbow runner (<i>Elagatis bippinalata</i>)	62.41 cm	70.42 cm	58.35 cm	70.25 cm
Mackerel scad (<i>Decapterus macarellus</i>)	26.15 cm	32.78 cm	28.64 cm	32.32 cm
Dolphin fish (<i>Coryphaena hippurus</i>)	47.55 cm	89.43 cm	45.55 cm	88.05 cm
Silky Sharks (<i>Carcharinus falciform</i>)	82.13 cm	102.3 cm	63.05 cm	80.62 cm
Oceanic white tip sharks (<i>Carcharinus longimanus</i>)	46.05 cm	97.18 cm	78.30 cm	96.55 cm

Table 8: Results of t-test calculations (test at 5% CL, df=degrees of freedom)

SPECIES	Overall			Lower Quartile			Upper Quartile		
	t _{cal}	df	t _{tab}	t _{cal}	df	t _{tab}	t _{cal}	df	t _{tab}
Rainbow runner	5.24	820	1.96	10.82	205	1.96*	0.77	205	1.96
Mackerel scad	0.94	213	1.96	4.11	52	2.01*	2.86	52	2.01*
Dolphin fish	0.15	58	2.01	0.32	13	2.16	1.3	14	2.14
Silky Sharks	4.78	95	1.99	2.56	23	2.07*	19.3	24	2.06*

* = significant at 5% CL, Ho=rejected, Ho: $\mu_{AFAD} = \mu_{FFO}$

Sex ratios

Tuna species

Skipjack

Observations of 449 skipjack from associated sets (AFAD and FFO) showed a significant deviation from the expected sex ratio of 1:1 male to female sex ratio. The ratio shows 1.00 male to 1.23 females ($\chi^2 = 4.92$, $P < 0.05$). Observations of 180 samples from FFO also showed a significant deviation from the expected sex ratio of 1:1, showing a ratio of 1.00 male to 1.54 female ($\chi^2 = 8.00$, $P < 0.05$). However, observations of 269 samples from AFAD showed a non significant deviation from the expected ratio. The observed ratio from AFAD sets showed a ratio of 1.00 male to 1.07 females ($\chi^2 = 0.30$, $P > 0.05$).

Yellowfin

No significant deviation from the expected ratio of 1:1 male to female was observed for a total of 373 yellowfin sampled from AFADs and FFO. The ratio from these observations show 1.00 male 0.82 female ($\chi^2 = 3.58$, $P > 0.05$). Samples from FFO (103 observations), showed a ratio of 1.00 male to 0.98 female, which was also a non significant deviation from

the expected sex ratio ($\chi^2 = 0.01$, $P > 0.05$). The sex ratio for observations from AFADs, however showed a significant deviation from the expected sex ratio. The ratio showed 1.00 male to 0.75 female ($\chi^2 = 4.82$, $P < 0.05$).

Bigeye

A significant deviation from the expected 1:1 male to female ratio was observed for 168 bigeye tuna sampled from both AFAD and FFO. The ratio showed 1.00 male to 2.18 female ($\chi^2 = 14.48$, $P < 0.05$). The sex ratio in 91 observations from AFADs showed 1.00 male to 2.00 females, which was also a significant deviation ($\chi^2 = 9.24$, $P < 0.05$).

Bycatch species

Rainbow runner

No significant deviations from the expected 1:1 male to female sex ratio was observed in 737 Rainbow Runner sampled from both AFAD and FFO. The observed ratio was 1.00 male to 0.93 female ($\chi^2 = 0.85$, $P > 0.05$). Sex ratios of 341 observed rainbow runners from AFADs also showed a non significant deviation from the expected ratio, with the ratio of 1.00 male to 1.05 female ($\chi^2 = 0.29$, $P > 0.05$). Sample from FFO (391 observations) showed a ratio of 1.00 male to 0.84 female. This was also a non significant deviation from the expected ratio of 1:1 male to female ($\chi^2 = 2.92$, $P > 0.05$).

Mackerel Scad

There was a significant deviation from the expected 1:1 male to female sex ratio for 161 observations of Mackerel Scad sampled from associated sets (AFADs and FFO). The ratio was 1.00 male to 0.30 female ($\chi^2 = 47.02$, $P < 0.05$). Observations of 81 samples from AFADs also showed significant deviation ($\chi^2 = 34.68$, $P < 0.05$), showing 1.00 male to 0.21 female. Eighty (80) observations from FFO also showed significant deviation, 1.00 male to 0.40 female ($\chi^2 = 14.45$, $P < 0.05$).

Dolphin fish

A significant deviation ($\chi^2 = 5.12$, $P < 0.05$) from the expected 1:1 male to female was observed for 33 Dolphin fish sampled. These observations were a combined total of the two set types and showed a ratio of 1.00 male to 2.30 female. Sex ratios for 18 observations on AFADs was 1 male to 2.6 females and showed no significant deviation from the expected ratio of 1:1 male to female ($\chi^2 = 3.56$, $P > 0.05$). The sex ratio for 15 observations on FFO showed 1.00 male to 2 females and also showed a no significant deviation ($\chi^2 = 1.67$, $P > 0.05$) from the expected ratio.

Silky sharks

No significant deviation from the expected 1:1 male to female ratio was observed for 62 silky sharks sampled on AFADs. The observations showed a ratio of 1.00 male to 0.88 females ($\chi^2 = 0.26$, $P > 0.05$). Twenty-eight (28) observations from FFO show a ratio of 1.00 male to 1.33 female which also show a non significant deviation from the expected ratio ($\chi^2 = 0.57$, $P > 0.05$).

Barracuda

A significant deviation from the expected 1:1 male to female ratio was observed for 26 Barracudas sampled from the associated sets. The observations showed a ratio of 1.00 male to 0.24 female ($\chi^2 = 9.84, P < 0.05$).

Golden Trevally

No significant deviation from the expected 1:1 male to female was observed for 13 Golden trevallies sampled from AFADs. The observations show a ratio of 1.00 male to 0.86 female ($\chi^2 = 0.08, P > 0.05$).

Wahoo

No significant deviation from the expected 1:1 Male to female ratio was observed for 14 Wahoo sampled from the associated sets. The observations showed 1.00 male to 1.29 female ($\chi^2 = 1.14, P > 0.05$).

Discussions

Species composition

Observer data on associated sets from the PNG vessels for years 2004 -2006, show on average that the skipjack accounts for about 59%, yellowfin 34%, bigeye 6% and bycatch 1% by weight. Observer data for years 2005 -2006 for the Philippine fleet fishing in PNG exclusively on associated sets show that Skipjack accounts for 60%, yellowfin 35%, bigeye 4% and bycatch 1% by weight. These data sets are not too far off from that shown by this study which showed that skipjack accounted for 62%, yellowfin 35%, bigeye 3% and bycatch >1% by weight (table 1). Earlier estimates of bycatch Bailey et, 1996. estimated the bycatch from associated sets by purse-seine in the western pacific in general to be about 3-7 %, however there indications that the bycatch levels from associated sets might actually be less. Observer data 1994-1996 for the SPC area indicate that the estimated overall bycatch rate was than one percent by weight of the total catch which was 0.9 percent for associated sets (Antony D Lewis, 1999). The estimates of the species composition from associated sets, though from different sources are very similar and it should give an indication of the level of species composition from associated sets especially AFAD and FFO. We can only hope that as the observer data improves better estimates can be made.

Size Structure

Target Species

The results showed that although there was no significant differences overall in the mean sizes of tuna from AFAD as compared to that of FFO, there was significant difference in the means of the upper quartile in all three tuna species. Big eye tuna was the only tuna species that showed a significant difference at the lower quartile. The differences indicated that there were bigger skipjack and yellowfin tuna around AFAD at the upper quartile level than FFO, but that FFO had bigger bigeyes at the upper quartile level than AFADs. For bigeye tuna, there was also significant indication that there were much smaller big eyes on FFO than AFADs at the lower quartile level. The association of bigger size tunas (skipjack

and Yellowfin) on AFADs can perhaps be explained by both the “meeting point hypothesis”, which proposes that tuna can use floating objects to form larger schools after school fission or dispersion and the hypothesis that tuna use the objects as reference points. In addition, the specific association to AFADs may be related to the design of AFAD. In the first instance, remnants of schools caught, may be regrouping as is the meeting point hypothesis, but are specifically regrouping around AFADs because AFADs are fixed and easier to find as reference points compared to FFO which is not stationary and therefore not very easy to find. Further more, the area of study has a lot of AFADs and the chances of tuna finding an AFAD is perhaps more than the chance of finding a FFO. Secondly, the anchor ropes of the AFAD might also be playing a part in aggregating bigger fish to AFADs, supposing it does have influence on tuna aggregation. If it does, then, in this instance, bigger tunas that are swimming deeper in the water column may be attracted to the anchor ropes, therefore the AFAD, whereas this wouldn't happen in the case of FFO as there is no influence through the water column therefore it would attract only those tunas that are swimming at shallower depth, which in most cases are likely to be smaller tunas. Unfortunately this explanation may be not hold true for bigeye which seems to be more associated to FFO than AFADs. The answer to this may lie in the difference in behaviour between skipjack, yellowfin and the bigeye.

Bycatch Species

Results indicate that for some of the bycatch species, such as the Dolphinfin and the Oceanic White tip Shark, there was no preference by size to either the AFAD or the FFO. For other species such as the Mackerel scad, the smallest and the biggest individuals on average were associated with AFADs showing a wider dispersion than FFO. For Rainbow runner the smallest size were associated with FFO. Other bycatch species, particularly the Silky shark showed a clear distinction in their association to the two set types. The smaller sizes were associated with FFO and the bigger sizes were associated with AFADs., The association of smaller fish to FFO could be due to the origin of the FFO in that FFO originating from shore would have larvae or smaller fish associated with it from the inshore areas and when this drifts out to sea, the fish stay around the object. This could be the case for Rainbow runners. The scenario, where both small and big fish are found around AFADs, maybe due to the ‘meeting place’ theory, where small groups of individual meet and form bigger schools. For those that don't show any preference, to either of the set types, they are probably just opportunist, associating to either of the set types whenever they come across them.

Sex ratios

Target Species

Although there is information on sex ratios of the skipjack, yellowfin and big eye tunas from longline and some from purse-sine catch, there is almost no information on sex ratios of these tunas especially from associated sets, including AFADs by purse-seine. The results for skipjack as is presented, show that the sex ratio of skipjack from the pooled data for all associated sets and the data from the FFO only, is significantly different from the 1;1 male to female ratios. A significant deviation from the 1:1 male to female ratios for purse-seine caught skipjack was also observed by Kurt M. Shaefer (2001) for the Eastern pacific

skipjack. He observed that there were more males (52.9%) compared to females (47.1%). On the contrary, this study shows that there are fewer males than females (1 male to 1.23 female for pooled associated set observations and 1 male to 1.54 females for FFO sets). Data from AFAD sets showed a no significant deviation.

For yellowfin tuna, 1,613 sex identified observations from Chinese Taipei longline fishery in the western Pacific, showed a significant difference (902 males to 711 females or 1.27 males to 1 female) from the expected 1:1 Male to female ratio (Chi-lu Sun etc.2005). The observation further show that there was a 1:1 male to female ratio for sizes of 104cm to 138cm, indicating more females at big size classes. In this study, there was no significant deviation from the 1:1 male to female ratio for pooled data and also for observations on FFO. But there was a significant difference for observations on AFAD. The difference shows that there were more males than females on AFADs.

Observation of bigeye caught by the Chinese Taipei fleet in the western Pacific, show that there is no significant deviation from the expected 1:1 male to female ratio (Chi-lu Sun etc, 2006). The results from this study however show that there is a significant deviation from the expected ratio of 1:1 male to female ratio.

Bycatch Species

Very few information on sex ratios of purse-seine by catch is available, more so on information on bycatch caught in association with AFAD or FFO. Where possible some information is provided but either the data is from different fishery to purse-seine or from a different area. In the case of this study, the information in some cases is based on very little data and therefore the results should perhaps be taken only as indicative.

In general, Rainbow runner, showed a non significant deviation from the expected 1:1 male to female ratio, Mackerel Scad showed a significant deviation from the 1:1 male to female ratio with indications that for every male there are very few females (3-5 males for every female). Dolphin fish observations showed a significant deviation from the expected 1:1 male to female ratio for pooled dated from the associated sets. The results show that there more females than males (1 male to 2.3 females). Similar trend in sex ratio (1 Male to more than 2 or equal to 2 females) was observed from catch associated with AFAD in New South Wales, Australia (Tim Dempster, 2003) and Chuen-Chi Wu, etc (2001), observed a 65% female ratio. The general trend then, for Dolphin fish seems to be that there is more females for every male. For Barracuda there was a significant deviation from the expected sex ratio, indicating few females per male. No significant deviation from the expected ratio was observed for silky sharks. Some information, based on observer data collected from the Longline fishery in the Western Pacific show a sex ratio for about 39% male to 44% female for silky sharks (P. Williams, 1997). Golden trevally and Wahoo both showed non significant deviation from the expected ratio.

Some past studies into sex ratios of especially tuna show predominance of one sex as the fish grow older. Sex ratio analysis by size class was not done in this study for the investigated, and is probably one reason for the differences in results between this study and those carried out in the past. The other reason for differences would be attributed to the exclusion of sex data for unidentified sex and the fact that for some species very few data is used.

Conclusions

Very few data is available in regards to associated sets from the purse-seine fishery and the data is not easy to collect. It is therefore advisable that the results of this study be treated with some caution as some information is based on very limited data. Independent studies like this should be encouraged where possible to validate fishery and observer data.

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