PNG Tuna Tagging Project

Summary Report of Cruise 1 (Aug – Nov 2007)

1 Introduction

The PNG Tagging Project is a joint research project being implemented by the Oceanic Fisheries Programme (OFP) of the Secretariat of the Pacific Community (SPC) and the PNG National Fisheries Authority (NFA). Its major objectives are:

1. **To obtain information on the large-scale movement of tuna in, and from, the PNG EEZ.** This information is important for understanding the relationship of PNG stocks with those of adjacent areas. Movement rates are particularly important for assessing the potential for interaction between fisheries operating in different areas. The comparison of tagged fish movements from the Bismarck Sea (the area of major anchored FAD deployment) that will result from this project with tagged fish movements from the same area in the early 1990s (before extensive anchored FAD deployment) will provide important new information on the meso- to large-scale effects on tuna movement of large anchored FAD arrays.

2. **To obtain information on current exploitation rates of tuna in the PNG EEZ.** Information on local exploitation rates is important for understanding the impact of fishing at the EEZ scale. In particular, it allows estimation of the extent to which current catch levels may reduce the standing stock of tuna and the catch-per-unit-effort of the fisheries, a phenomenon commonly known as “local depletion”.

3. **To obtain information on the dynamics of tuna associations with FADs, in particular species-specific information on residence times, vertical and horizontal movements and FAD interactions.** This information is required for a better understanding of the effects of FADs on tuna stocks and their vulnerability to fishing, and for the design of appropriate management measures.

4. **To obtain data that will contribute to regional tuna stock assessments.** Conventional tagging data are an important component of tuna stock assessments, providing quasi-fishery-independent information on exploitation rates, natural mortality, movements and other parameters.

5. **To obtain information on the trophic status of free-swimming schools of tuna, and tunas associated with FADs, other floating objects and seamounts**. This information is required for the general understanding of the ecosystem impacts of FADs compared to other types of tuna aggregations.

6. **To characterize the variability and extent of catches of by-catch species from purse seine catches in PNG.** NFA runs an observer programme with high coverage rates, which offers the opportunity to document by-catch levels and their variability in purse seine sets on anchored FADs and other set types.

These objectives are being pursued through a tagging programme, and associated data collection activities in PNG waters. Funding support for the project has been generously provided by the PNG National Fisheries Authority, New Zealand Agency for International Development, Australian Centre for International Agricultural Research, European Commission 8th European Development Fund (through the PROCFish project) and the Global Environment Facility (through the Pacific Oceanic Fisheries Management Project).

This progress report presents the results of the first of two three-month cruises by the chartered pole-and-line tagging vessel *Soltai 6*, owned and operated by Soltai Fishing and Processing Ltd, a Solomon Islands based company. The operational objectives of this first cruise were:

- To familiarize the vessel officers and crew with fishing operations for the purpose of tuna tagging and biological sampling;
- To train scientific staff, including two full-time PNG biological technicians, on tagging and sampling methods;
- To tag and release 15,000 tuna (i.e. half the project target of 30,000 tuna) using conventional tuna tags, with an ideal species composition of skipjack: 60%; yellowfin 30%; and bigeye 10%.
- To tag and release up to 150 tuna (i.e. half of the project target of 300 tuna) using electronic archival tags, with an eventual species composition of approximately one-third for each species;
- To undertake trial sonic tagging and deployment of FAD monitors to establish methodology to be used during cruise 2 in 2007;
- To undertake biological sampling (length, sex, stomach contents and tissue samples) according to an experimental design in order to obtain information on the trophic status of tunas in different school associations.

Additional activities related to tag recovery were undertaken separately to the activities of the tagging vessel and are reported in section 7 of this report.

2 Summary of results

The project (and the charter) began with the departure of the *Soltai 6* from Noro, Solomon Islands, on 12 August 2006. During the previous three weeks, various vessel preparations and crew training was carried out in Noro and Honiara, to enable the prescribed Terms of Reference for the charter to be met.

Tagging operations proper began in PNG on 17 August, after some initial fishing and tagging work for training purposes was conducted while in transit from Noro to Rabaul. During the following 3 months, a large area of the Bismarck Sea and surrounding area was visited and worked by *Soltai 6* (Figure 1).

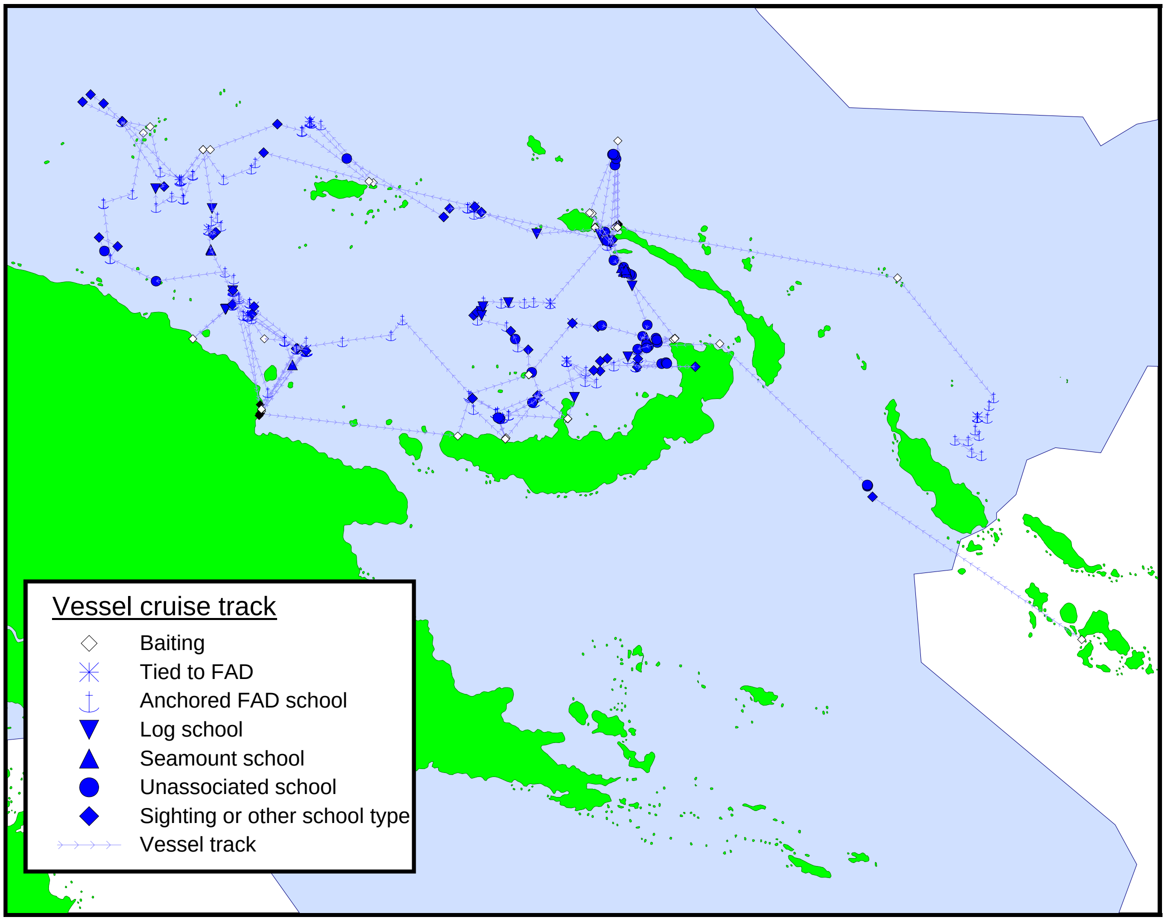

Figure 1. Cruise plot of Soltai 6, 12 Aug - 12 Nov 2006.

During Cruise 1, a total of 22,420 tuna were tagged with conventional tags (skipjack 62%; yellowfin 35%; bigeye 3%). Of these, 106 were also tagged with archival and/or acoustic tags. Further details of these releases are given in the following sections.

As at 30 November, 2,090 tag recoveries had been recorded for an overall recovery rate of 9.3%. Of course, the majority of these recoveries were made very soon after release, and within the general area of tag release, which is a feature of most tuna tagging experiments. Nevertheless, this indicates that tag recovery arrangements are working and that survival of fish following tagging is good. The data are also providing useful information on short-term movements among individual FADs.

3 Conventional tag releases

3.1 Conventional tagging methods and equipment

The project has adopted tagging methods and equipment that have been tried and tested in previous SPC projects, notably the Regional Tuna Tagging Project in the early 1990s. Conventional tagging is carried out primarily from three tagging stations – on the starboard and port bow and on the port stern. During the last two weeks of the cruise, an additional tagging cradle was utilized on the starboard stern for a combination of conventional and archival tagging. Specially designed tagging cradles consisting of a vinyl fish support attached to a metal frame are used to restrain the fish during the tagging procedure. Fish are captured using pole-and-line fishing, and tagged with a single conventional tuna tag near the posterior insertion of the second dorsal fin, securely anchoring the tag head in the pterygiophores. Tags are inserted using stainless steel applicators. The tags are 11 cm or 13 cm Hallprint™ dart tags. The 11 cm tags are generally applied to tuna <38 cm and the 13 cm tags to larger tuna. All tuna are measured prior to release using a scale drawn on the cradle. The tagging operation typically lasts less than 20 seconds from fish capture to release.

3.2 Total releases

As noted above, total conventional tag releases during cruise 1 were 22,420. This exceeded the nominal Cruise 1 target of 15,000 by almost 50%. The species composition of releases (62:35:3) was close to the target (60:30:10), although the overall proportion of bigeye tagged was less than desired. It has thus far proved difficult to catch and tag large numbers of bigeye in the Bismarck Sea by pole-and-line fishing, which is not entirely unexpected based on past experience. Bigeye can be caught in small numbers by line fishing at night while tied up to anchored FADs. While this type of operation will provide bigeye in numbers suitable for archival and sonic tagging, it will not be possible to catch sufficient numbers by this method to reach the conventional tagging targets for bigeye. During Cruise 2, the project will make all attempts to augment the bigeye release numbers by further targeting seamounts. We will also investigate the feasibility of deploying an anchored FAD on the Dyaul Seamount off the northwest coast of New Ireland.

The total numbers of conventional tag releases (and recaptures as at 30 November 2006) by species and school association is given in Table 1.

Table 1. Total tag release numbers by species and school association, and recaptures as at 30 November 2006, for PNG Tagging Project Cruise 1.

	Releases					Recaptures									
School association	SKJ	YFT	BET	OTH	TOTAL	SKJ	%	YFT	%	BET	%	OTH	%	TOTAL	%
Seamount	968	657	54	0	1,679	11	1.1	2	0.3	0	0.0	0	-	14	0.9
Current line	6	11	0	0	17	0	0.0	0	0.0	0	-	0	-	0	0.0
Anchored FAD	10,681	6,701	513	13	17,908	1,177	11.0	786	11.7	88	17.2	0	0.0	2,091	11.7
Log	1,257	376	28	0	1,661	12	1.0	2	0.5	0	0.0	0	-	15	0.9
Unassociated	1,031	124	0	0	1,155	10	1.0	2	1.6	0	-	0	-	15	1.3
TOTAL	13,943	7,869	595	13	22,420	1,210	8.7	792	10.1	88	14.8	0	0.0	2,135	9.5

3.3 Spatial distribution of releases by school association

The spatial distribution of releases, by species and school association, is shown in Figure 2. Releases have been concentrated towards the periphery of the Bismarck Sea, in large part reflecting the distribution of anchored FADs in the area (Figure 3). Few fish have been tagged in the centre of the Bismarck Sea because of navigational difficulties in some areas (many uncharted reefs) and low fishing success in the areas that were visited. Two visits to the area north of New Ireland were made with limited success. This area (Tench Island and vicinity) was a very productive fishing and tagging area during the previous Regional Tuna Tagging Project and further efforts will be made here, and in other areas not visited during Cruise 1, during Cruise 2 in 2007.

The majority of tag releases to date (~80%) have been made on schools associated with anchored FADs (Table 1; Figure 2). Some limited success was had fishing and tagging tuna in unassociated and seamount-associated schools in the area around the northern end of New Ireland known as the "Morgado Square". FAD deployment is not allowed in this area (Figure 3) and therefore the frequency of encountering unassociated or seamount-associated schools was higher than elsewhere in the Bismarck Sea. It was notable that unassociated tuna schools were rarely encountered in the majority of the Bismarck Sea where there is a high density of anchored FADs.

Because the experimental design for tag releases (and biological sampling; see below) called for distribution of tag releases across set types, further efforts will be made to search for and fish unassociated and seamount-associated tuna during Cruise 2.

3.4 Size distribution of releases

The size distributions of tag releases by species and the corresponding size distributions for the locally-based purse seine fleet in PNG are shown in Figure 4. For skipjack, the size range tagged is similar to the size range of fish captured by purse seiners setting on anchored FADs in PNG. For yellowfin, the purse seine size distribution is bimodal, with the tag releases corresponding in size to the smaller mode. The larger mode centred at around 80 cm in the purse seine distribution was not available to any substantial degree to the pole-and-line tagging vessel. For bigeye, the numbers tagged are concentrated into two modes within a wider overall range of sizes taken by purse seiners. These differences in size distributions of tag releases and purse seine catch mean that size will need to be included in any models utilizing both the tagging and fishery data.

These size distributions include significant numbers of fish <40 cm fork length. These small fish are often not seen in landed purse seine catches in the western and central Pacific because they are discarded at sea. However, they are seen in the catches in PNG because the locally-based purse seine companies have a "retain all" policy.

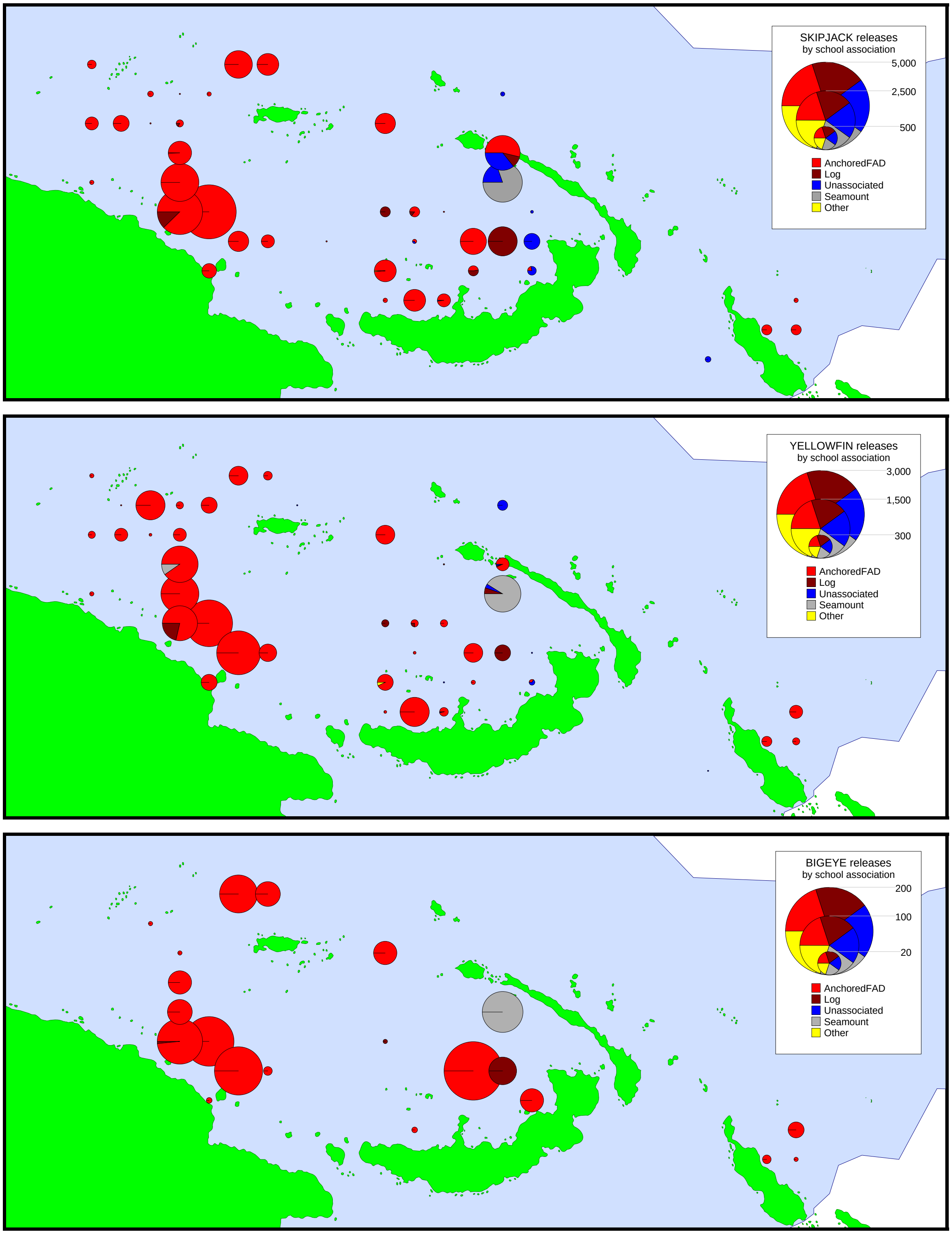

Figure 2. Spatial distribution of releases of skipjack (upper), yellowfin (middle) and bigeye tuna (bottom) by school association.

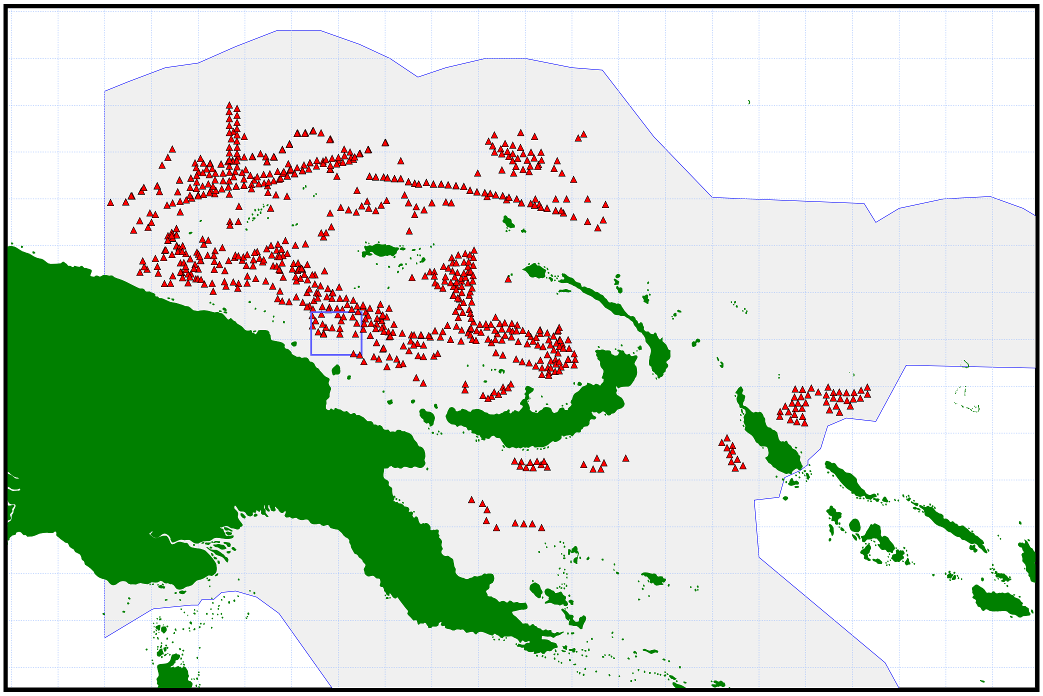

Figure 3. Anchored FAD positions in PNG waters (as at June 2006). The blue rectangle indicates the area of FAD monitor deployment.

4 Archival tagging

4.1 Archival tagging methods and equipment

The SPC Oceanic Fisheries Programme began deploying archival tags in tuna in 1999. Since that time, electronic tag technology has made considerable progress, especially in reducing tag size, allowing the possibility of deploying tags in much smaller fish. Battery and memory capacities have also been greatly improved and some tags can now store more than 4 years of data when sampling depth, fish temperature, sea temperature and light-level once per minute.

Archival tags are inserted in the fish body cavity through a small incision made in the ventral body wall. The incision is closed by one or two sutures of resorbable suture material. The fish is also tagged with a red conventional tag to assist in archival tag discovery at recapture. The whole process usually lasts less than one minute.

Most of the fish tagged on Cruise 1 were caught using jigging lures and rods at night around FADs; this method allows the capture of slightly larger yellowfin and bigeye tuna compared to classical pole-and-line operations. A dedicated sling was used to lift fish over 8–10 kg on to the deck. During tagging, a special V-shaped cradle was used, permitting better fish handling during the surgical procedure.

MK9 tags from Wildlife Computers and LTD-2310 tags from Lotek have been used for fish larger than 8 kg. Smaller tag models, Lotek LTD-2410 and LTD-1110, have been deployed in smaller fish down to 2 kg. These latter models have also been deployed in conjunction with a sonic tag in several fish. The sonic data will be useful for identifying data sequences on the archival tag record when the fish is associated with a monitored anchored FAD.

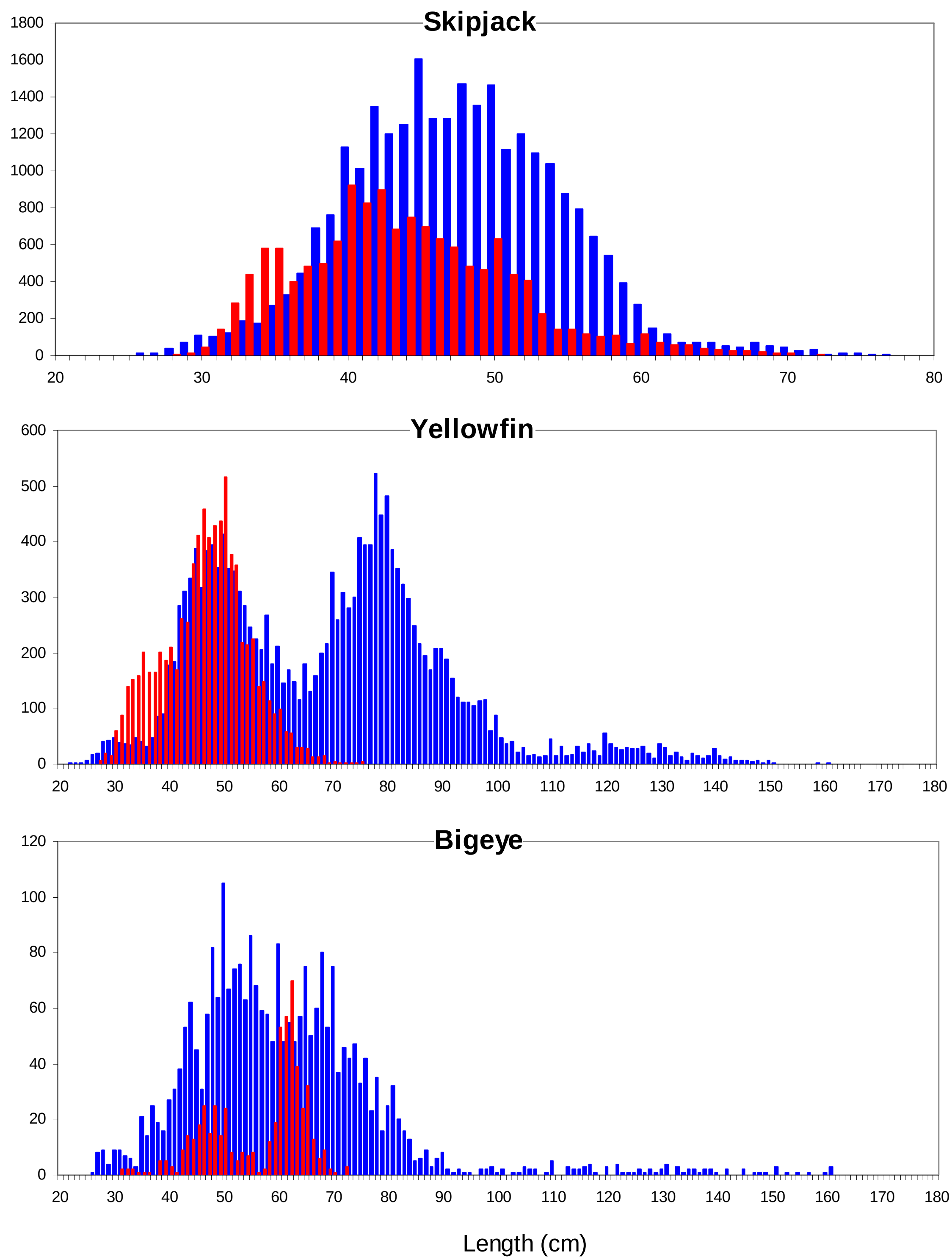

Figure 4. Size distributions of conventional tag releases (red histogrammes) compared to the 2005 size distributions for PNG locally-based purse seiners (blue), by species.

4.2 Archival tag releases

In Cruise 1, 73 archival tags were deployed, consisting of 46 yellowfin, 26 bigeye and 1 skipjack. During Cruise 2, we will add a dedicated archival tagging cradle at the bow. This tagging station will permit us to take advantage of the occasional capture of medium-sized bigeye by the pole-and-line operation.

5 Sonic tags and FAD monitors

The use of coded sonic transmitter tags and compatible acoustic monitors allows the collection of fine-scale spatial behaviour of pelagic resources from specific environments. This technology is particularly suited to the examination of FAD-specific tuna behaviour, if receivers are mounted beneath FADs capable of detecting sonic tags within a spatial range that approximates FAD associated tuna schools. Sonic tagging was incorporated into the overall project goals through a collaboration with the Pelagic Fisheries Research Program (University of Hawaii) that has funded similar studies on anchored FADs in Hawaiian waters[1].

The strength of this approach focuses on the adoption of individually coded “pinger” tags in conjunction with pressure sensing sonic tags that provide accurate depth data at fine time scales. All data are transmitted to and stored by the FAD-mounted sonic receivers, thus providing size and species-specific “presence/absence” and vertical behaviour comparable to archivally tagged individuals. The real strength of this approach is that tagged fish provide data without the need to recapture and download a data archiving tag and all information is specific to a particular FAD association.

5.1 Sonic tagging methods and equipment

The project employed underwater telemetry gear manufactured by VEMCO[2] which has been used successfully to monitor the movements and behaviour of tropical tunas in a variety of environments. Coded V9 pinger tags and depth recording V9P tags were chosen due to their adequate power range balanced with a small size capable of being used on a wide size range of all three species of interest (skipjack, yellowfin, bigeye tuna). This aspect of gear selection allows the sonic tagging of all three species in small and large sizes on the same mixed-species aggregations on the same FAD. The approach allows direct comparisons of species and size-specific vertical behaviour, residence times and inter-FAD movements.

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[1] Dagorn, L., Holland, K.N., and D.G. Itano. (2006) Behavior of yellowfin (*Thunnus albacares*) and bigeye (*T. obesus*) tuna in a network of fish aggregating devices (FADs). Mar. Biol. 227(511). 12 pp.
[2] http://www.vemco.com/

VEMCO VR2-500 sonic receivers, capable of detecting the V9 tags at approximately 750 m, were attached to anchored FADs during the cruise. These receivers must be manually retrieved and downloaded at periodic intervals. VR2 receivers are mounted directly to the FAD mooring system at 18 meters depth and regularly changed for data acquisition by scuba equipped personnel. Scuba gear is not available to the PNG project, requiring the development of a system to deploy and retrieve receivers from the surface. Receivers were mounted directly on the FAD buoys using 4 m of 12 mm galvanized chain with VR2 units shackled to the bottom of the chain (white arrow, Figure 5) to facilitate rapid retrieval and change out of gear.

Figure 5. VR2 receiver mounting system.

Sonic tags were surgically implanted within the peritoneal cavity of selected tuna using the same procedures outlined for archival tagging. The relatively small tag sizes allowed sonic tagging of tuna as small as 40 cm FL.

An added bonus of their small size and tagging methodology permits the double tagging of tuna with sonic and archival tags. This approach was adopted during Cruise 1 as the surgical implantation and suturing procedures are identical for each tag type and it only requires a few seconds to introduce a sonic tag before the archival tag is placed. Double tagging in this manner allows archival data to be more accurately characterized as “on FAD” vertical behavior and can be used to refine geolocation estimates from recovered archival tags.

5.2 Sonic tag releases and FAD monitor deployment

A total of 47 sonic tags were deployed in all three species of tropical tuna during Cruise 1, with 38 released with V9 coded tags and 9 implanted with V9P depth tags (Table 2). The species composition of sonic tag releases differed from conventional releases with an initial emphasis on sonic tagging bigeye and yellowfin tuna, resulting in sonic release numbers of bigeye (15/32%), yellowfin (25/53%) and skipjack (7/15%). Thirty per cent of sonic tag releases were double tagged with an archival tag of some type as indicated in Table 1. Bigeye and yellowfin tuna implanted with sonic tags were caught primarily by vertical jigging at night while the tagging vessel was tied up to an anchored FAD. Toward the end of the cruise, successful procedures to sonic and archival tag tuna during poling operations were developed resulting in seven skipjack sonic tag releases.

Table 2. Summary of sonic tag releases for Cruise 1.

Sonic tag type	Archival tag	BET	YFT	SKJ	Total
V9 coded	sonic tag only	5	13	7	25
V9 coded	LTD1110	6	0	0	6
V9 coded	LTD2410	1	0	0	1
V9 coded	MK9	1	5	0	6
	V9 coded subtotal	***13***	***18***	***7***	***38***
V9P depth	sonic tag only	2	6	0	8
V9P depth	LTD1110	0	1	0	1
	V9P depth subtotal	**2**	**7**	**0**	**9**
	Sonic tag release total - Cruise 1	**15**	**25**	**7**	**47**

Nine anchored FADs were equipped with VR2 receivers that were located within two anchored FAD clusters in the Bismarck Sea northeast of Manam and Karkar Islands (Figure 3). Receiver deployments generally required 15 minutes to accomplish with all receivers picked up at the end of the cruise.

5.3 Results to date

All sonic receivers were successfully picked up and downloaded except for one unit that was lost after a 17 day deployment with rough sea conditions prevailing throughout the period. This unit was the first to be deployed with an experimental stainless steel harness that prompted the development of the all chain attachment method outlined above. Downloaded data proved to be of good quality with a high rate of data acquisition, suggesting the mounting of the receivers at 4 meters below the FAD will be suitable to meet project goals. However, the loss of a critical receiver where many fish were released and the short duration of other FAD monitor deployments will require more intensive sonic tagging work during Cruise 2. However, the methodology to attach, retrieve and change receivers and release sonic tags on all three species on the same FAD were successfully developed and tested.

6 Biological sampling

Biological sampling is being conducted as a part of the tagging cruises to obtain information on the trophic status of tunas in different types of school association. A sampling design was developed prior to Cruise 1. The design stratification included species, school association type, area (Bismarck Sea, Morgado Square, Solomon Sea) and time of day. The sampling strategy was to sample 15 individuals from 2 schools within each stratum. For each individual, we recorded species, length and sex, and collected stomach contents and a muscle tissue sample.

A total of 791 individuals were sampled during Cruise 1 (Table 1). Most of the samples were taken from schools associated with anchored FADs, as this was the predominant fishing operation undertaken during the cruise. However, samples from other association types were taken for some species. Non-tuna species were also sampled opportunistically and this will be continued in Cruise 2.

During Cruise 2, attempts will be made to obtain additional samples of bigeye tuna generally, and from tuna and other species in non-anchored-FAD associations.

Table 3. Number of biological samples taken during Cruise 1.

Species	Unassoc-iated school	Log	Anchored FAD	Seamount	Total
Skipjack	62	57	294	29	442
Yellowfin	3	24	228	28	283
Bigeye			22	5	27
Dolphin fish			2		2
Rainbow runner		5	24		29
Silky shark		2	2		4
Kawakawa	3				4
Total	69	88	572	62	791

7 Tag recoveries

7.1 Recovery procedures

Considerable efforts have been made to publicize the project and establish tag recovery procedures in the main locations where recoveries are likely to occur. Tagging posters, providing information to tag finders on what information to collect, where to send the tags and information, and the rewards that will be paid, have been produced in 13 languages. Posters have been sent to industry and government contacts throughout the Pacific and east Asian regions. Arrangements have been made in key locations, including PNG ports, other Pacific Island catch landing sites, Philippines, Indonesia, Thailand, Japan and Korea, for tags to be collected, rewards paid, and the tags and recovery data sent to SPC. The rewards being paid for the return of tags and recovery data are:

Conventional tags: USD 10 or a project shirt or cap

Archival tags: USD 250

Sonic tags: USD 50

7.2 Interim tag recoveries (at 30 November)

As at 30 November 2006, 2,090 tagged tuna had been recaptured and the tags and recapture data sent to SPC (Table 1). Of these, 7 also had archival tags and one had a sonic tag implanted in addition to the conventional tag. The returned archival tags (4 yellowfin, 3 bigeye) have all functioned correctly and have provided 2 to 42 days of detailed information on vertical swimming behaviour, body and ambient water temperatures and geolocation.

Some tagged tuna have shown considerable movements, up to several hundred nautical miles (nmi) (Figure 6). However the majority of tags have been recaptured close to the point of release, but show increasing dispersal with increasing time at liberty (Figure 7).

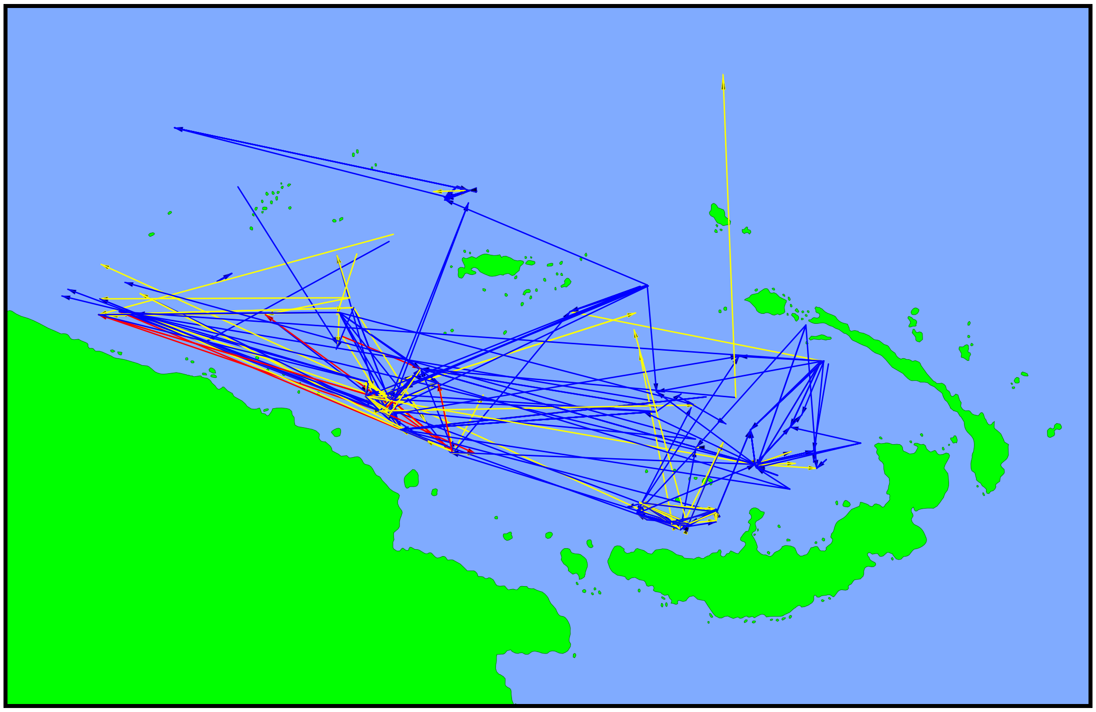

Figure 6. Displacements of recaptured tuna. Blue - skipjack; yellow - yellowfin; red - bigeye.

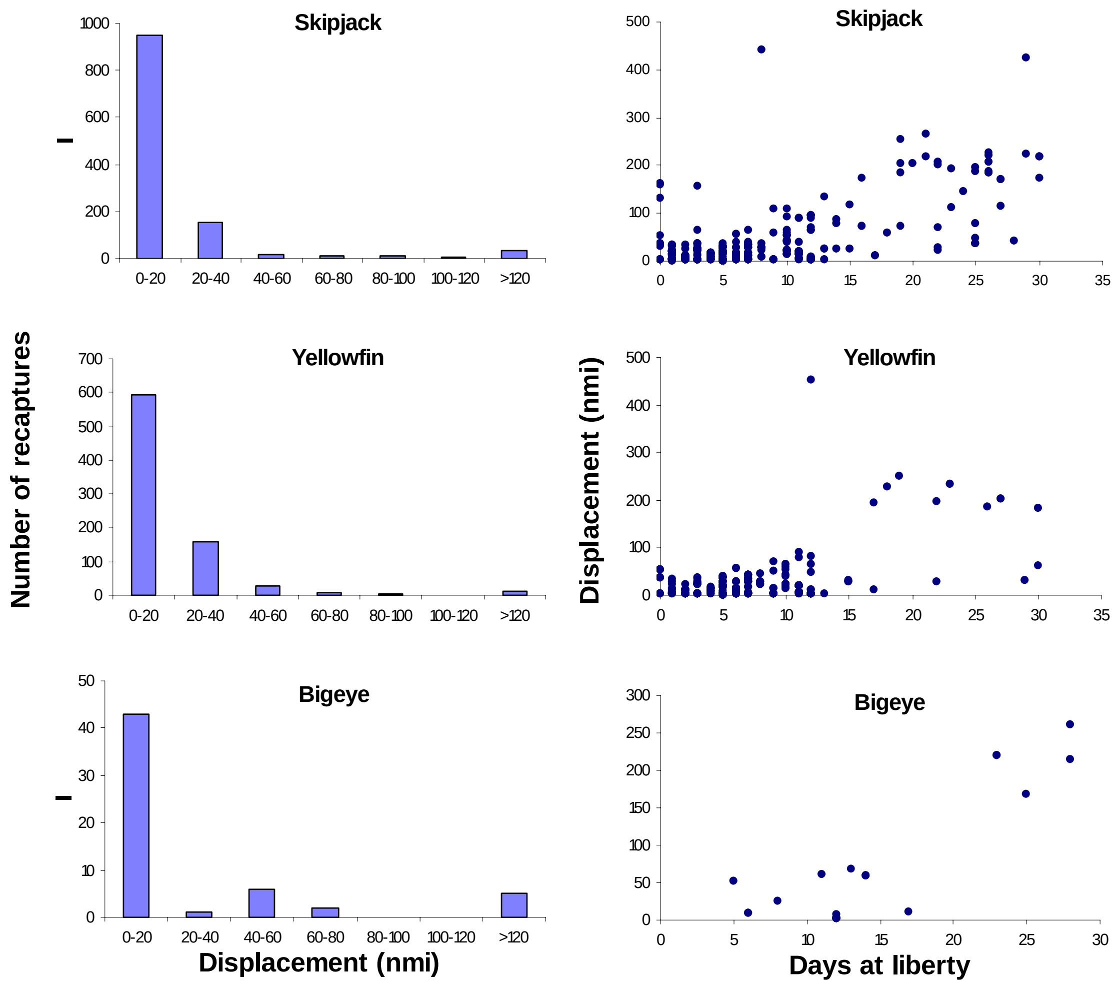

Figure 7. Tag recapture displacement frequencies (left panels) and displacement versus time at liberty (right panels), by species.

8 Cruise 2 (2007) plans

Cruise 2 is planned to take place from 19 February to 19 May 2007. The operational objectives for Cruise 2 include:

- Tag and release 15,000 tuna using conventional tags, ideally with a species composition of 60% skipjack, 30% yellowfin, 10% bigeye;
- Make special efforts to increase the numbers of bigeye tuna tagged; to this end, we are investigating the feasibility of deploying an anchored FAD on the Djaul Seamount;
- Widen the distribution of tag releases to include, in order of priority, a) Tench Island and northwards to the equator; b) east of Bougainville and the Solomon Sea; c) the far western Bismarck Sea; and d) the central Bismarck Sea;
- As far as possible, increase the proportion of tuna released from unassociated schools, schools associated with seamounts and schools associated with drifting logs and FADs;

- Deploy up to 200 archival tags on the three tuna species, and as far as possible distribute the releases over a wide area and across all school association types;
- Train NFA personnel in the deployment of archival tags;
- Deploy approximately 36 FAD monitors and tag 170 tuna with sonic tags during the first half of Cruise 2. Three FAD groups will be targeted for monitoring, located in the western Solomon Sea; southwest of West New Britain; and southwest Bismarck Sea. Sixty tuna will be double tagged with coded sonic and archival tags while 110 depth recording sonic tags will be deployed alone, with an attempt to spread sonic tags among the three species of tropical tuna. FAD monitors will be changed and downloaded opportunistically during the cruise with all monitors collected during the final 2 weeks of Cruise 2.
- Continue biological sampling of stomach contents and tissues for isotope analysis. As far as possible, increase the proportion of samples taken from unassociated schools. Take daily samples of particulate organic matter throughout Cruise 2.

The following provisional schedule, which is subject to change as circumstances dictate, is proposed for Cruise 2.

Dates	Moon	Area	Port/Activity
19 Feb – 3 Mar	New 18 Feb	NE Bougainville, New Britain south coast	Clear PNG customs Buka 22 or 23 Feb
4 – 5 Mar	Full 4 Mar	Lae	Full moon break, Lae
6 – 20 Mar	New 19 Mar	New Britain south coast to NW of Madang	Madang 19 Mar
21 Mar – 3 Apr	Full 3 Apr	West New Britain, Dyaul Seamount	Kavieng 4 Apr
4 – 5 Apr		Kavieng	Full moon break, Kavieng
6 – 17 Apr	New 17 Apr	Tench Is. and north to Equator	Kavieng 17 Apr
18 Apr – 2 May	Full 2 May	Manus Is., Hermits, Wewak	
3 – 4 May		Wewak	Full moon break, Wewak
5 – 19 May	New 17 May	Vanimo, Madang, West New Britain, Solomon Sea	Clear PNG customs Madang 15 or 16 May, steaming for Noro

9 Conclusion

Cruise 1 of the PNG Tuna Tagging Project has been very successful. All operational objectives of the cruise were achieved, with the exception of conventional tag release numbers for bigeye. However, the achievements of Cruise 1 were nevertheless outstanding, with the overall target for total conventional tag releases being exceeded by 50%, and the target for yellowfin releases exceeded by 75%. Additional efforts will be made during Cruise 2 to increase the bigeye tag release numbers.

The excellent results of Cruise 1 were possible in no small part due to the trouble-free operation of the *Soltai 6* during the three-month cruise, which is a tribute to the professionalism of the Solomon Island officers and crew, and the support provided by Soltai Fishing and Processing Ltd. The teamwork and dedication of the officers, crew and scientific staff were instrumental in the success of the cruise. We thank all involved for their efforts, and look forward to an equally successful Cruise 2 in 2007. We also thank the tuna fishing industry and our tag collection contacts in various locations for their cooperation and assistance in the return of tags.

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Or visit the project website: http://www.spc.int/oceanfish/Html/TAG/index.htm