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PACIFIC TUNA TAGGING PROJECT PROGRESS REPORT AND WORKPLAN FOR 2010

WCPFC-SC6-2010/GN IP-04

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Introduction

The Pacific Tuna Tagging Programme (PTTP) is a joint research project being implemented by the Oceanic Fisheries Programme (OFP) of the Secretariat of the Pacific Community (SPC), the PNG National Fisheries Authority (NFA) and the members and participating non-members of the Western and Central Pacific Fisheries Commission. The goal of the PTTP is to improve stock assessment and management of skipjack, yellowfin and bigeye tuna in the Pacific Ocean. The specific objectives are:

1. *To obtain data that will contribute to, and reduce uncertainty in, WCPO tuna stock assessments.*

Conventional tagging data are an important component of tuna stock assessments, providing quasi-fishery-independent information on various biological and fishery processes, such as exploitation rates, natural mortality, movements and growth rates, and their spatial and temporal variability.

2. *To obtain information on the rates of movement and mixing of tuna in the equatorial WCPO, between this region and other adjacent regions of the Pacific basin, and the impact of FADs on movement at all spatial scales.*

This information is important for understanding the relationship of tuna stocks in the tropical WCPO with those in the sub-tropical WCPO and the EPO. Movement rates are particularly important for assessing the potential for interaction between fisheries operating in different areas. The comparison of tagged fish movements from areas of high FAD density with tagged fish movements from the same areas in the early 1990s (before extensive FAD deployment) will provide important new information on the meso-to large-scale effects on tuna movement of high-density FAD arrays. This will allow various hypotheses regarding the impact of FADs on the movements of small tuna, e.g. the "ecological trap" hypothesis (Marsac et al 2000), to be tested. The movement data will also provide critical information on appropriate spatial structuring of stock assessment models.

3. *To obtain information on species-specific vertical habitat utilisation by tunas in the tropical WCPO, and the impacts of FADs on vertical behaviour.*

Vertical habitat utilisation plays a large role in determining vulnerability to all major gear types operating in the fishery. This objective seeks to characterise the effect of FADs (anchored and drifting) and other possible impactors (e.g., seamounts) on tropical tuna vertical behaviour and habitat utilisation This information will allow better estimation of abundance indices and standardised effort for the main fisheries and possibly contribute directly to the design of management measures for FAD fishing.

4. *To obtain information on local exploitation rates and productivity of tuna in various parts of the WCPO.*

Knowledge of local exploitation rates, productivity and movements is important for understanding the impact of fishing at more local scales. 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".

These objectives are being pursued through a tagging programme and associated data collection activities in the WCPO. Funding support for the project has been generously provided by the PNG National Fisheries Authority, New Zealand Agency for International Development, the Government of the Republic of Korea, Australian Centre for International Agricultural Research, European Community 8th European Development Fund (through the

PROCFish Project), European Community 9th European Development Fund (through the SciFish Project), the French Pacific Fund, the Government of Taiwan and the Global Environment Facility (through the Pacific Oceanic Fisheries Management Project).

The PTTP is a multi-phase programme that commenced in mid-2006. It has the following operational structure:

	Time period	**Operational area**	**Tagging vessel**
Phase 1	Aug – Nov 2006	Papua New Guinea	*Soltai 6*
	Feb – May 2007	Papua New Guinea	*Soltai 6*
	Oct – Nov 2007	Solomon Islands	*Soltai 6*
	Feb – Mar 2008	Solomon Islands	*Soltai 6*
	Apr 2008	Solomon Islands	*Soltai 105*
Phase 2 (to date)	May – Jun 2008	Central Pacific (CP1)	*Double D*
	Jun – Nov 2008	Western Pacific (WP1)	*Soltai 105*
	Mar – Jun 2009	Western Pacific (WP2)	*Soltai 105*
	May – Jun 2009	Central Pacific (CP2)	*Double D*
	Jul – Oct 2009	Western Pacific (WP3)	*Soltai 105*
	Oct – Nov 2009	Central Pacific (CP3)	*Aoshibi Go*
	May – Jun 2010	Central Pacific (CP4)	*Aoshibi Go*
	Oct – Nov 2010	Central Pacific (CP5)	*Pacific Sunrise*

Phase 1 focused very successfully upon the waters of Papua New Guinea and the Solomon Islands with their large domestic fisheries and significant contribution to overall regional catches. Phase 2, approved in August 2007 with substantial new funding initially from New Zealand and subsequently from Korea, aimed to considerably extend the operational area of the PTTP, as well as broadening the scope and operations of the project. Three extended pole-and-line based tagging cruises (WP1, WP2 and WP3), comprising a total of 11 months of charter operations, have been completed within Phase 2. These cruises have operated widely throughout the western equatorial Pacific, in accordance with work plans, ranging from Indonesia and Philippines in the west (120ºE) to Kiribati (180º) in the east.

As a additional component of Phase 2, a different strategy has been adopted for the Central Pacific (140°W – 170°W) where pole-and-line operations are difficult, with two multipurpose handline vessels based in Hawai'i being used to tag and release primarily bigeye tuna in this area during four separate cruises during 2008 (CP1), 2009 (CP2 and CP3) and 2010 (CP4). We have plans to undertake a further cruise (CP5) later this year using a similar vessel based in Tonga.

This report provides a review of 2010 Phase 2 activities, an update of overall project results to date and the plan for further work over the next 12 months.

General methods

Conventional tagging methods and equipment

The PTTP 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 or four tagging stations – on the starboard and port sides at the bow, and on each side of the stern, if personnel numbers allow. Specially designed tagging cradles consisting of a vinyl cover attached to a metal frame are used to restrain the fish during the tagging procedure.

Fish are captured using pole-and-line gear, 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 (Y11) or 13 cm (Y13) Hallprint™ dart tags. The Y11 tags are generally applied to tuna <38 cm and the Y13 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 15 seconds from fish capture to release, with information on each fish (species, fork length, fish condition and tagging quality) recorded on voice recorders.

For the central Pacific tagging, somewhat different fishing techniques are employed to catch and tag tunas associated with the equatorial TAO buoys. These fishing operations utilize short handline, or “dangler” fishing methods pioneered in Hawaii for fishing seamount and FAD aggregations of tunas. The methods require only thawed frozen bait, rather than live bait.

Electronic tagging methods and equipment

Two additional collapsible tagging cradles designed for archival/sonic tagging were also available on pole-and-line cruises (see Figure 1). These cradles increased the possibilities of deploying archival and sonic tags during standard pole-and-line fishing operations but also increased the numbers of conventional tag releases during fast biting schools. For the central Pacific cruises, one dedicated archival tagging cradle is operated in addition to the standard conventional tagging cradle.

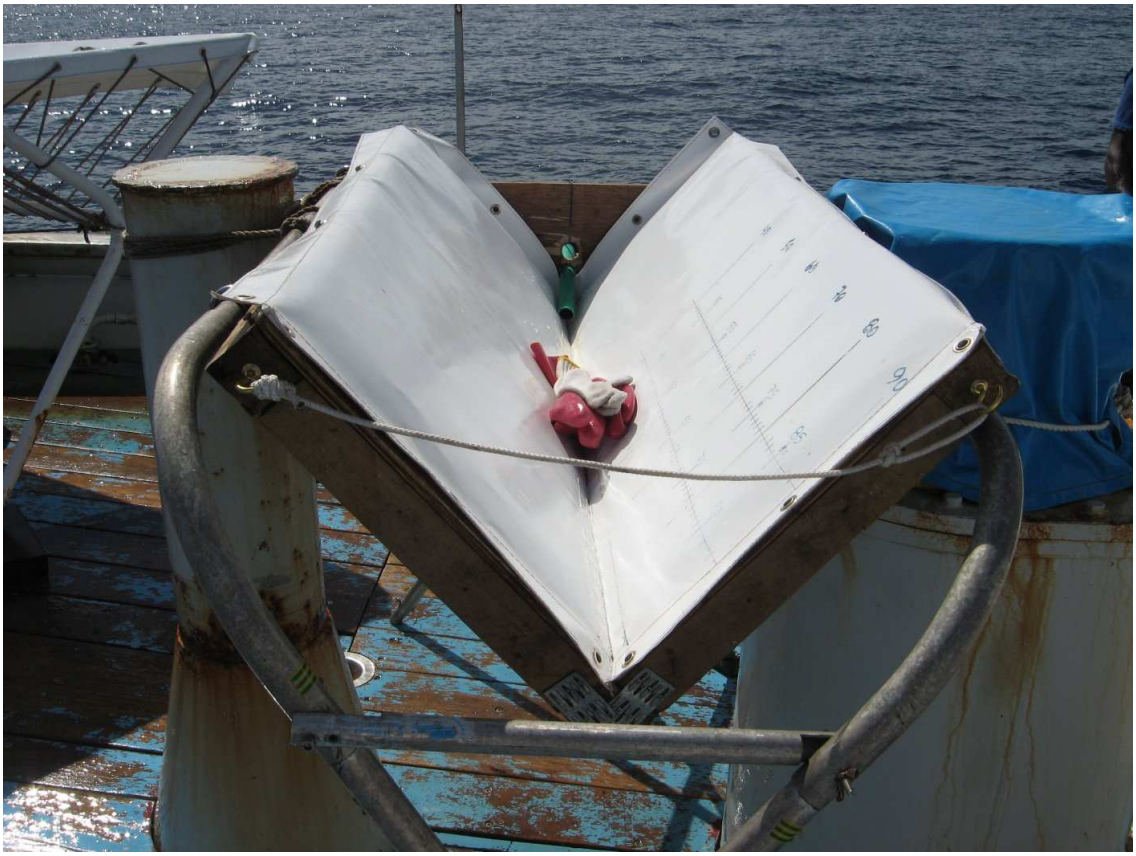


Figure 1. V-shape tagging cradle re-designed for archival tagging.

Archival tagging

Fish were captured for archival tagging during pole-and-line operations during the day, and also at night by using hand lines or rod-and-reel techniques when tied up to a FAD. Smaller bigeye and yellowfin (< 70 cm FL) were prioritized for tagging during pole-and-line fishing as fish condition was not compromised by the fishing technique. Larger-sized fish (> 70 cm FL) were generally caught with rod-and-reel or hand line at night and lifted from the water using a purpose-built sling, to minimize injury or stress.

Two different size classes of archival tag were used: (1) the larger LTD-2310 (Lotek Wireless, Newmarket, Canada) and the Mk9 (Wildlife Computers, Redmond, USA) which were surgically implanted into fish 60 cm and larger; and (2) the smaller LTD-2410 (Lotek Wireless, Newmarket, Canada) which were implanted into fish 40 cm and larger. During 2009 pole-and-line cruises, a newer model archival tag from Lotek, the LTD-2510, was used instead of the LTD-2410. Depth, fish and sea water temperatures and ambient light were recorded each minute for LTD-2310 and Mk9. The LTD-2410 and LTD-2510 have limited memory capacity (128 Kb and 512 Kb, respectively) and to extend the period of sequential records of all data, the tag was programmed to record every 4 minutes.

Sonic tagging

Sonic tagging of tuna associated with FADs monitored with an acoustic receiver to record the presence and depth of tagged tuna was undertaken during Phase 1 of the PTTP in PNG. This work is described in Leroy et al. (2007)[1]. No further sonic tagging has been undertaken.

Surgical procedures

Tuna selected for archival tagging were placed in a smooth vinyl tagging cradle or left in the vinyl landing sling if greater than 10 kg. The eyes were immediately covered with a wet artificial chamois cloth, a sea water hose inserted in its mouth to gently irrigate the gills, and the hook removed. If fish condition was judged suitable, an electronic tag(s) was surgically implanted. Implantation involved the insertion of the Betadine-rinsed tag into the body cavity through a small incision (3 cm) made with a knife-blade, which for yellowfin and bigeye tuna was closed using a dissolvable suture after insertion. Each fish was also marked with a conventional dart tag placed below the second dorsal fin. Orange colored dart tags were used to mark fish receiving an archival (or archival plus sonic tag). Green colored tags were used for sonic tag releases. Fish were measured to the nearest cm (FL) before being released. The time of release with school and location data were recorded and stored on an Access database. The tagging operation lasted between 50 seconds and 2 minutes. Identical methods were used for the implantation of archival and sonic tags with one exception – skipjack receiving an internal sonic or archival tag were closed using three stainless steel staples delivered by a 3M 35W surgical staple gun.

Recovery procedures

Considerable efforts have continued to publicize the project and establish tag recovery procedures in the main locations where recoveries are likely to occur. Tagging posters, providing information to 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, and other media, e.g. radio, TV, newspapers have been used to publicize the project where possible. Tag Recovery Officers have been appointed in key locations, including PNG ports, other Pacific Island landing sites, Philippines, Thailand, Japan and

[1] Leroy, B., D. Itano, and S. Nicol. 2007. Preliminary analysis and observations on the vertical behaviour of WCPF skipjack, yellowfin and bigeye tuna in association with anchored FADs, as indicated by acoustic and archival tagging data. WCPFC-SC3-BI SWG WP-4.

Korea, to publicize the programme, collect tags, pay rewards, and arrange for the tags and recovery data to be sent to SPC. SPC staff have made regular visits to key recovery locations throughout the programme to review procedures and deal with any issues arising.

The rewards being for the return of tags and recovery data are:

Conventional tags	USD10 or a project shirt or cap
Archival tags	USD 250
Sonic tags	USD 50

Biological sampling

Biological sampling has been conducted as a part of the tagging cruises to obtain information on the trophic status of tunas in different types of school association and ultimately provide information for ecosystem modelling. A sampling design was developed that included stratification by species, school association type, area and time of day. The sampling strategy was to sample 15 individuals from 2 schools within each stratum. For each individual, species, length and sex were recorded, stomach contents collected and muscle and liver samples taken.

In addition to stomach/muscle/liver sampling, measurements using a Fatmeter were undertaken. The Fatmeter is a non-destructive, non-invasive method that can be used on live fish. This electronic device measures the lipid content of the fish. The lipid content of fish is related to the water content of the sample; by measuring the water content using a micro strip sensor the amount of lipids can be inferred by conversion with the appropriate calibration (required for each species). Calibration for yellowfin was built in to the device but muscle samples have been collected for checking the calibration in the lab. More muscle samples were collected for skipjack to establish a proper calibration for this species.

Progress on the biological sampling is reported in a separate information paper to SC6 in the Ecosystem and Bycatch Theme (see EB-IP-10).

Summary of Phase 2 Activities in 2010

Phase 2 activities from August 2009 to July 2010 comprised a single pole-and-line cruise, WP3 in the tropical western Pacific, two handline cruises, CP3 and CP4 in the tropical central Pacific, a mid-term review of the PTTP, data preparation for use in the 2010 WCPO skipjack tuna stock assessment and preliminary data analyses on tuna movement and the effects of FADs.

Tag releases during WP3, CP3 and CP4

WP3 consisted of a three month cruise from June to October 2009, operating primarily in the EEZs of FSM, PNG and Indonesia (**Error! Reference source not found.**) using the chartered pole-and-line vessel, *Soltai 105*. CP3 and CP4 were cruises of 6 weeks duration conducted in October-November 2009 and May to June 2010 targeting bigeye tuna aggregations associated with the TAO oceanographic moorings (

Cruise WP3 – July-October 2009	Cruise CP3 – October-November 2009	Cruise CP4 – May-June 2010

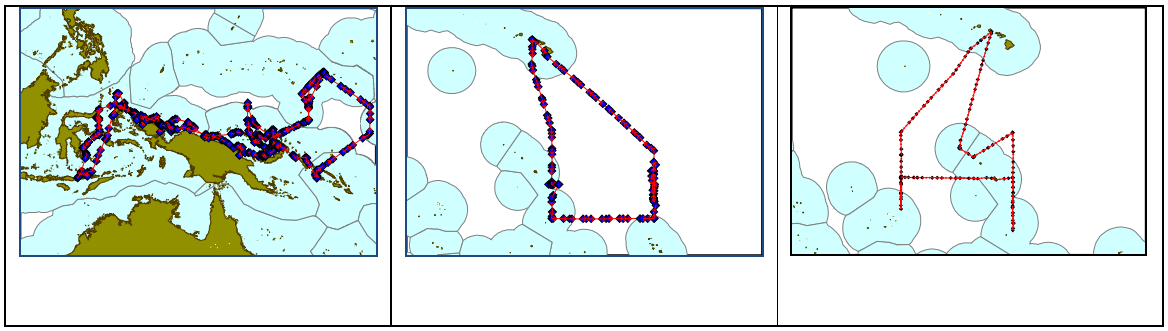


Figure) using the Hawaii-based handline vessel *Aoshibi* Go.

A total of 38,843 tuna (30,769 skipjack, 7,339 yellowfin and 735 bigeye tuna) were tagged during WP3. As expected, bigeye tuna release numbers were less than the 10% target because of the more westerly operational area of this cruise. 70 archival tags were deployed on skipjack (56), yellowfin (13) and bigeye tuna (1). The number of tuna tagged in the high seas was low due to the logistical difficulties of maintaining live bait and the likely movement east of fish in response to the El Nino event that coincided with this cruise.

During CP3, 5,105 tuna (4,802 bigeye, 237 yellowfin and 66 skipjack) were tagged. All releases were made at the 155°W and 140°W TAO moorings with most of the releases occurring at the 5°N, 2°N, and equatorial moorings. 135 archival tags were deployed on yellowfin (28) and bigeye tuna (107).

A total of 2,411 tuna (2,284 bigeye, 120 yellowfin and 7 skipjack) were tagged during CP4. The 155°W and 170°W TAO moorings were visited, but most of the releases (96%) occurred at the 170°W, 02°N TAO. 59 archival tags were deployed on yellowfin (20) and bigeye tuna (39). At the conclusion of CP4 the total number of tuna tagged for the PTTP was 262,142 (Table 1).

Figure 3, Figure 4 and Figure 5 show the overall size distributions of releases of skipjack, yellowfin and bigeye, respectively, tagged during WP3, and CP3 / CP4 cruises combined. These figures show the selectivity differences between the 2 fishing methods (pole & line versus trolling) and the much higher bigeye % that occurs around FADs in the central equatorial Pacific Ocean.

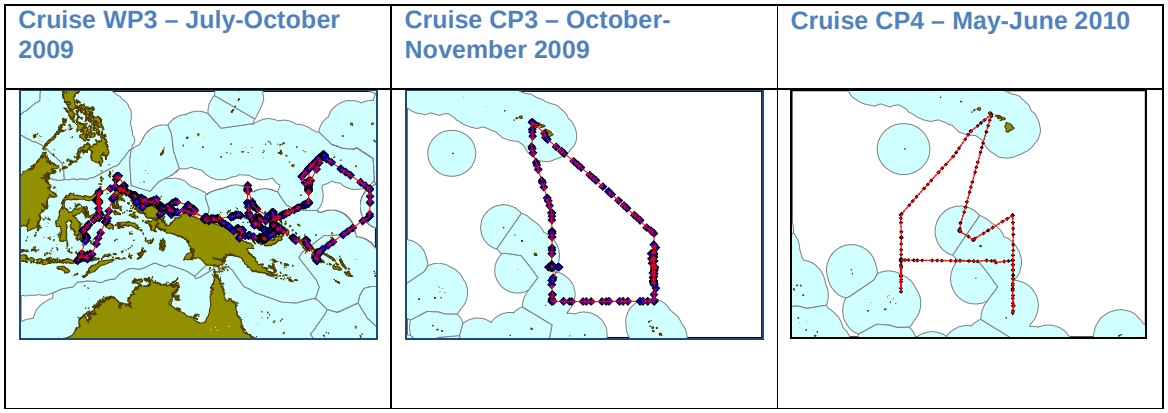


Figure 2. Cruise tracks during WP3, CP3 andCP4.

Table 1. Total PTTP releases to date of conventional and archival tags.

Tag type	Skipjack	Yellowfin	Bigeye	Total
Conventional	166,216	78,206	17,720	**262,142**
Archival	97	404	444	**945**

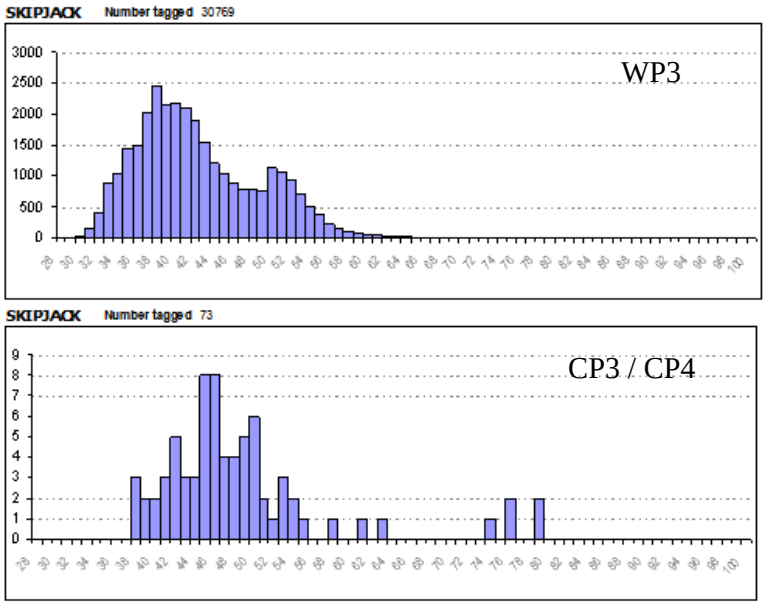


Figure 3. Size distribution of skipjack released during WP3 (n = 30,769) and during CP3/CP4 (n= 73).

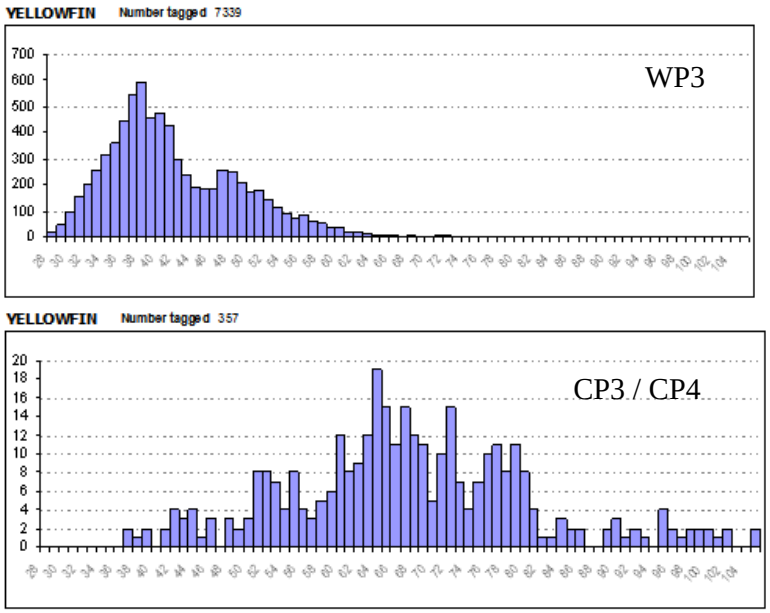


Figure 4. Size distribution of yellowfin released during WP3 (n = 7,339) and during CP3/CP4 (n= 357).

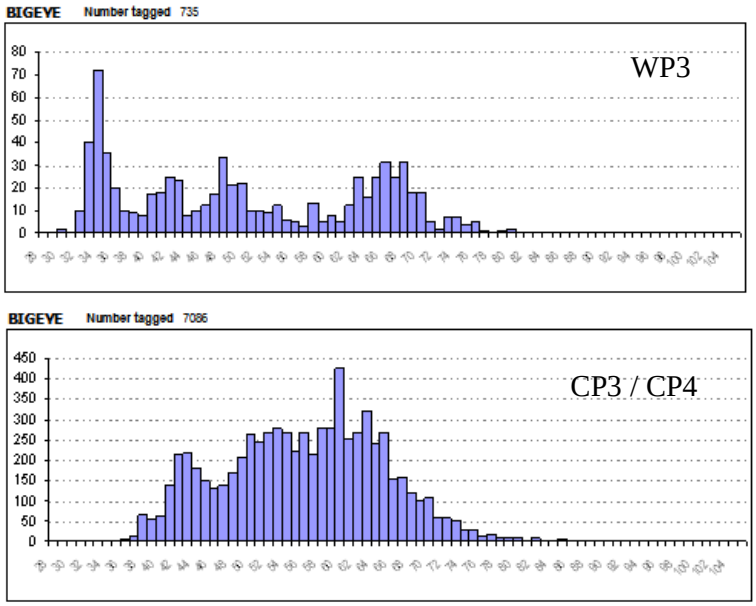


Figure 5. Size distribution of bigeye released during WP3 (n = 735) and during CP3/CP4 (n= 7,086)

Conventional and archival tag recoveries

As at 20 July 2010, a total of 38,378 tagged tuna had been recaptured and the data reported to SPC. The number of conventional tag recoveries by species is given in **Error! Reference source not found.**. Tag recoveries have occurred over the duration of the project, and are expected to continue for several years. Tag attrition follows the expected declining pattern (Figure) with the rate of decline in skipjack tag returns indicating their shorter expected lifespan and higher natural mortality when compared to yellowfin and bigeye tuna. Recoveries are still being received in considerable numbers from WP3 releases and in lesser numbers from the earlier cruises. The recovery rates of yellowfin and bigeye tagged with archival tags are very similar to the conventional recovery rates. Significant numbers of skipjack have only recently been tagged with archival tags.

The recovery rates are highly variable by location due to a number of factors, including tag reporting performance and the level of fishing activity in the vicinity of the tag releases which results in large variation in the numbers of tag recoveries soon after release. However, some trends appear consistent over the duration of PTTP recoveries. These being:

- The relatively high recovery rates of bigeye tuna in several locations and overall;
- The high recovery rates of bigeye and yellowfin tuna from the central Pacific releases, in an area of relatively low purse seine effort (indicating higher catchability in the central Pacific).
- The higher recovery rate of skipjack from the SOL 1 releases in comparison to SOL 2 indicating the importance of natural mortality on tag attrition (Figure 7).

Table 2. Fractional recovery rates, by species, for PTTP conventional tag releases.

Cruises	Releases				Recoveries (numbers and %)			
	SKJ	YFT	BET	Total	SKJ	YFT	BET	Total
PNG 1 Aug-Nov 2006	13,948	7,806	562	22,316	2,634 (18.9%)	1,797 (23%)	229 (40.7%)	4,660 (20.9%)
PNG 2 Feb-May 2007	26,493	12,845	129	39,467	2,473 (9.3%)	1,680 (13.1%)	6 (4.7%)	4,159 (10.5%)
SOL 1 Oct-Nov 2007	7,479	3,565	139	11,183	1,972 (26.4%)	781 (21.9%)	18 (12.9%)	2,771 (24.8%)
SOL 2 Feb-Apr 2008	15,327	14,404	414	30,145	1,749 (11.4%)	2,374 (16.5%)	59 (14.3%)	4,182 (13.9%)
WP1 Jun-Nov 2008	37,693	17,650	1,467	56,810	6,235 (16.5%)	1,952 (11.1%)	354 (24.1%)	8,541 (15%)
WP2 Mar-Jun 2009	34,208	13,919	3,145	51,272	4,175 (12.2%)	1,918 (13.8%)	406 (13%)	6,499 (12.7)
WP3 Jul-Oct 2009	30,769	7,339	735	38,843	4,836 (15.7%)	933 (12.7%)	89 (12.1%)	5,855 (15.1%)
CP1 May-Jun 2008	57	116	1,736	1,909	4 (7%)	24 (20.7%)	545 (31.4%)	573 (30%)
CP2 May-Jun 2009	169	205	2,307	2,681	5 (3%)	16 (7.8%)	328 (14.2%)	349 (13%)
CP3 Oct-Nov 2009	66	237	4,802	5,105	1 (1.5%)	49 (20.7%)	736 (15.3%)	786 (15.4%)
CP4 May-Jun 2010	7	120	2284	2411	-	-	-	-
TOTAL	**166,216**	**78,206**	**17,720**	**262,142**	**24,084 (14.5%)**	**11,524 (14.7%)**	**2,770 (15.6%)**	**38,378 (14.6%)**

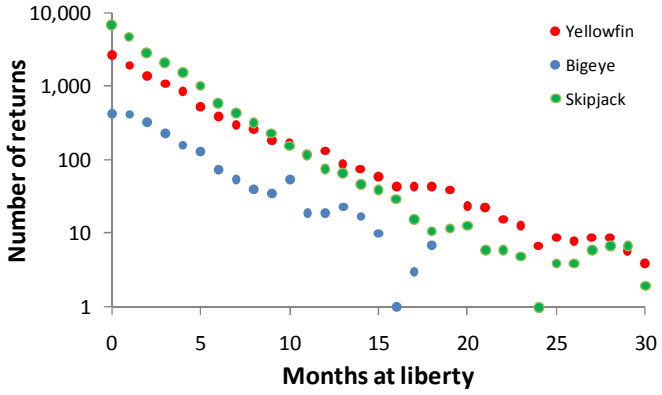


Figure 6. Tag recoveries by time at liberty for skipjack, yellowfin and bigeye tuna.

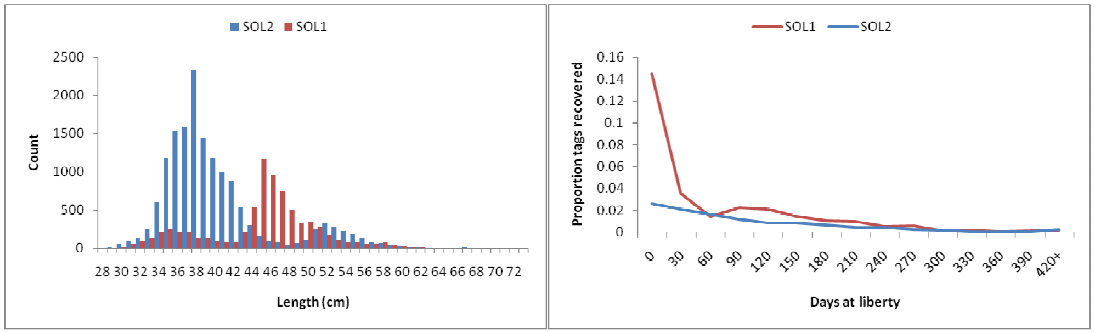


Figure 7. Left Panel: Length frequency distribution of skipjack released during SOL 1 and SOL 2 cruises. Right Panel. Proportion of available tags return per quarter for skipjack from releases during SOL 1 and SOL 2 cruises. Note the higher proportion of tags returned from SOL 1 releases for the first year after release in comparison to SOL 2. This is most likely explained by the differences in size at release with natural mortality higher for the smaller sized fish released during SOL 2.

Recoveries by vessel nationality

Tag recoveries have been received from all vessel nationalities involved in the purse seine fishery (Table 3). In Figure , we present the number of tags returned and reported as recaptured by different purse seine vessel nationalities, in relation to the catch of those vessels during the period of the PTTP (August 2006 – present). To aid interpretation of Figure 8 we also present the distribution of catch by vessel nationality in the WCPO and the distribution of tagged tuna at release (Figure 9). Inspection of Figure reveals that:

- The numbers of tags reported by Indonesia, Philippines, PNG and Solomon Islands vessels has been very high in relation to their catches.
- In the case of Indonesia, this is thought to be a combination of a large number of tag releases in Indonesian waters, the proximity of intensive fishing effort to the tag releases and good tag recovery procedures in Bitung, Sorong, Kendari, Ambon and Ternate.
- In the case of Philippines, this has been due to the proximity of tag releases in PNG to Philippines purse seiners fishing in PNG, considerable fishing effort by Philippines vessels adjacent to the large number of tag releases in Indonesia, and good tag recovery procedures in the main Philippines tuna unloading port of General Santos City.
- For PNG, large numbers of tags were recovered by the domestic purse seine fleet fishing in the Bismarck Sea, particularly in 2006 and 2007, and also by PNG seiners fishing more widely in the region but unloading their catch in Wewak – see PNG panel in **Error! Reference source not found.**. High returns have been facilitated by excellent cooperation of the PNG-based fishing companies – Frabelle, RD Tuna and South Seas Tuna Corporation.
- Likewise in Solomon Islands, the large number of returns from Solomon Islands vessels reflects the large number of releases in Solomon Islands archipelagic waters, highly concentrated fishing effort in that area by Solomon Islands purse seiners – see Solomon Islands panel in **Error! Reference source not found.** – and very good cooperation in tag recovery by the two locally-based companies Soltai and NFD.
- Japanese seiners fished relatively close to the main centers of tag release, which, in combination with good tag recovery procedures in the main unloading port of Yaizu and excellent assistance by the Japan National Research Institute of Far Seas Fisheries, results in a moderately high number of tags/catch.
- In the case of Vanuatu, a large number of tags have been recovered by several vessels fishing in Solomon Islands archipelagic waters, which largely accounts for their very high tags/catch.

- Chinese Taipei seiners had moderate tags/catch fishing in an area similar to the Japanese fleet. The lower tags/catch of this fleet compared to the Japanese probably reflects the lower tag detection/reporting rates in transshipment operations compared to direct unloading at home port.
- United States seiners had moderate tags/catch despite the fact that its main area of activity was somewhat displaced to the east of the main tag release centers in PNG and Solomon islands. Most US recoveries came from fish that had been transshipped to Thailand, probably recaptured by vessels fishing closer to the main tag release sites. Very few tags have been recovered from vessels unloading in American Samoa (see following section).
- Korean vessels had a relatively low number of tags recovered, despite their fleet recording the highest overall catch since the start of the tagging programme. While the fishing activity of this fleet is largely to the east of the main tag release areas, it is similar to the areas fished by the United States and Vanuatu fleets. Possibly, the propensity of Korean purse seiners to target larger yellowfin tuna in free schools and a relatively low reliance on FAD sets resulted in fewer numbers of tags being recaptured per unit catch.
- Some of the smaller fleets, such as Marshall Islands and New Zealand, had very low numbers of tags/catch, possibly due to their more easterly distribution of fishing effort.

Overall, most of the variability in numbers of tags returned in relation to the catch of the various fleets are potentially explainable due to the operational characteristics of these fleets. The trends observed in 2010 are similar to those reported to the PTTP steering Committee in 2009.

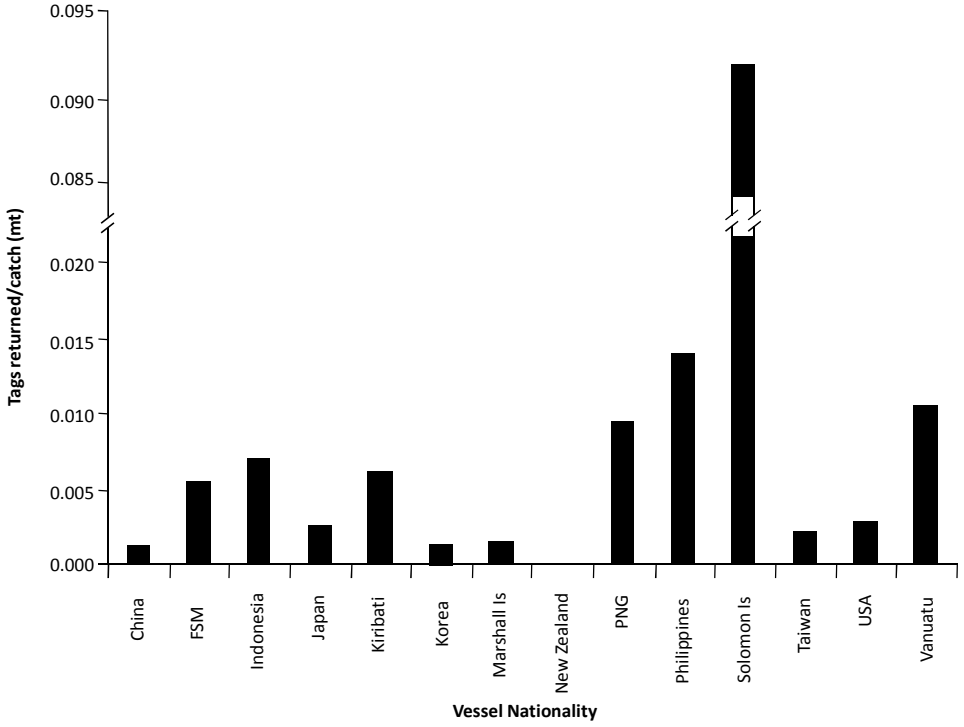
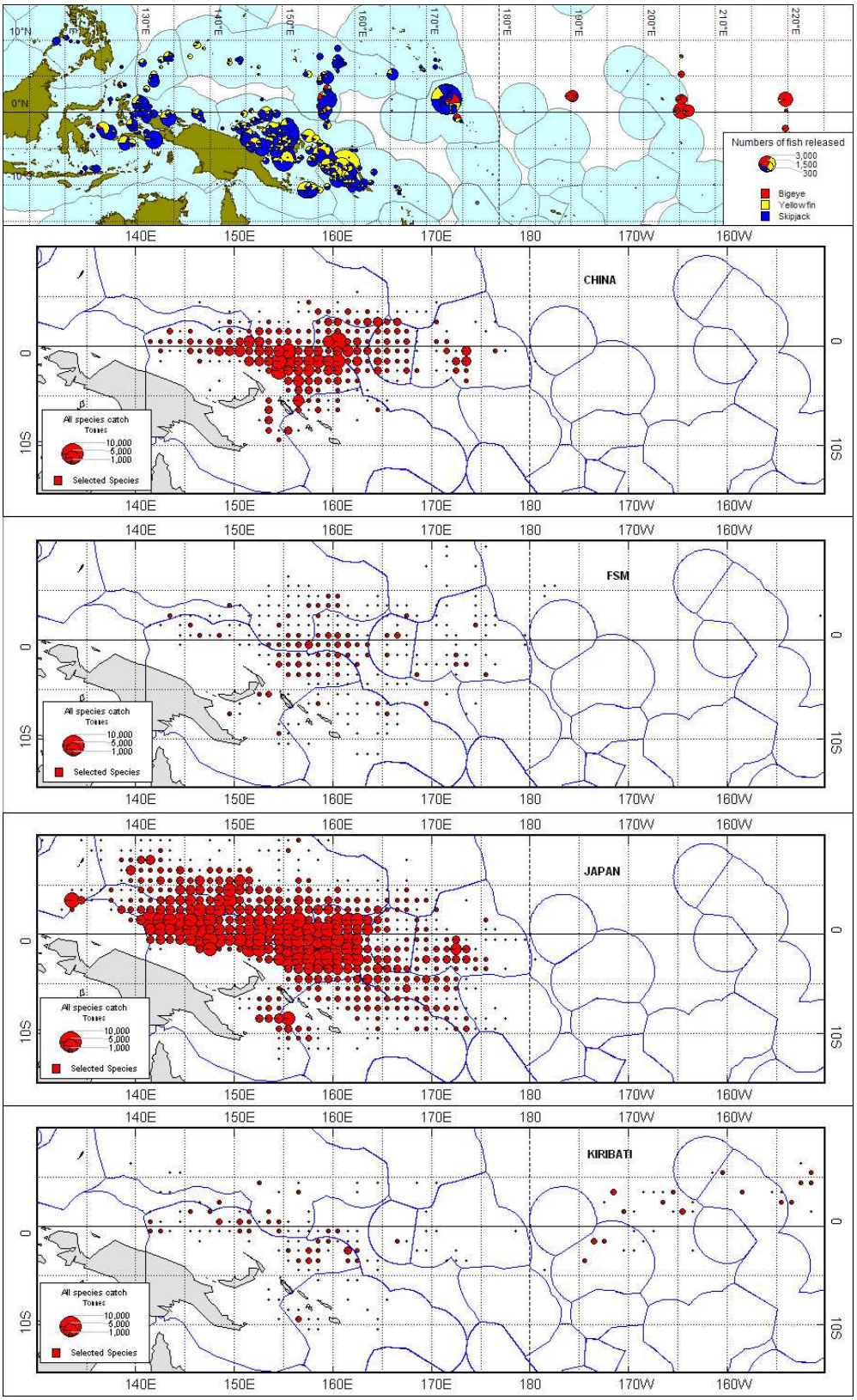


Figure 8. Tag returns by purse-seine vessel nationality as a proportion of the total purse-seine catch (mt) of that nationality for the period 1 August 2006 to 31 December 2009 within the boundary of 130°E to 180°E longitude and 10°N to 15 °S latitude.


Numbers of fish released
3,000
1,500
300
Bigeye
Yellowfin
Skipjack
CHINA
FSM
JAPAN
KIRIBATI
All species catch
Tonnes
10,000
5,000
1,000
Selected Species
140E
150E
160E
170E
180
170W
160W
10S
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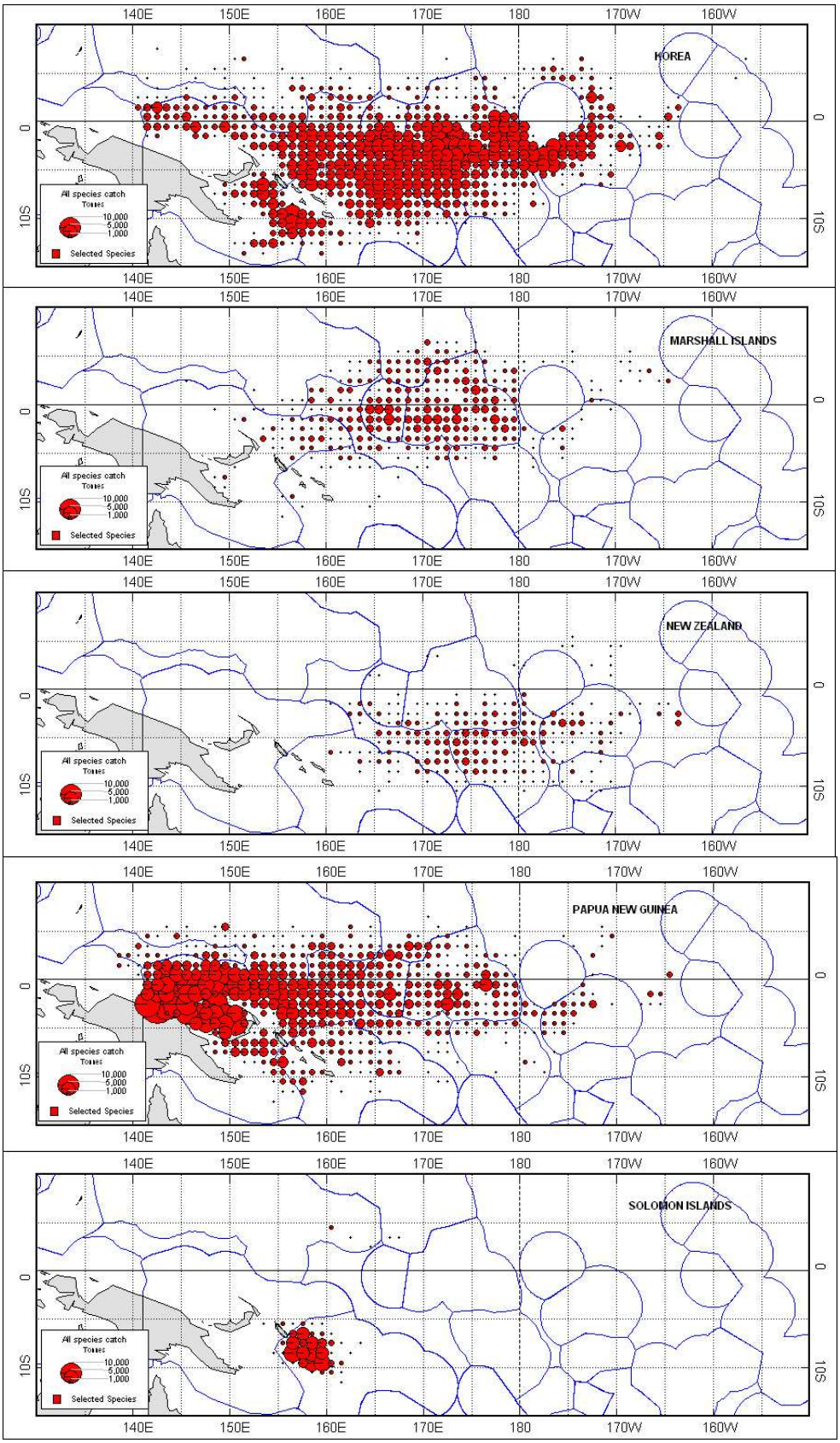
140E
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All species catch
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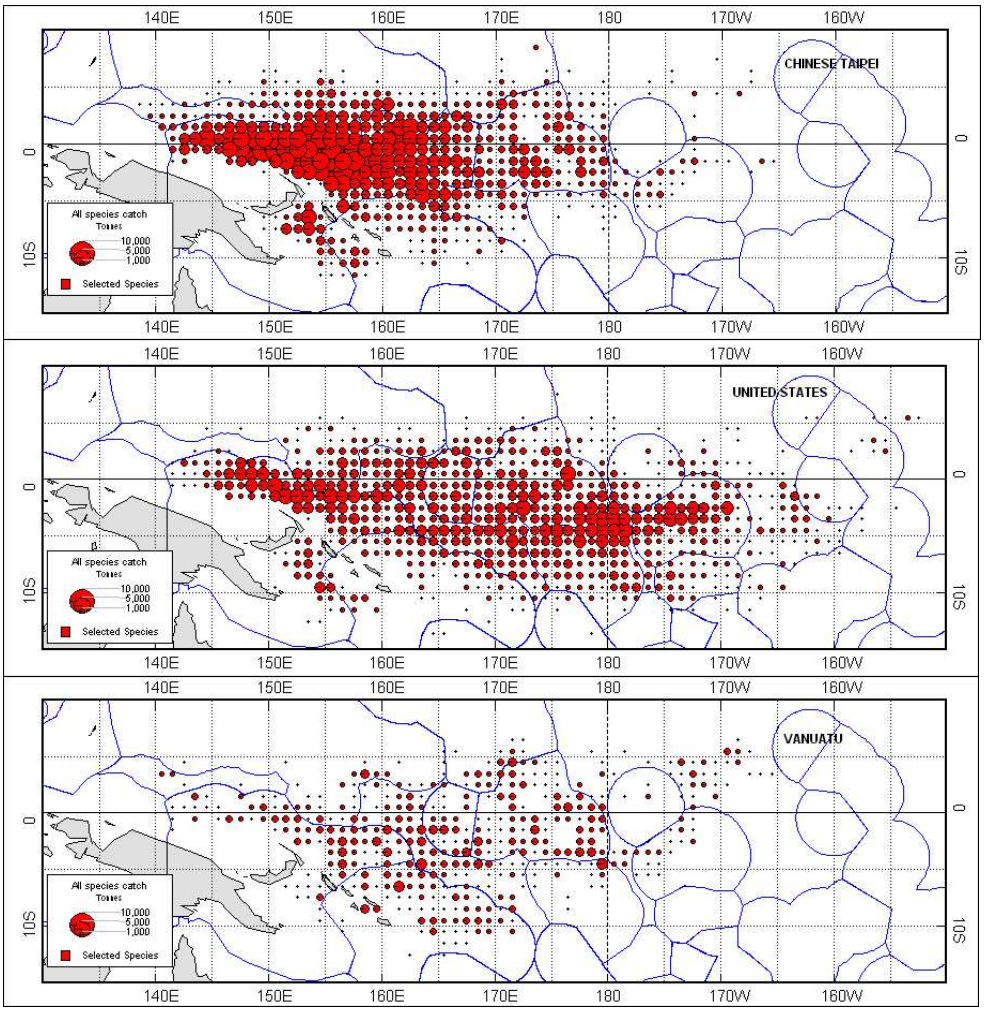


Figure 9. Top Panel. Distribution map of tag releases from 2006-2010. Lower panels. Maps with pies showing the distribution of total catch (1°X1°) between 1 August 2006 and 31 December 2009 for the major purse-seine fleets operating in the WCPO.

Recoveries by source

Examination of the number of tag recoveries by source location (**Error! Reference source not found.**) noted the following observations:

- The continuation of low numbers of tag recoveries from American Samoa. We initially considered that this may be partially because vessels unloading in American Samoa generally fish further east, away from the main tag release locations. However the completion of 4 central Pacific cruises and WP2 has resulted in increases in recoveries in the Marshall Islands and Kiribati (Tarawa and Kiritimati) and it is surprising that similar increases have not been observed in American Samoa. Furthermore a significant amount of fish is also delivered to American Samoa by reefer vessels. This fish is likely to have been captured more broadly throughout the western and central Pacific. Considerable efforts to raise awareness amongst cannery staff and stevedores have been made and it is hoped that the situation will improve.
- Tag recoveries have commenced in China and Kiritimati Island after visits by SPC-OFP staff to raise awareness of the PTTP.

- Tag detection and reporting at various transshipment locations in the region (Pohnpei, Majuro, Tarawa, Honiara) have generally been low. This may be due to the speed of the transshipment operation not being particularly conducive to tag detection. However, special efforts have been made to alert crews to the possibility of tags being present in catches, and significant improvements in tag reporting from some locations have recently occurred. We are grateful for the assistance of the national fisheries offices in these locations in this regard.

Tag Seeding

From February 2007 to July 2010, 175 conventional tag seeding kits (consisting of 25 tags, applicators and data forms) had been distributed to observer coordinators in PNG, Solomon Islands, FSM, Marshall Islands, and American Samoa for deployment aboard purse seine vessels by senior observers. Since 2009, to enhance the retention of seeded tags, tags with metal attachments were distributed, in order to better secure anchorage within the flesh of the fish. Trained observers on purse seine vessels were asked to deploy up to 25 tags in the catch during a trip. Optimally, observers were asked to tag 15 tunas with a single tag and to double tag 5 fish; making up the 25 tags released during the trip. Fish are tagged discretely, usually on the wet deck, just below the work deck where the catch is landed before entering the well via a chute or in the well as part of an observer's routine sampling regime onboard. Tag numbers, dates, species, fork lengths and well numbers are recorded on a specific tag seeding datasheet and the information sent to SPC at the completion of a voyage. Upon recovery, seeded tags are processed in the same fashion as genuine tag recoveries. Tag finders are paid the standard reward for tag recoveries and are not informed that the tags are part of a tag seeding experiment.

Tag seeding releases and recoveries

Ninety-seven kits have been distributed to observers for deployment. Forty-eight tag seeding datasheets have been received for these observer trips and seeded tags from an additional 15 kits have been received at SPC (but the datasheets have not yet been provided to SPC). It is worth noting that it can take 6 months or more for datasheets to be returned to SPC after deployment due to observers often being required to undertake consecutive trips. The returned datasheets are from tag seeding kits that were deployed across seven flags (China, Marshall Islands, New Zealand, Papua New Guinea, Philippines, Taiwan and USA), with a higher proportion of tagging seeding kits deployed on PNG and USA flag vessels (Figure 10). The proportion of seeded tags returned is variable by vessel flag, with recoveries from Chinese and New Zealand flagged vessels very low (Figure 10). The source of tag seeding returns appears consistent with that observed for the PTTP (Figure 10).

Table 3 Numbers of tags recovered from different source locations categorised by the process when the tag was found.

Source	Fishing vessel	Reefer (Transfer)	Fish market/ port	Cold storage	Cannery/ Loining	Unknown	Total
Am. Samoa	12	12	23		38	50	135
China					10	1	11
Fish. vessel	31	18	18			311	378
FSM	18	1	1			41	61
FSM (SPC)	41	3				17	61
IATTC	129	1,067	87	18	27	1,017	2,345
Indonesia	15		55	1	19	5,705	5,795
IOTC					2	6	8
Japan	6		196	1	3	1,850	2,056
KI (Kiritimati)	6	4		2		1	13
KI (Tarawa)	25	1				172	198
Korea	2					452	454
Marshall Is	130	1	110	1		257	499
Nauru						1	1
Other	28	2			6	14	50
PH (direct)	2,149	537	223	250	308	213	3,680
PH (Frabelle)	1					162	163
PH (NFRDI)	60	11	8			28	107
PNG (Frabelle)	382	73		2		1,133	1,590
PNG (NFA)	35	4	1	1		147	188
PNG (other)	20	2	1		1	34	58
PNG (RD)	2,371	141	54	54	25	3,861	6,506
PNG (SST)	434	41	73	23	258	163	992
SB (Global Invest.)	49					994	1,043
SB (MFMR)	16	3				151	170
SB (NFD)	411	5	3	5	18	3,237	3,679
SB (other)	4	1	1			25	31
SB (Soltai)	471	1	1	1	10	2,136	2,620
Tagging vessel	31					162	193
Taiwan	14						14
Thailand			8	262	4,697	312	5,279
Total	6,891	1,928	863	621	5,422	22,653	38,378

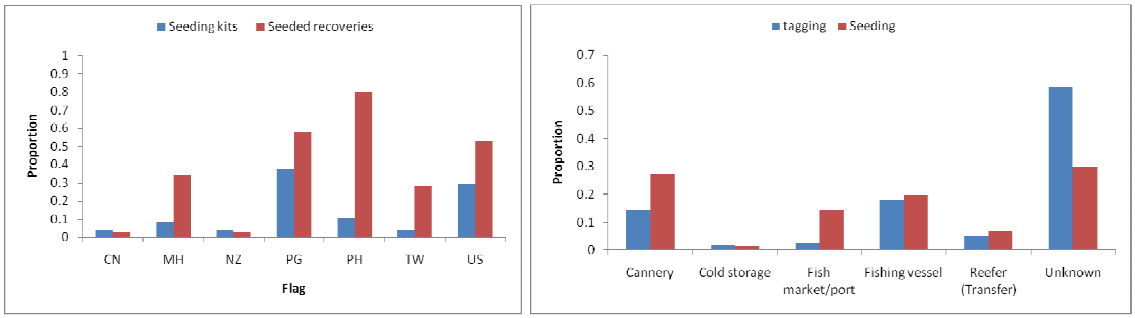


Figure 10. Left Panel – Proportion of tag seeding kit deployed and seeded tag recoveries by vessel flag. Right Panel – Proportion of tag and seeded tag returns by tag source.

Stock Assessment Data Preparation

Verification of the large number of recoveries received (~ 38,000), mostly with good data, but all in need of corroboration from logsheet and VMS matching has commenced. Approximately 7,000 recovery records have been verified with VMS. Verification of the remaining tags is expected to be completed in 2011.

Movement

Movement trends observed from both conventional and archival tags are consistent with expectations for highly migratory species with larger movements positively related to time at liberty (Figure 11). The information collected from geo-locating archival tagging data indicates that individual tuna are wide ranging and utilise all suitable pelagic habitats within PNG (Figure 12).

The examination of vertical movements of tuna identified the occupation of shallow depths (<120m) as the predominant behaviour for small bigeye, yellowfin and skipjack when associating with anchored FADs making each species susceptible to capture by purse seine. There was some vertical separation between species however it is unlikely that purse-seine setting techniques could be altered sufficiently to exclude bigeye or yellowfin based on the small differences in depths observed. While more detailed analyses are planned, preliminary work suggests that the deployment of the large number of anchored FADs in the Bismarck Sea has not resulted in a clear change in the movement characteristics of tuna.

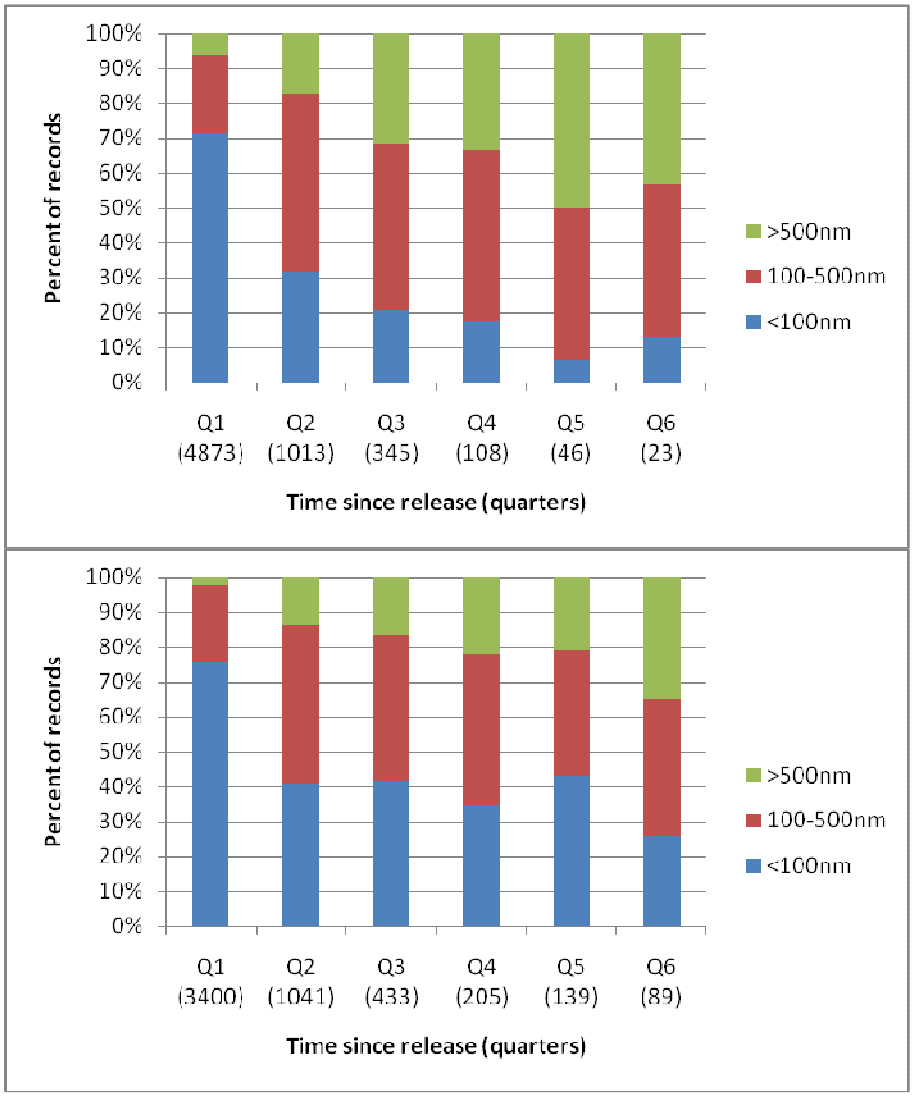


Figure 11. Reported recoveries within 100nm, 100-500nm and >500nm in the first 6 quarters (18 months) since release for skipjack (upper graph) and yellowfin (lower graph). The sample size for each quarter is provided in the parentheses below the quarter label on the x-axis.

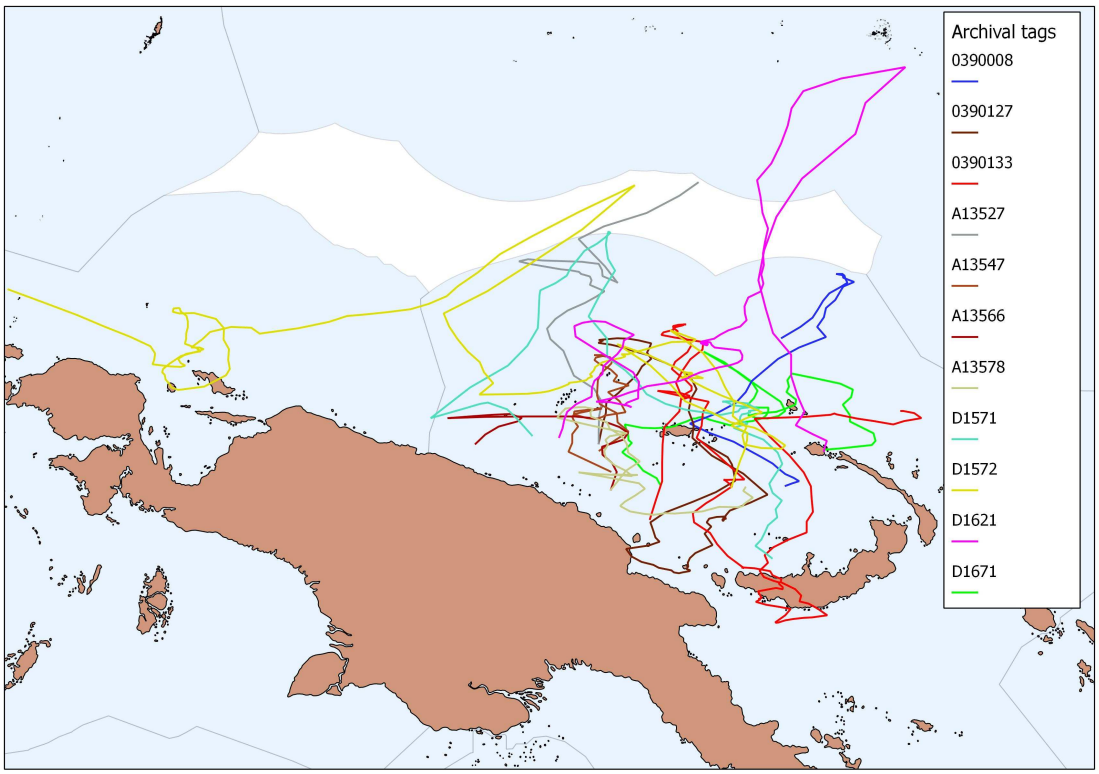


Figure 12. Examples of movement tracks estimated from geo-locating tags in yellowfin tuna tagged in the Bismarck Sea, PNG.

PTTP Mid-term Review

The mid-term review of the PTTP was held from 22-26 February 2010 at SPC, Noumea, and brought together key individuals involved in the current and previous field programmes, and some renowned expertise in tuna stock assessment and tagging data analysis to review all aspects of the current PTTP. Attendees were Dr Mark Maunder (IATTC), Dr Dale Kolody (IOTC), Dr Jim Ianelli (NOAA), Dr Pierre Kleiber (NOAA), Professor John Sibert (University of Hawaii), Dr Jeremy McKenzie (NIWA), Dr Tony Lewis (PTTP), David Itano (University of Hawaii/PTTP), Thomas Isu (National Fisheries Authority, PNG), Dr David Fournier (Otter Research), Sylvain Caillot (SPC), Bruno Leroy (SPC), Dr John Hampton (SPC), Dr Shelton Harley (SPC), Dr Simon Hoyle (SPC), Dr Don Bromhead (SPC), Ms Caroline Sanchez (SPC) and Dr Simon Nicol (SPC).

The review examined the progress of the PTTP towards achieving 3 higher level objectives:

- Improving stock assessment of skipjack, yellowfin and bigeye in the WCPO
- Advancing knowledge on the population dynamics of these species
- Capacity building PICTs.

The first day of the review examined these objectives and identified how implementation of large scale tagging projects can be improved in the future. The remainder of the review considered specific analytical approaches, looking at both stand-alone analysis of the tagging data, and more assessment focussed integrated analysis and prepared an analytical work plan for the coming 2 years.

Progress towards achieving higher level objectives

1. Improving stock assessment of skipjack, yellowfin and bigeye in the WCPO

The mid-term review considered the PTTP in the context of all tagging data available for application in stock assessments in the WCPO for skipjack, yellowfin and bigeye. The review noted the following for stock assessment:

- The PTTP is the third large-scale tuna tagging campaign undertaken in the Western and Central Pacific Ocean (Figure 13). The fishery has changed significantly since the first tagging campaign. During the SSAP (implemented from 1977-1981) the WCPO was dominated by pole and line fisheries with an annual catch of 300,000 mt. The RTTP (implemented from 1989-1992) provided a source of information on the change to purse-seine dominated fisheries in the WCPO. Since the RTTP, the annual catch has increased from 1.4 to 2.4 million mt in the WCPO.
- Tagging has been broadly distributed over the WCPO equatorial region and has been consistent across the 3 programs (Figure 6). The PTTP should complement the existing data. For BET, SKJ and YFT, the PTTP data will allow the spatial disaggregation of each stock assessment model to be refined.
- Improvements in stock assessment are also expected over the next few years as data quality improves through cross validation with VMS and logbook data.
- Skipjack assessment is currently reliant upon SSAP and RTTP tagging data as the index of abundance is highly uncertain. PTTP data are being evaluated for use in the 2010 stock assessment for SKJ and the expectation is that PTTP will be equally as valuable. To date tagging data have not been as influential for the stock assessments of YFT and BET in comparison to SKJ as the sample size of tags has been low and

index of abundance more certain. The tagging of ~80,000 YFT (double that of RTTP) raises expectations that PTTP data will help improve stock assessment for YFT. Similarly, expectations of the benefits of the tagging for BET are high with tagged number now approaching 18,000 individuals.

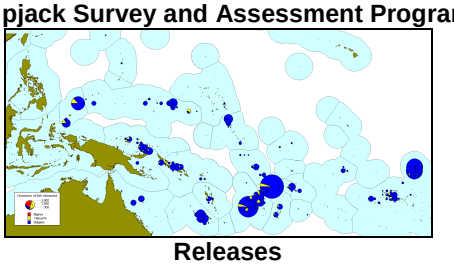
- Given the influence of tagging data for stock assessment, the option of a longer term tagging project was raised to measure more precisely how the fisheries change in response to varying effort, technology changes and the environment. Simulation of the benefits of continual tagging would be extremely worthwhile. One of the main advantages of long term tagging is that it results in overlapping cohorts which make it easier to estimate tag attrition rates. Tag attrition rates from single-event tagging are affected by temporal variation in reporting rates. Long term tagging avoids this problem because attrition can be estimated from the relative return rates of the different cohorts at the same time.
- All three large scale tagging programs in the WCPO have been implemented over a period of years, but tagging locations have generally changed through time (with some replication). This is necessary for good spatial coverage and information. However, it means that the separate cohorts are not released at the same locations, so there is less information in the relative return rates (i.e., area and time are confounded). A long term tagging program that occurred consistently in one area would avoid this confounding. It would also be possible to implement at lower cost than a long term large scale effort. One option for a long term tagging program could be to have a component (perhaps the main component)) based in one location, such as the Bismarck Sea, but with expansion every 5-10 years for broader spatial coverage.
- The importance of tag seeding experiments for stock assessment purposes was emphasised during the course of the meeting. The preferred design for tag seeding is the representative deployment of tags for each fishing fleet in order to reliably estimate the recovery rate for each fleet and handling/processing location.
- Implementation of seeding for the PTTP has only partially satisfied this design as availability of suitably experienced and trained observers have been limited. A substantial effort to train observers in tag seeding principals was initiated in 2009 and it is expected that the number of experiments should increase in 2010 and 2011. A further limitation to seeding experiments to date has been the provision of data sheets from observers back to SPC with delays on 6 months or more experienced as observers have typically been involved in consecutive observer trips.

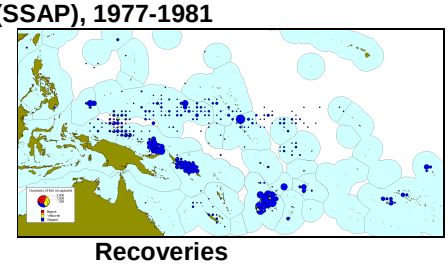
2. Advancing knowledge on the population dynamics of these species

The review team noted that analysis at this stage of the PTTP is preliminary, which is expected given the infancy of the project. Once sufficient returns have been received and quality assurance procedures and tag seeding experiments have been implemented the analyses should progress more rapidly. The design of the PTTP should allow for:

- Updated fishing and natural mortality estimates;
- Estimation of movement estimates from both conventional and electronic tags using high-resolved spatial models;
- Description of the vertical movement of BET, YFT and potentially SKJ;
- Testing of FAD effects for the first time at the WCPO scale;
- Updated growth estimates.

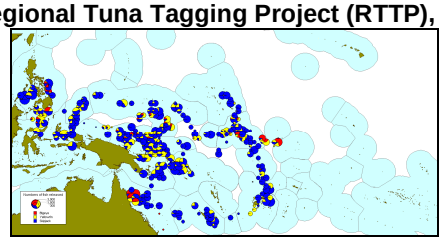
Skipjack Survey and Assessment Programme (SSAP), 1977-1981

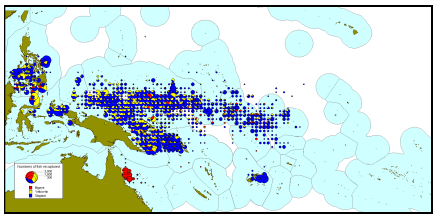




	Releases		Recoveries	
SKJ	147,507	93.7%	7,126	4.8%
YFT	9,884	6.3%	281	2.8%
BET	65	0.0%	0	0.0%

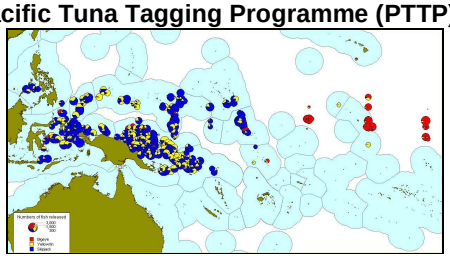
Regional Tuna Tagging Project (RTTP), 1989-1992

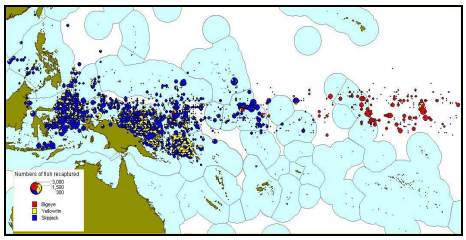




	Releases		Recoveries	
SKJ	98,401	67.1%	12,447	12.6%
YFT	40,075	27.3%	4,950	12.4%
BET	8,074	5.5%	975	12.1%

Pacific Tuna Tagging Programme (PTTP), 2006-2010





	Releases		Recoveries	
SKJ	166,216	63.4%	24,033	14.5%
YFT	78,206	29.8%	11,510	14.7%
BET	17,720	6.8%	2,841	16.0%

Figure 13. Distribution of tag releases and tag recoveries from the three large scale regional tuna tagging programs implemented in the WCPO.

3. Capacity building PICTs.

Capacity has been increased within Pacific Island government and private industry. The largest increase in capacity is within the PNG National Fisheries Authority (NFA) with two NFA officers trained and actively involved in project implementation since project inception (Figure 14). NFA has committed to an expanded tuna tagging program in PNG with both officers expected to take lead roles in implementation of both the tag release and tag recovery programmes.

Two fisheries technicians from the Solomon Islands were trained and employed to assist with tagging activities in Phase 2. Along with the NFA officers these technicians are considered to be highly experienced in tuna tagging and capable of implementing tagging activities autonomously.

The crew of Soltai 6 and Soltai 105 are also very experienced in tuna tagging and are probably the most experienced and capable for implementing pole and line tuna tagging.

Figure 14. SPC scientist Valerie Allain (left) and NFA scientists Brian Kumasi (centre) and Thomas Usu (right) undertaking additional biological sampling on board the tagging vessel in PNG in 2006.

Recommendation from the Review of Implementation

The review noted that the implementation of the PTTP has been highly successful as evident by the high numbers of tuna tagged and broad spatial coverage. A significant reason for this success was attributed to the past experience of the project team who were involved in the implementation of the RTTP. The key issues for future implementation of tagging activities are summarised in Table 4.

PTTP data analysis

The review devoted considerable time to discussion of the analysis of the PTTP data for stock assessment and provision of advice for management of tuna in the WCPO. Key topics identified were: tag related mortality and tag loss; tag reporting (including seeding), movement; fishing and natural mortality; FAD effects; and growth. The recommended tasks are incorporated into the 2010-2011 work plan (see below).

Table 4 Key issues identified by the mid-term review and options for implementation in future tagging activities.

Key issue	Future Options
Tag Seeding	Inclusion of tag seeding training in recognised observer training courses
	Employ observers specifically for tag seeding implementation
	Plan tag seeding based on regular product flow analysis. Stratify releases according to fisheries and product flow.
	Obtain transhipment records to track seeded tags
	Steel head tags only
	Replicate IOTC with co-operative skippers
Tag Recovery	Establishment of TROs in all unloading/processing points at start of project
	Consider employing sub regional TROs to work fulltime on recovery particularly to service transhipment and LL
	More industry based TROs
Tag Implementation	Vessel and crew critical
	Bonus scheme (ie. extra payment for achieving particular tagging targets) appears an excellent incentive for crew to maintain enthusiasm for tagging.

PTTP 2010-2011 work plan

	Task	2010	2011
TAGGING			
1.	**CP5** *Background*: 6 week cruise focusing upon the NOAA TAO Oceanographic Buoys along the 170°W meridian (waters of Kiribati, Phoenix Islands and High Seas) and along the 180°W meridian (High Seas, waters of Kiribati, Gilbert Islands and Tuvalu). This is the fifth Central Pacific cruise designed to improve overall spatial coverage of PTTP tag releases in areas difficult to access between the Date line and French Polynesia and investigate movement parameters and vertical habitat utilization of tuna in the central Pacific region. The cruise will charter the *FV Pacific Sunrise*, a multi-purpose pelagic handline/longline vessel which is based in Nuku'alofa, Kingdom of Tonga. *Target*: BET 1,000 conventional tags; BET & YFT 50 Archival Tags		
2.	**PNG (to be confirmed if under the PTTP umbrella)** *Background*: 3 month cruise focused upon tagging within the EEZ of PNG and managed by NFA in collaboration with SPC using a pole and line vessel. *Target*: 30,000 tuna conventionally tagged with an ideal species composition of skipjack: 60%; yellowfin 35%; and bigeye 5%.		
3.	**CTI Indonesia and Philippines (funding dependent & to be confirmed if under the PTTP umbrella)** *Background*: 2-3 month cruise focused upon tagging within the EEZ of Indonesia and the Philippines in collaboration with WWF. *Target*: 30,000 tuna conventionally tagged with an ideal species composition of skipjack: 60%; yellowfin 35%; and bigeye 5%.		
4.	**Philippines Archival Tagging (funding dependent & to be confirmed if under the PTTP umbrella)** *Background*: 2-week cruise focused upon archival tagging on FADs within the EEZ of the Philippines in collaboration with WWF. *Target*: 30 YFT with archival tags		
TAG SEEDING			
1.	Update product flow analysis to guide future tag seeding experiments in line with expected number of tag returns per vessel/unloading point.		
2.	Prioritise seeding of Japanese PS to confirm suspected high reporting rate		
3.	Prioritize continued tag seeding in order to improve understanding of the processes involved in tag reporting		
4.	Appoint locally based tag seeding co-ordinators		
5.	Undertake Observer training in tag seeding		
DATA MANAGEMENT			
1.	PTTP data verification with VMS and Logbook		
2.	Revision of PTTP web access		
3.	Migration of all WCPO tagging data into single database		
4.	Database developments to incorporate tag seeding tracking and PSAT.		
5.	Development of country specific PTTP web pages		
DATA ANALYSES			
1.	**Tag related mortality and tag loss.** *Purpose*: To estimate the effective number of tags released. *Task*: (1) Complete preliminary analyses of tag shedding, mortality due to fish condition and tagger and define tagger cohort groups for use in MFCL or develop a discount multiplier per tagger. (2) Add tag loss/mortality parameter by tag group to MFCL (3) Investigate alternative 'base mortality' values in a sensitivity analysis to evaluate its influence in stock assessment		
2.	**Tag reporting and seeding** *Purpose*: Critical for any estimation of fishing mortality as it is a direct scalar for fishing mortality. *Tasks:* (1) Determine detection rate of double tags (test for impact on tag seeding returns); (2) Undertake an external analysis of seeding data to identify what influences recovery rate (vessel, flag/fleet, unloading locations);		
3.	**Movement (horizontal)**		

	Purpose: Define regional structure of stock assessment models and provide estimation of mixing rates. *Tasks*: (1) Estimate movement from conventional tags and test for spatial variability in movement (use multiple models & compare ADR estimates); (2.) Estimate horizontal movement from archival tags; (3) Compare movement rate estimates among species & fish size from both archival and conventional tags, using AD models and simple approaches such as maximum displacement; (4) Add time structure to MFCL movements so that movements can be introduced from analyses outside the model and environmental covariates can be estimated; (5) Integration of archival tagging data into stock assessments		
4.	**Movement (vertical)** *Purpose*: Identify vulnerabilities to fishing gear. *Tasks*: (1) Statistically categorise vertical behaviour states from archival and sonic tagging data.		
5.	**Fishing and natural mortality** *Purpose*: Provide external validation to estimates from within MFCL and identify fishing mortality changes in response to expansion of the WCPO fisheries. *Tasks*: (1) Repeat RTTP analysis, including an overlay of PTTP tags on RTTP parameter estimates.		
6.	**FAD effects** *Purpose*: Identify impacts of FADs on tuna biology, identify changes in vulnerability to fishing gears. *Tasks*: (1) Compare movement model estimates between tagging projects and within tagging projects to identify changes in diffusivity estimates between SSAP and RTTP (no FADs) and PTTP (FADs); (2) Analyse vertical movement tracks to compare vulnerability/associations between species, size classes and locations; (3) Investigate relationships between season/location FAD density, fish size, and fish species, and time spent in each state; (4) Investigate ways to model relationship between time spent in each state and vulnerability		
7.	**Growth** *Purpose*: Key stock assessment model outputs are sensitive to both the mean and variation in growth curves and external analyses of growth will assist with documenting spatial and temporal variance in growth. *Tasks*: (1) Apply Grotag type analyses (Eg CSIRO) and IATTC revised methods; (2) Investigate the application of state-space methods to incorporate observation error in release and recapture lengths and time at liberty; (3) Investigate the application of integrated analysis to account for selectivity issues particularly for bet and yft		
PTTP REPORTING			
1.	PNG Country Report		
2.	Solomon Islands Country Report		
3.	Indonesia/Philippines Regional Report		
4.	FSM/RMI/Kiribati Regional Report		
5.	PTTP 2011 Steering Committee Report		

Conclusion

The cruises undertaken in 2009 - 2010 succeeded in considerably expanding the PTTP coverage of the WCPO. The large number of recoveries already received suggests that mechanisms to receive and return recaptured tags are working well, and that good results can be expected in the longer term, in fulfilment of project objectives. With the number of PTTP releases now over 260,000, the project has over-achieved its nominal target numbers, although bigeye numbers are still lower than hoped. Recoveries continue to be received, with an overall return rate of 14.7% to date. This is expected to continue to increase to >15% as further tag recoveries are processed. Verification and analyses of these data will be a strong focus of the PTTP over the coming years.