IPTP/92/WP/25

Review of national tuna tagging experiments in the Philippines, Indonesia and Malaysia

by

Antony D. Lewis

INDO-PACIFIC TUNA DEVELOPMENT AND MANAGEMENT PROGRAMME
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Abstract

Tagging programmes supported by IPTP in Philippines, Indonesia and Malaysia were reviewed and compared with a fourth programme in Maldives. Only that of the Maldives was able to fully achieve stated objectives, deficiencies identified in the others included tagging methods, publicity and tag recovery mechanisms. Nonetheless. useful preliminary results were obtained in each case. Recommendations were made for future tagging involving both neritic and oceanic tuna species in the southeast Asian region.

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List of acronyms

DASF	Department of Agriculture, Stock and Fisheries
TNFRI	Tohoku National Fisheries Research Institute
JAMARC	Japan Marine Resources Centre
SSAP	Skipjack Survey and Assessment Programme
RTTP	Regional Tuna Tagging Project
IPTP	Indo-Pacific Tuna Development and Management Programme
MFAM	Ministry of Fisheries and Agriculture
COI	*Commission de l'océan Indien*

1. INTRODUCTION

1.1. Background to the study

Since its establishment in 1982, the Indo-Pacific Tuna Development and Management Programme (IPTP), as the successor to the South China Sea Programme (SCSP), has worked to improve the statistical coverage of Indo-Pacific tuna fisheries, supported the development of national tuna fisheries and national capacity to provide management inputs to them, and, through expert consultations and conferences, made available relevant information and expertise to member countries.

Through its policy of providing technical and financial support to national tuna research projects, rather than direct involvement, IPTP has assisted with the implementation of tuna tagging projects in four countries - the Philippines, Indonesia, Malaysia and the Maldives. The present study was commissioned to review the results obtained in the three projects carried out in the Southeast Asian area, and to recommend possible future activity. The fourth IPTP-assisted project, in the Maldives, was reviewed in less detail, to provide further contrast in view of its apparent success.

1.2. Terms of Reference

(1) To review results of tuna tagging experiments conducted by national agencies in the Philippines, Indonesia and Malaysia with assistance from IPTP.

(2) To recommend orientation of future tagging experiments in these countries.

1.3. Approach used in the study

The consultant compiled all background documentation on the tagging projects available to him, and prepared a checklist of characteristics common to tuna tagging experiments for use in the evaluation (Table 1). He then visited the three countries, reviewing all aspects of the projects with field and administrative staff, and examining available data. In the case of the Philippines and Indonesia, the consultant had extensive previous contact with tagging projects in those countries, having been involved in joint tagging experiments during 1990/91 as part of the SPC Regional Tuna Tagging Project (RTTP). Less time as a result was spent in those two countries. One full week was however spent in Malaysia, with two weeks in total spent on the three country visits.

A third week was spent in Colombo, to consult with IPTP staff, assemble further background information on the projects, present preliminary results of the review, and seek IPTP views on possible future directions for the projects.

A final week was spent at the consultant's base (Nouméa), compiling and comparing the results of both the projects under review and of complementary tagging work in the same or adjacent areas, and completing the report.

Annex 1 provides an itinerary of the study, and Annex 2 a list of persons contacted during the study.

1.4. Status of tuna fisheries

Recent reviews of the tuna fisheries of the three countries are given in papers presented to the Fourth Southeast Asian Tuna Conference in November 1990 (IPTP/91/GEN/19) i.e. Isa and Kamaruddin (1991) - Malaysia; Barut and Arce (1991) - Philippines; Naamin and Bahar (1991) - Indonesia.

Indonesia and Philippines both support large tuna fisheries, with recent landings in the range 250,000 to 310,000 tonnes (t) per year, supplying 13-14% of the total fisheries catch, and contributing a significant proportion of fisheries export earnings. The Malaysian tuna fishery, centered on the East coast of peninsular Malaya, is much smaller, contributing only 2% (20,000t) of total catches of 1,000,000t (Annual Fisheries Statistics 1990), but with possibilities for expansion, particularly in East Malaysian waters (Sabah, Sarawak, Labuan).

The Indonesian tuna catch has doubled since 1980 (Naamin and Bahar, 1991) to 300,000t in 1990, primarily due to the development and expansion of pole-and-line fisheries in eastern Indonesia, and more recently, longline/handline fisheries in several locations for export of quality chilled fish. The eastern Indonesian fisheries exploit skipjack and large tunas (yellowfin, bigeye), oceanic species whose patterns of movement and stock structure (and hence relationship to the large developing tuna fisheries in the adjoining Western Pacific), remain largely unknown. Coastal tunas (kawakawa, frigate tuna) and tuna-like species still provide nearly half of the total catch, mainly through artisanal and subsistence fisheries, but the catch of these species has remained stable since 1980.

The Philippines tuna fishery, with a total catch of approximately 310,000t in 1990, increased steadily during the 1980s. Coastal tunas (kawakawa, frigate tuna) provide 60% of the catch, with some increases in the catch of these species still being recorded. Skipjack and yellowfin catches, which primarily supply domestic canneries, have been stable, or even declining in some cases in recent years. There is some reason to believe that declines in the domestic catch of these species may have been to some extent masked by increased domestic landings of Philippine vessels operating in the western Pacific and Indonesian waters.

The Malaysian tuna catch, primarily from troll and handline catches on the East coast and comprising longtail tuna and kawakawa, peaked in 1987 at 29,000t, but has since declined to 18,000t in 1990. Smaller quantities of oceanic tunas are taken in East Malaysia.

The relative catch by species in the three countries is summarized as Figure 1.

1.5. IPTP role and objectives

IPTP was established with UNDP funding in 1981 (as INT/81/034), and became operational in 1982, with headquarters in Colombo, Sri Lanka. Central to its mandate was the task of assisting member Governments to establish a reliable source of fisheries data for tuna and tuna-like species, upon which they could base their development and management decisions. With additional funding from the Japan Trust Fund (GCP/RAS/099/JPN), also in 1981, the biological aspects of small tunas were to be studied. Since 1989, member countries and regional economic integration organisations have contributed the funds for the UNDP component of IPTP.

The IPTP is in its fourth phase of activities, UNDP funding (INT/91/025) for which concludes at the end of 1993. The supplementary JTF funding was also

extended to 1993, following a favourable review of the first ten years of operation in January 1991.

The overall work plan of GCP/RAS/O99/JPN, "The Investigation of Indian Ocean and Pacific Ocean Small Tuna Resources" as listed in Annex 3, provides specifically for "the conduct of pilot activities to determine possible tagging and sample techniques for small tunas, including in-depth evaluation of the fishing techniques used in the artisanal fisheries in selected areas of the IPFC/IOFC area using, when necessary, locally chartered vessels which can be funded by national governments". All work plan activities were to be carried out in close collaboration with existing international organizations, including FFA and SPC, and the relevant FAO regional projects e.g. BOBP, SWIOP, ASEAN SSF.

The intent was, and clearly still is, for IPTP to assist countries with the design and initiation of appropriate tagging projects on a national rather than international scale, utilizing local vessels, by providing technical expertise and advice. Operational costs in the main would be met by national governments. IPTP support would be provided with data processing, where necessary, and analysis of results. Equipment for tagging experiments (tags, applicators) and costs associated with information/publicity campaigns (poster printing) could also be covered by IPTP.

Financial summaries of IPTP inputs to tagging projects are provided where available under the national reviews.

2. FEATURES OF TUNA TAGGING PROGRAMMES IN GENERAL

2.1. Rationale for tagging experiments

Tagging experiments are so heavily relied upon in tuna research that it is useful to consider the rationale for their use. Tuna populations, particularly those of mobile oceanic species which demonstrably can move thousands of miles, are difficult to directly observe and measure in their potentially vast three-dimensional habitat. Additionally, the cost of surveying/monitoring such areas would be prohibitive. Tagging experiments aim to mark and release a portion of the population which, after mixing with the population at large, can be assumed to be representative of the total population, and more amenable to study.

The pattern of tag returns in time and space can be used to provide information on movement, stock structure, growth and, in carefully designed experiments where reasonable catch and effort data are available, an understanding of population dynamics and estimates of potential yield.

Tagging experiments make many assumptions and incorporate many variables. Some of the key assumptions are that the tagging process does not unduly modify the behaviour of tagged fish relative to non-tagged fish, and that tagged and non-tagged fish have identical and independent survival and capture probabilities. With careful design and execution, tagging can be a useful research and management tool, providing information not readily available in a cost-effective manner from any other source. Hampton (1989) provides a good account of the experimental design features for the estimation of growth, mortality, population size, movement and interaction from tagging experiments.

2.2. Tagging techniques

Techniques for the tagging of tunas are shaped by the physiological characteristics of the fish:

- high oxygen demand, associated with the constant high speed swimming, and supplied by ramjet ventilation;
- high metabolic rate and internal heat retention mechanisms, which see lactic acid build up and a rapid rise in internal temperatures during capture;
- susceptibility to damage during capture, and during struggles when out of the water, due to the soft skin and the sub-cutaneous location of some key physiological features;

These characteristics mean that the capture time and the time spent out of water during tagging must be minimized, and great care taken when handling these powerful but vulnerable fish.

Additionally, the tag applied must not result in excessive hydrodynamic drag on the fish, and be firmly anchored so as to be retained during constant high speed movement.

Given these criteria, the use of pole-and-line gear as the capture method, since fish can be delivered in a few seconds without damage or excessive struggle, and dart tags well anchored under the second dorsal fin, has become the preferred approach for the tagging of small to medium sized tunas. Shomura (1987) reviewed tuna tagging options for IPTP, and noted that, whilst other gears can be used e.g. trolling, handline and longline, extra capture and/or handling time is involved, and they generally result in fewer fish being caught, as well as typically lower return rates, presumably due to increased tagging mortality.

Tagging tunas caught by encircling nets (purse seine, ring net) remains an attractive option, if only because of the large number of fish available from these gears, but the long confinement time in the net during hauling and stress resulting from lowered oxygen levels, remains a major difficulty, as does the physical damage sustained in the crowded net and when being netted for tagging.

Pole-and-line gear does have some potential constraints, in that a supply of suitable live bait is required, and this cannot always be assumed. The gear also does not usually catch larger fish (> 10 kg), although this has been achieved in some recent cases. Cradles, or some similar arrangement for landing the fish on a non-injurious surface, confining and measuring it prior to release, are often used.

The use of other gears to supply tunas in optimal condition for tagging will generally require some modification of normal capture methods and the development of special handling techniques. This may not always be possible, but in some situations, there is no choice but to pursue such options, at least on a trial basis.

Fish may be doubled tagged (two tags placed independently on opposite sides of the fish) to provide estimate of tag loss through slippage; tags may also be discreetly "seeded" in commercial catches to provide information on the level of non-reporting of tagged fish, at least during the post-capture period.

Other types of tags, such as sonic tags and archival tags, are available for use in tuna tagging experiments. While they provide much more detailed data on fish movement and behaviour than the point-to-point information provided by conventional tags, their high unit cost has thus far deterred wide scale use. Sonic tagging experiments have however been an invaluable source of behavioural data on diurnal and vertical movement patterns of tunas on local scales over short time periods, in response to features of the environment and endogenous physiological requirements.

2.3. Publicity and tag recovery

Publicity is clearly an important component of tuna tagging programmes, particularly those involving oceanic tunas which may be captured by subsistence and artisanal, national commercial/industrial and international tuna fisheries in numerous countries over a wide area. Considerable effort may be required first to ascertain what countries and fleets need to be covered (extensive migration should be assumed), and to ensure the information campaign reaches all possible tag finders: landing points and processing plants (canneries), as well as capture fisheries, need to be covered, and information material in local languages will usually be required.

Publicity is ideally directed at three levels - a public level, involving the use of posters displayed in markets, landing points etc. and the media (radio is particularly effective, in that most people, however poor, have access to this medium, but also television and newspapers), a mail-out level, where material in accessible form is sent to fishing companies, fleet owners and prominent individual fishermen i.e. the next interest level down from the general public, and finally, direct personal contact with fishermen and others potentially capturing or handling tagged fish.

The success of any tagging programme is ultimately dependent on the cooperation of fishermen in returning tags, with necessary information. Efforts must be made to convince them that it is in their long-term interest to return tags with accurate information, or at least unlikely to be a negative influence. This may not always be easy where, for example, fishery access is restricted and contentious, and political complications exist.

A reward for the return of the tag and recapture information will normally be offered, reinforced perhaps by lotteries in large scale international programmes. Initial publicity efforts should be repeated at intervals during the experiments, and information regularly fed back to tag finders.

Appropriate mechanisms for the recovery of recaptured tags need to be put in place, often using selected contact points in each country of release and expected return. It is additionally effective if such contact points can distribute rewards on the spot. Recovery forms clearly setting out the information required of finders, in local languages, normally prove to be very helpful.

Allocation of adequate resources, including funding, to publicity and tag recovery efforts is clearly a crucial decision in the design of tagging experiments. International tuna tagging programmes typically allocate far more time to field aspects of the work, when it may be more appropriate in some cases to allocate approximately equal resources to publicity and tag recovery efforts.

2.4. Analysis and interpretation of tagging data

Analysis of the tagging data should initially involve some examination of the assumptions inherent in tagging experiments.

Interpretation of tag return data will be greatly assisted by access to relatively complete catch and effort or landings data for all fleets reporting tagged fish (as well as those not). The data may also be applied to models such as attrition models, where the rate of decay of tag return rates with time is partitioned into its main components - natural mortality, fishing mortality, tag loss (slippage, non-reporting) and emigration. The parameters estimated can then, in combination with the available catch/effort data, be entered to equilibrium or other models to estimate

turnover, exploitation rate, potential yield and other dynamics of the exploited population.

2.5. Evaluation of national tagging programmes

The three national programmes have been evaluated with reference to a set of features or guidelines common to successful tuna tagging programmes with which the consultant is familiar. The guidelines cover most aspects of the experiments - statement of objectives, planning, experimental design and implementation, results and analysis/reporting. The results of relevant tagging experiments in the same or adjacent areas are considered, and some conclusions drawn on the success of the programmes in meeting stated objectives. The guidelines are listed as Table 1.

It is recognized however that the programmes being reviewed were largely exploratory in nature, with tuna movements in the ASEAN area poorly understood, and little or no history of tuna tagging in the area. Figure 2 shows the general locality of the programmes.

2.6. Tagging programmes by other regional and national agencies in the IPFC/IOFC area

Given the need to coordinate IPTP activities with those of other agencies active in tuna research, and given also that national tagging programmes involving oceanic tunas cannot be considered in isolation, the results of other tagging programmes have been briefly reviewed in the evaluation, and particularly in considering future tagging work. These are summarized in the table below, and are considered in more detail when relevant national programmes are reviewed.

WESTERN PACIFIC (FAO AREA 71)

Papua-New Guinea	DASF, 1971-1976 Skipjack and yellowfin, 9,500 releases Pole-and-line Longtail tuna, 414 releases Handline and troll
Japan	TNFRI 1968 - end of 1991 114,169 skipjack, 6,017 yellowfin, 519 bigeye. 95,500 skipjack releases Pole-and-line, some purse seine
Japan	JAMARC, 1985-present 5,000 skipjack and yellowfin (?) Pole-and-line and purse seine
SPC	SSAP, 1977-1981 140,443 skipjack, 9,596 yellowfin and 98 bigeye Pole-and-line
SPC	RTTP, December 1989-April 1992 85,278 skipjack, 32,112 yellowfin, 6,161 bigeye, and 82 longtail Pole-and-line, some handline and purse seine

INDIAN OCEAN (FAO AREAS 57, 51)

IPTP/MFAM	Maldives, 1990 8033 skipjack,1908 yellowfin Pole-and-line, some handline
Japan	JAMARC, 1981-1990 2139 skipjack, 3749 yellowfin, 1344 bigeye Purse seine
IOC	Association Thonière, 1988-1989 359 skipjack, 419 yellowfin, 175 bigeye Pole-and-line

3. NATIONAL TAGGING PROGRAMMES

3.1. PHILIPPINES

3.1.1. Background

Tuna fisheries in the Philippines, employing a great diversity of gears for the capture of the various species (de Jesús, 1982), are widely spread throughout the densely populated archipelago, and involve a significant proportion of the country's 60 million population in subsistence/artisanal (municipal) and industrial fisheries. This list of gear types does not however include pole-and-line, involving the capture of live bait for tuna fishing, since those bait species typically used have a nominally higher value as food. There have however been live bait/pole-and-line surveys in the past (see Lee (1978)).

Industrial fisheries for the primary market species of tuna (skipjack, yellowfin) are concentrated in southern areas (Moro Gulf, southern Sulu and Celebes Seas) and more recently, the South China Sea, with purse seine and ring-net vessels, although these tunas are caught throughout the Philippines (Barut and Arce, 1991).

Tagging experiments, in this case to investigate movements and stock relationships, thus have some potential constraints in the Philippines situation, in that the accepted optimal gear for tagging, pole-and-line fishing, is not available.In addition, the fishery is a widespread multi-gear one, involving large numbers of fishermen not always easy to establish contact with, and landing their catch at a great number of locations.

The joint Indonesian/Philippine tuna working group recommended as early as 1981, and even earlier in an SCS working group (SCS/GEN/79/21), that a joint tuna tagging programme be implemented as soon as possible, to monitor movements of skipjack and, to a lesser extent, yellowfin, determine inter-relationships with other fisheries in the region and estimate parameters required for stock assessment (IPTP/82/GEN/3).

In November 1985, a five-year tuna tagging plan, to start in 1986, was proposed by the Bureau of Aquatic Resources and Fisheries (BFAR), for IPTP support. There remained some doubts concerning the suggested use of ring net gear as the capture method, and further study of this was recommended (IPTP/85/GEN/8). Two proposals for tagging, employing respectively a Japanese pole-and-line training vessel for medium-sized tunas, and a commercial ring net vessel for juvenile tunas, were then presented to the 1986 meeting (IPTP/86/GEN/10). Previously available funds had however been withdrawn.

The following year, a review of possible options for tagging in the Philippines, as well as Indonesia and Malaysia, was undertaken, and indicative budgets prepared (Shomura, in IPTP/87/GEN/12). Philippine options included charter of pole-and-line bancas, the use of ring net vessels with operational modifications to reduce capture stress, conversion of a vessel for pole-and-line operations, and charter of a foreign pole-and-line vessel.

In late 1988, plans for the tagging work were finally confirmed, and a Japanese scientist made available, along with an IPTP tuna biologist based in Indonesia, to initiate the work in southern Mindanao, utilizing ring net and purse seine vessels.

3.1.2. Objectives

The Bureau of Fisheries and Aquatic Resources (BFAR) five-year master plan for tuna and skipjack tagging outlined the following objectives :-

> " To gather information on stock identity, migration, growth, food habit and maturity of skipjack and other tunas present in Philippines waters for management and development of the resource."

IPTP assistance was sought for the provision of expert advice and purchase of equipment.

3.1.3. Planning

The master plan provided for tagging throughout the waters of the Philippines, involving commercial purse seine and ring net vessels (Annex 4). Two hundred days of field activity per year were proposed, with a yearly budget of 1,020,000 Pesos (approximately US$40,000).

With IPTP assistance, the Japanese scientist and the IPTP fishery biologist were made available in September 1988.

Skipjack were nominated as the priority species for tagging, with yellowfin and bigeye also to be tagged. Five areas were designated for tagging activity according to the following schedule:-

- Moro and Davao Gulfs, and Mindanao Sea
- Sulu Sea (all parts) and Bohol Sea
- South China Sea and Luzon Sea
- North Philippine Sea (Pacific Ocean)
- South Philippine Sea.

Eight BFAR staff were to be involved for varying proportions of their time.

Concomitant biological sampling of tunas at landing points throughout the Philippines was also planned.

3.1.4. Design of the tagging experiment

Given the various uncertainties associated with tagging from Philippine purse seine and ring net vessels, a first cruise was planned for late September 1988, when the feasibility of tagging on board such vessels would be assessed and test tagging carried out. The payao-associated operations do have the distinct advantage that only one set is normally made each day, allowing ample time to tag fish from the partly hauled net, with the cooperation of the vessel crew.

Compensation for fish tagged and released was to be paid according to the prevailing market value of the fish - 10.00 P. per kg in 1989-90, and 15.00 P. per kg in 1990-91. Some vessel charter had originally been budgeted for, but insufficient funds were available to operate in this way.

No nominal targets were set for the project, but it was assumed that as many fish as manpower, time and fishing conditions would allow would be tagged, with skipjack being the priority species.

Industry support for the work was apparently strong, and cooperation good.

3.1.5. Tagging methods

Methods are described in detail in Ishida (1989 - WPFCC Tuna Workshop), Shiohama and Ishida (1990), Anon, (1989), and Barut and Arce (1991).

A team of four people was used whenever possible - a fish scooper, a fish handler, the tagger and a recorder.

Yellow 'Hallprint' tags - 100mm by 1.5mm diameter - were used. These were considered appropriate for the size of fish expected to be tagged i.e. 20 - 30cm caudal fork length (LCF). Larger tags were recommended for fish over 40cm. The tags were stored after checking in cloth holders, in sequence, in lots of 100.

Active tunas were scooped from the net by a nylon mesh scoop 45cm in diameter, and brought on board, where they were placed in a cradle for tagging. Often, more than one tuna was scooped and several fish tagged from one scoop. It is difficult to gauge the quality of fish (i.e. physiological fitness), both on removal from the confines of the net, and subsequent to tagging; similarly, no estimates of the time taken to tag tunas after removal from the net are available. Some idea can however be gleaned from video footage taken at the time of the first and second cruises, and observations made by an SPC RTTP scientist who participated in one short tagging cruise (Bailey, 1989). Improvements in handling since the earlier cruises were noted, with more rigorous selection of active fish, only one or two fish scooped at a time, and times out of water averaging 10 seconds. Despite this, it was estimated that 32% and 11% of releases in two sets probably did not survive the tagging process.

It is therefore concluded that the quality of many fish tagged was not optimal.

The duration of tagging time following the hauling of the net is not known in all cases, but Bailey (1989) records total hauling times of two hours for two ring net hauls in 1989, excluding tagging time, which was respectively 12 and 16 minutes for catches of 2.0 and 1.6t. With larger hauls, tagging times were probably much longer. The numbers of fish tagged per day (one net set per day) suggest it may have been considerable. Over 350 fish were tagged per day on average, with only one tagger on most days (see below).

A description of the tag placement (Shiohama and Ishida, 1990, p.4) suggests that, in some cases, it may have been placed too low down on the side for fish of the size tagged, providing insufficient anchorage and increasing the risk of damage to mid-lateral red muscle mass. Bailey (1989) does indicate this had been largely rectified in the case of at least one principal tagger.

The cradle used in the experiments, a sheet of transparent vinyl chloride slung in a wooden trough at deck level, seems to have been excessively deep for the size of fish tagged, but may have been useful in confining the fish while they were measured and tagged.

Individual lengths were measured to the nearest cm.

No quality control criteria are mentioned, but possibly were noted by the recorder.

No double tagging was carried out; there is reference to tag seeding during cruise 2 (Shiohama and Ishida, 1990), but this was not pursued.

3.1.6. Publicity

Posters in English and Tagalog were prepared to publicize the project, supported by radio broadcasts, newspaper articles and visits to some fishing areas. Much of this material was unfortunately not distributed until well after the tagging had started, due to delays in printing posters.

A reward of a shirt bearing the project logo was offered.

Some effort was generally made to provide tag finders with information on the release of recaptured fish.

Given the special difficulties posed by the Philippines fishery for tag recoveries, with large amount of small-scale fishing spread out over a wide area, with a multitude of landing points, the amount of publicity undertaken may not have been sufficient.

3.1.7. Tag releases

On seven cruises between 27/9/1988 and 1/11/1990, a total of 10,723 tuna were released, consisting of 5,722 skipjack, 4,405 yellowfin and 240 bigeye tuna. 30 tagging days were involved, and both ring net and purse seine vessels were utilized. Two teams operated concurrently on ring net and purse seine vessels on three of the cruises. Releases by species for the two gears are shown in Table 2.

All but 251 of the releases were made near the Moro Gulf, in the northern and western Celebes Sea (3°N-6°N, 121°E-124°E). The remainder were made on a short cruise in the South China Sea in April 1990 (10°-30"N-11°30"N, 115°E). Summary data on the releases are given in Table 3, and in more detail in the four reports listed above. Release locations are shown in Figure 2.

The size of the releases by species is summarized in Figure 3. Although the size range of tuna of all species was 15-55cm LCF, the great majority of fish tagged were in the 25-30cm range.

Few biological data were collected, as ample opportunity for this existed with port sampling programmes, but plankton tows to collect tuna larvae were made on one cruise.

3.1.8. Tag recovery mechanisms

Tag returns were subsequently made, as expected, from a variety of sources throughout the Philippines. Table 3 lists the number of returns received from the various fishing gears in use. Returns were made through fishing companies, BFAR regional offices, and direct from fishermen. Standard forms on which to record the required data were not however used.

Many returns were accompanied by very little, or even incorrect, information (Anon., 1989). All reported recaptures were made by domestic vessels.

Rewards were paid on receipt of tags directly from BFAR Manila. This often resulted in lengthy delays in the payment of rewards.

Recapture data were entered on a rather basic dBase IV programme developed by an IPTP staff member on a visit to Manila.

3.1.9. Tag returns

A total of 225 returns had been received by the end of April 1992. It is not anticipated that significant numbers of additional returns will be received. There are however reports of tags recovered, but being retained by fisherman for various reasons. The overall return rate thus stands at 2.05%.

141 skipjack (2.4%), 80 yellowfin (1.7%), and 4 bigeye (1.7%) were returned. There was no apparent difference in the return rate of fish tagged by purse seine and ring net respectively. Return rates by cruise were generally uniformly low, except for the 4th cruise, when return rates of 13.9% (from 868) and 4.1% (from 410) for yellowfin and skipjack respectively were achieved.

Of the 225 returns, 197 were accompanied with some recapture data. Only in 74 of these 197 returns (37%) was the recapture gear specified. The number of returns, by species and recapture, is summarized in Table 4. Purse-seine (35) and handline gears (27), both presumably fished in association with payaos, accounted for most recaptures where information on recapture gear was available.

The size at release for fish subsequently recaptured does not appear to show any evidence for differential tagging mortality, with 90% of the yellowfin, and 70% of the skipjack returns comprising fish 30cm or less at release. This does not differ from Figure 3.

Most returns were made within 60 days of release (approx. 80% for both skipjack and yellowfin); the longest periods at liberty were 686 days for skipjack, and 430 days for yellowfin. Approximately 20% of recaptures were not accompanied by accurate data on date of recapture, and a much higher percentage were without accurate lengths at recapture.

As noted above, all returns were made within Philippines waters, nearly all in areas adjacent to the point of release.

The amount of non-reporting is not known, but, on the basis of anecdotal information, is believed to be considerable. Reasons given for not returning tags have included lack of awareness of return procedures, rewards insufficient to take the trouble to take or send the tag to a central location, and a belief that the tag is more valuable as a personal charm or talisman than the reward offered. Returns from industrial vessels were probably good, but clearly the difficulties of achieving good reporting from municipal and artisanal sources are formidable. The municipal sector has accounted for slightly more of the estimated skipjack catch than the commercial sector in recent years, and the municipal sector takes considerably more yellowfin (although this includes the handline catch of sashimi tunas). There may be as many as 1,500 registered commercial vessels (i.e. > 3 GRT), and many times that number of smaller municipal vessels. There are, for example, 8,000 handliners in General Santos alone fishing for sashimi-grade tunas (Barut and Arce, 1990).

No estimates of biological parameters, such as growth and mortality, have been made from the tagging data. With the relatively small number of returns and the poor quality of some of the return data, this is understandable. The data set could however be examined to see if there are sufficient reliable data to provide preliminary growth estimates, given the general lack of growth data on tropical tunas of the 25-30cm size range.

3.1.10. Analysis of data

No analyses of the data have been attempted, given the small size of the database and problems associated with it.

No returns were made outside Philippine waters, this result providing, at face value, no additional understanding of the relationship with other fisheries in the region. However, as will be seen later, this may be significant.

Even returns made within Philippines waters have mostly been on a local scale and short-term in nature. In the absence of good catch and effort coverage, it is difficult to interpret local movement patterns.

3.1.11. Reporting

Three detailed reports on the tagging experiments have been prepared, and other accounts given to various international meetings e.g. WPFCC TRC, SEATC.

3.1.12. International Cooperation

Since the tagging programmes in the Philippines and Indonesia were first conceived, there has been regular consultation through the series of tuna working groups and workshops, which eventually transformed into the broader South East Asian Tuna Conferences; dialogue also occurs through the Expert Consultations on Indian Ocean Tunas.

IPTP support allowed two scientists each from Thailand and Indonesia to join the second tagging cruise in November 1988, in addition to the Japanese scientist and the Jakarta-based IPTP fishery biologist. Assistance was also given with international publicity for the tagging programme.

An SPC scientist joined one of the national tagging cruises, in October 1989, and suggested various improvements to tagging methods that appear to have been adopted on later cruises. With the visit of the SPC Regional Tuna Tagging Project (RTTP) chartered vessel to the Philippines on two occasions (July 1990, April 1991), cooperation between BFAR and SPC has increased markedly. Philippines, along with Indonesia, regularly participate in the Standing Committee on Tuna and Billfish (SCTB), the peer review group for the SPC Tuna and Billfish Assessment Programme (TBAP). This increased cooperation is logical, in view of the probable shared nature of tuna stocks exploited by Pacific island countries and Philippines/eastern Indonesia.

3.1.13. Results of other tagging work in the same area

a) Releases in the Philippines

As noted above, the SPC RTTP made two visits to the Philippines in July 1990 and April 1991 with the chartered pole-and-line vessel *Te Tautai*, providing for the first time the opportunity to tag and release with this capture method in the Philippines. Despite some difficulties with bait capture, the vessel was able to release 6,117 tuna (5,074 skipjack - 83%), mostly in the Sulu Sea (see Appendix 1 for details; also Bailey and Lewis (1990), and Itano (1991).

By 23/4/1992, 655 returns, or 10.7% overall, had been received, with tags still being returned. This contrasts markedly with the return rate achieved by the national programme, and is attributed to several factors:-

- The higher survival rate of the pole-and-line caught fish, and better tag placement, at least relative to the earlier cruises.

- The generally larger size of fish tagged by the RTTP, with over 95% of fish over 30cm, and most over 35cm. However, return rates comparable to the overall rate were recorded for the modest number of small fish tagged, mostly in the Moro Gulf (150 fish <35cm, for 18 recoveries -12%).
- The greater attention (and direct funding) given to publicity efforts and recovery mechanisms. Nonetheless, it is believed that non-reporting was still considerable with the RTTP tags, given several examples coming to light of fishermen in remote areas retaining tags since it was not known what to do with them.

Most RTTP recoveries were made in Philippines waters (95%), but some 30 were made in the EEZs of other countries, as follows :-

- Indonesia 3, Japan 1, Malaysia 1, Palau 3, Federated States of Micronesia 1, Solomon Islands 1, Papua New Guinea 20[1], and 6 others without accurate recapture data, but known to have been taken outside the Philippines.

These data provide some preliminary indication of the apparently limited outward movement of tagged tuna, particularly southwards to adjacent Indonesia.

b) Recaptures in the Philippines

Several tagging programmes in the western Pacific have provided significant numbers of tag returns in Philippine fisheries.

Japanese tagging activity in the area northeast of the Philippines (14°-21° N, 131°-144° E) during the period 1978-1987 resulted in 56 recoveries of skipjack in Philippine fisheries and 4 in Indonesia. Releases in equatorial waters produced relatively few returns in the Philippines (Ganaden, 1987).

The SPC Skipjack Survey and Assessment Programme (SSAP), tagging over a wide area of the western Pacific during 1977 to 1981, resulted in 8 recoveries in the Philippines (7 from nearby Palau, and one from FSM) and 31 in Indonesia.

Releases during the Indonesian national programme have resulted in only one recovery in the Philippines.

The SPC RTTP releases in Indonesia resulted in only two returns in Philippines waters, whereas 70 returns were received from a wide area of the western Pacific, including Papua New Guinea, Palau, FSM and high seas areas. RTTP releases from other areas of the western Pacific (i.e. excluding Indonesia and Philippines) have resulted in only 10 returns in the Philippines to date, with the majority from Palau releases.

These data on incoming tagged fish are also indicative of relatively limited movement into the Philippines from other areas, with the possible exception of the northern Philippines Sea. No tagging has been done in the South China Sea, to the West, and the relationship of fish in this area to fish in the adjacent Sulu Sea in particular remain unknown.

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[1] Some uncertainties remain about the veracity of these returns.

3.1.14. Conclusions

The relatively low recapture rates in the Philippines tagging experiments have been disappointing, as the work was the subject of considerable careful planning and diligent implementation. The recapture rates per se (~ 2%) would not necessarily give cause for concern, were it not for the fact that pole-and-line releases in the same area have subsequently provided return rates of up to 16%.

The choice of gear to supply fish for tagging was constrained in the national context by the absence of preferred pole-and-line vessels. The fish released after capture by ringnet and purse seine gear were clearly in fair or even poor condition, and tagging mortality was almost certainly quite large, particularly given the small size (25-30cm) of fish being tagged. This factor, along with an unknown amount of tag slippage, probably accounted for the majority of the observed depression in tag return rates.

It is the consultant's view that successful tagging of small tunas from such vessels may yet prove feasible, if the tagging activity was transferred to water level, using a small vessel (rubber inflatable) alongside the confined net, to more efficiently scoop and tag fish in a shorter time, whilst also being more readily able to assess the condition of individual fish. SPC experience with tagging from Japanese group seiners on a trial basis (Itano,1991), which achieved a return rate of 21.6% with larger fish, recommended that the scoop net design and construction was important, with a suitable mesh size to limit entanglement, soft lay material of knotless construction, and shallow depth to facilitate removal of fish.

The time frame during which fish could be tagged and released after confinement might also need to be reduced. Complete cooperation of the vessel crew would be essential, and would possibly involve some additional incentive payment, as it may take some time to also adjust the hauling methods as well.

The Philippines payao fishery, with the single net set per day, probably still represents the best opportunity to develop a routine tagging technique for the small tunas about which so little is known. A recent attempt was made in the Philippines to adopt some of the approaches outlined above, by tagging from a small dinghy at water level, and restricting tagging of yellowfin and bigeye to ten to fifteen minutes only after net confinement. Results of this work are awaited with interest.

Given the difficulties of achieving full coverage of all possible sources of tag returns in the complex Philippines situation, the publicity efforts were inadequate. The initial campaign was late, and subsequent efforts were limited by funding constraints. A good tag recovery system, with sufficient contact points, was not established, with nearly all contact handled from Manila and unavoidable delays in feedback to finders and reward payment. These facts underline the vital need to adequately budget for information campaigns, both initially and regularly thereafter, and to plan for a manpower commitment which may approach the time allocated to the initial fieldwork.

Associated with this was the relatively poor quality of the return data provided, thus limiting the value of the already small data set. An established procedure for the return of tags, utilizing tag return forms and verification procedures at the point of return, would have greatly assisted in this regard.

The catch/effort data available at present probably do not allow local movements within Philippines waters to be interpreted from tagging results, and if further work was planned to meet the original objectives, this situation should be improved. Unfortunately, Government policy in the Philippines has seen, since

1988, a downgrading in the priority and funding allocated to the fisheries statistical system.

In conclusion, it must be said that the results of the tagging experiments have gone only a small way towards meeting the original objectives. Some useful experience has been gained in attempting to utilize gear types which were known beforehand to present considerable problems, and this experience may be applied to any future work planned with these gears. In the short term, the use of pole-and-line gear represents the best opportunity for meeting the project objectives, albeit at greater cost, given the need for external charter. The desirability of continuing to develop and improve purse seine/ringnet tagging techniques should be recognized.

3.2. INDONESIA

3.2.1. Relevant background

Indonesian tuna fisheries involving the capture of oceanic species on an industrial scale began to develop during the 1970's in eastern Indonesian areas which are generally sparsely populated and less well developed than other parts of the vast archipelago. Pole-and-line gear was the technique of choice in the State-driven development plans for the area, given the adequate supplies of bait, the abundance of surface-schooling tunas in these internal waters, and the relative technical simplicity of the fishing method.

As these developments were taking place concurrently with the rapid expansion of the western Pacific tuna fishery, the need to understand the relationship between the exploited stocks in the two areas was voiced as early as 1979, and calls for extensive tagging and blood sampling, involving skipjack as priority, were made in several scientific meetings (SCS/GEN/79/21; Workshop on Assessment of Selected Tuna and Billfish Stocks in the Pacific and Indian Oceans, Shimizu, 13-22/6/1979). The Indonesian Government requested that the SPC Skipjack Survey and Assessment Programme visit Irian Jaya during July 1979, but difficulties were encountered on entry. It was reported that the Indonesian Government had already formulated a tagging project on a national scale at this time (SCS/GEN/79/21), but funds could not be identified to allow it to proceed.

In 1983, a plan for tagging in Indonesian waters, with GCP/RAS/099/JPN funding support, was favourably reviewed by the Philippines/Indonesia joint tuna workshop (IPTP/83/GEN/4), and the urgency of initiating the work as soon as possible stressed. An IPTP-funded scientist was despatched to Jakarta in June 1983 to finalize plans and initiate the tagging experiments, which commenced in December 1983, utilizing local pole-and-line vessels based in Sorong, Irian Jaya.

3.2.2. Objectives

Initial priority was given to the study of migration and stock relationships of skipjack and young yellowfin in eastern Indonesian waters, to "clarify the extent of intermingling of the stock there with Philippines or further offshore (western Pacific) stocks". It was expected that information on growth and estimates of mortality rates would be generated at the same time.

3.2.3. Planning

The charter of local pole-and-line vessels of two sizes was approved, with skipjack and young yellowfin as the target species. Activities would initially focus on Sorong (October - December), then Bitung, North Sulawesi (January-February). It

was anticipated that the probability of recapture would be high, given the level of exploitation in Indonesian and adjacent western Pacific waters.

Two Philippine biologists were attached to the project at an early stage in the implementation. Otherwise, two Indonesian scientists (BPPL) and the IPTP expert were to be involved throughout the project.

No time frame was attached to the project, with planning to proceed on a year-by-year basis, according to results achieved.

All funds for the project, with the exception of IPTP scientist travel costs and equipment purchase (tags), were provided by the Indonesian government. Charter costs were waived by the State enterprise companies operating the vessels utilized, and compensation paid for the fish tagged at commercial rates.

Improved statistical coverage of landings and some biological sampling had earlier been initiated at the main landing points of Sorong, Bitung, Ambon and Ternate.

3.2.4. Design of the tagging experiment

Two vessel sizes were evaluated during the initial tagging period in December 1983: the widely used 30 GT wooden pole-and-line vessel with crew of 16-17, using ice and undertaking 5 to 6 day trips, and the large 300 GT steel Japanese vessel, with a crew of 30, and undertaking 1 to 2 month trips.

After the initial cruise, the smaller vessel type was opted for because of the greater ease of handling and tagging fish, under safer conditions, despite their more limited operational range.

Nominal targets of "more than 2,000 fish" were set for the two initial tagging periods off Sorong and Bitung respectively.

After the relative success of the first tagging period, the second period was re-scheduled to involve simultaneous tagging in three locations - Sorong, Bitung and Ambon (Banda Sea) - all from 30 GT vessels operated by State enterprises in each location.

Further work, after a lapse of two years, was undertaken in Bitung in January/February 1986, Labuha (Halmahera) in November 1990 and October 1991, and Luwuk (North-East Sulawesi) in November 1990. Most of these second phase releases were associated with payaos (rumpons) deployed in eastern Indonesian waters from 1984 onwards.

The timing of the experiments was to coincide with peak fishing seasons in each location where possible.

Industry support for the work was strong, at least in terms of the State enterprises, and cooperation good.

3.2.5. Tagging methods

Methods are described in detail in Yonemori *et al.*(1985), Gafa *et al.*(1987) and Gafa and Susanto, in press. A tagging manual had earlier been prepared as part of the initial operational plan.

A team of three people was generally used - one person to provide fish to the tagger from the deck, a dedicated tagger, and a recorder to note species and length, with a tape recorder back-up.

Two tag types were used initially, both yellow dart tags - a polyurethane 140 mm by 3 mm "A" series tag, and a smaller nylon 115 mm by 2 mm "B" series tag, with appropriate stainless steel applicators. During the 1990/1991 experiments, yellow 'Hallprint' tags (100 mm by 1.5 mm "C" series) were used. The tags were stored in canvas holders in ordered series of 50.

On the 30 GT vessels, tunas were poled directly onto the bow deck, which was covered with 10 sheets of 6cm thick foam rubber. These sheets were initially uncovered, which may have resulted in significant mucus loss on initial contact, but were covered with plastic during the 1990/1991 experiments.

Active fish in good condition were checked for damage, and physically carried to a tagging cradle (heavy duty plastic slung off an aluminium frame), measured to the nearest cm (LCF), and released over the starboard side. The cradle was stationed just behind the aft end of the raised bow deck. It is reported that as many as 60 to 70% of fish landed could be tagged with this method (Uktolseja, pers. comm.). It is not clear if care was taken to keep the cradle wet and clean, to minimize mucus loss, although this was clearly specified in the tagging manual.

The time typically taken to tag and release fish from hook-set is not known, but it was suggested by staff involved that the time from arrival in the cradle to re-entry to the water may have been 20 seconds plus in most cases. The relatively deep cradle would not have assisted in this regard. With the time taken to select, retrieve and carry the fish 3-4 metres to the cradle for tagging, the total tagging time in some cases is felt by the personnel involved to have exceeded one minute in some cases. There was unfortunately no video or movie footage of the operation to enable this to be verified.

Tag placement, on the basis of instructions provided in the manual, appears to have been good i.e. beside the second dorsal fin.

Skipjack were tagged as priority, with yellowfin also tagged when available. Juvenile bigeye were taken and recognized, but not tagged.

No double tagging or tag seeding was carried out.

3.2.6. Publicity

Posters publicizing the project were printed in English and Indonesian, and widely distributed within Indonesia and beyond, the latter with the help of international organizations. Rewards of T shirts and towels were offered to finders of tags.

With the relatively small number of landing points for oceanic tunas in Indonesia, at least relative to the Philippines, and the low level of artisanal fishing activity directed at these species in eastern Indonesia, adequate publicity coverage on a local scale was clearly achievable. The support of State enterprises was good; it is less clear how effective the coverage was of the private enterprises which predominate in some fishing areas e.g. Kendari, Kolaka (South Sulawesi), Ternate, Maumere.

3.2.7. Tag releases

A total of 10,247 tunas were tagged and released during the period December 1983 to October 1990. As can be seen from Table 5, most of these were skipjack (9,355, or 91 %), as per established priorities, and the remainder yellowfin. Over 6,400 fish were tagged during the first two periods (December 1983 to June

1984), with a further 1,400 during 1986 at Bitung, and 2,031 and 373 at Labuha and Luwuk respectively during 1990/91.

In terms of releases by area, approximately 3,000 fish were released in both Sorong and Bitung, 2,000 fish near Ambon and Labuha, and a smaller number (400) at Luwuk.

Prior to 1986, all releases were made on unassociated schools; during 1986, in Bitung, a small number of payao-associated fish (~60) were tagged and released, and subsequent to that, all releases involved payao-associated fish.

The size of fish tagged and released is given in the various published summaries and shown in Figure 4, but can be summarized by cruise and species as follows:-

Skipjack

Sorong 12/1983 - 1/1984	:	29-59cm, but most 44-55cm
Sorong 4/1984 - 5/1984	:	34-62cm, but most 45-56cm
Ambon 4/1984 - 5/1984	:	24-64cm; most 40-55cm, but modes at 30,36 and 40cm
Bitung 4/1984 - 5/1984	:	26-58cm, but most 38-50cm
Bitung 1/1986 - 2/1986	:	24-57cm; most 40-53cm, but smaller mode at 31cm
Bacan, Luwuk 10/1990	:	30-54cm; mean 43.4cm
Bacan 11/1991	:	no data.

The great majority of skipjack tagged were thus in the 45-55cm size range, with small numbers of fish 40cm or less. The payao-associated fish appear not to have been significantly smaller than unassociated fish.

Yellowfin

Sorong 12/1983 - 1/1984	:	24-69cm; modes at 34 and 50cm
Sorong 4/1984 - 5/1984	:	33-66cm, modes at 42,46 and 54cm
Ambon 4/1984 - 5/1984	:	25-63cm; most 25-45cm
Bitung 4/1984 - 5/1985	:	25-56cm; most 40-50cm
Bitung 1/1986 - 2/1986	:	21-57cm; main mode 28cm
Bacan, Luwuk 10/1990	:	34-57cm; mean 47cm
Bacan, 11/1991	:	no data.

Yellowfin sizes were thus more variable, with a higher proportion of fish tagged both smaller than 40cm, and larger than 55cm.

Figure 4 provides a total size distribution of releases, by species, provided by BPPL. It should be noted that, according to tagging project staff, priority was given to tagging smaller fish, given that compensation was based on weight, and the available budget was limited. This may have had some influence on the overall size distributions, given the longer tail at the lower end of the skipjack distribution, and the higher numbers of smaller yellowfin. The average of fish tagged was still, however, much larger than those tagged in the Philippines from ring net and purse seine vessels (typically 25-30cm).

Releases were entered daily on prepared data sheets and later entered to a dBase III database for later analysis.

3.2.8. Tag recovery mechanisms

Tag recaptures were made primarily by State enterprise vessels, but from a variety of other sources as well. Table 6 lists the source of returns for the Indonesian experiments.

Tags were generally returned to fishing companies, then forwarded to Jakarta for the payment of rewards. No specific forms for the reporting of tag return information were provided, and it is conceded that this would have facilitated an improvement in the quality of recapture data supplied.

Information on tag returns was apparently regularly fed back to fishing companies; the need to compare responses from private concerns relative to State enterprises has already been noted.

3.2.9. Tag recaptures

Return rates overall have been relatively low, with 392 skipjack (4.1%) and 11 yellowfin (1.2%) returns. These rates have improved from the initial very low returns for 1983/1984 releases - 0.4% for Sorong releases, 0% for Ambon releases, and 1.1% for Bitung releases - to 4.5% for 1986 Bitung releases, and 14.5% for 1990/91 Bacan releases.

The significant improvement seen may be due to a number of factors, including the usually higher recapture rates with payao-associated fish, reduced tagging mortality with the use of covered foam pads on deck, improved publicity, and the use of smaller tags during the most recent experiments.

All but 5 of the 1990/1991 returns, which account for 300 of the 403 total recaptures (Gafa, pers. comm.), were within 70 days of release, and in most cases, near the payao of release. 282 of the recaptures (94%) were within 30 days of release.

The 376 returns for 1986 and 1990/1991 releases were all made within Indonesian waters. The much smaller number of recaptures (25 skipjack, 2 yellowfin) from earlier periods (1983/84) however produced four recoveries in the western Pacific, in northern PNG waters, or in the high seas corridor North of PNG, and one return in southern Philippines waters.

These returns demonstrated, for the first time, the outwards movement of skipjack from Indonesian waters to the broader western Pacific.

Data are not available on recapture rates by size at release. Figure 9, in Uktolseja (1989), suggests that return rates from skipjack in the 41-47cm size range were proportionally higher.

The amount of non-reporting is not known, but is believed to be low in the case of State enterprises, where the relatively small number of landing points was well covered by the publicity campaign. In the case of landing points where there is no State enterprise in operation e.g. Kendari, Kolaka, Maumere, few if any tags have been received, and the possibility of non-reporting in these areas should be investigated.

Growth estimates from the tagging data have been made by Suhendrata *et al.*, 1986, and Uktolseja, 1989. Given the relatively small data set in each case, these estimates should be regarded as useful, but preliminary.

3.2.10. Analysis

No detailed analysis of the data has been attempted as yet, given the relatively limited data set and the imperfect nature of the catch statistics. The experiments have however demonstrated several important features of tuna movements in line with the original objectives.

3.2.11. Reporting

Results of the tagging experiments have been summarized in a series of IPTP reports (IPTP/85/WP/12), Ministry journals and international meeting reports (see References).

3.2.12. International Cooperation

Cooperation and the exchange of information with neighbouring Philippines has been regular since the tagging experiments were first recommended. This occurred initially through the South China Sea Programme, then through the series of joint Indonesia/Philippines tuna working groups under IPTP auspices, which was eventually transformed into the wider South East Asia Tuna Conference in 1986.

Two Philippines scientists participated in the second period of tagging (4-5/1984), with IPTP funding support. Various international organizations with involvement in tuna research assisted with publicity for the tagging programme, and with the return of tags recaptured by international fleets.

The SPC Regional Tuna Tagging Project visited Indonesia during March 1991 (see below), and research cooperation between SPC and BPPL/Indonesia has increased significantly, under the umbrella of the Western Pacific Fisheries Consultative Committee (WPFCC), in recent years.

3.2.13. Results of other tagging work in the same area

a) Releases in Indonesian waters

Attempts to have the SPC SSAP visit Indonesia in July 1979, at the request of the Indonesian Government, to tag tunas in Irian Jaya waters, using a chartered pole-and-line vessel, were thwarted by bureaucratic difficulties at the point of entry (Jayapura).

Eleven years later, however, the RTTP was able to visit eastern Indonesia for three weeks during March 1991 with the chartered pole-and-line vessel *Te Tautai*, as a cooperative research exercise with BPPL. With access to abundant bait supplies, fishery intelligence and local support, 7,652 tunas (2,702 yellowfin, 4,830 skipjack, 46 bigeye and 74 longtail tuna) were tagged during the three week visit (Itano and Opnai, 1991). Releases were made in western Irian Jaya (Waigeo), Maluku and North Sulawesi waters, with just over half the releases comprising payao-associated fish. Most fish tagged and released were relatively small, measuring less than 45cm (see Appendix 2).

By 30/4/1992, 1,284 tag returns had been received, for a recapture rate of 17.0%. Recapture rates for payao-associated releases exceeded 25%. These high return rates relative to those experienced by the national programme, especially as most returns (94%) came from Indonesian domestic vessels, are attributed to several factors:-

- The quality of fish at release was probably better, as a result of shorter tagging times and less direct handling (fish are landed directly

onto cradles and usually released within 10 seconds of hook-set, as opposed to possibly a minute in some cases during the national experiments). The charter arrangement also generally allowed much greater control over fish delivery and quality.

- The direct funding and greater attention directed to publicity and tag recovery. With the support of fishing companies, attractive cash rewards were paid directly to tag finders at landing points in most cases.
- The procedures established by the RTTP throughout the western Pacific to deal with international recoveries, and the generally increased awareness of the tagging programme.

Although most recoveries were made in Indonesian waters, 68 international recaptures were made, mostly eastwards in the waters of FSM (25) and adjacent high seas areas (9), but extending as far East as 179°W. Only two recaptures were made in adjoining Philippines waters. 23 recaptures made by Taiwanese and Korean purse seiners and recovered in canneries could not be assigned to an EEZ.

Yellowfin accounted for proportionally more international returns than skipjack (1.3% of releases cf. 0.7%).

Patterns of movement within internal waters have yet to be analyzed. Significantly, no returns have been received South of Ambon, where sizeable fisheries exist (Nusa Tenggara - Maumere, Larantuka -approx. 4,000t p.a.), and no Indian Ocean recoveries have been made. On the other hand, releases near Ambon (Ceram) produced numerous tag returns in the western Pacific. Relatively few recoveries have been made in the large South Sulawesi fishery, based in Kendari and Kolaka, which takes nearly 30,000t of skipjack per year (Uktolseja and McElroy, 1991).

b) Recaptures in Indonesian waters

Until recently, other tagging programmes in the western Pacific had provided relatively few returns in Indonesia. The 9,500 DASF releases in PNG waters during 1971-1974 produced only one recapture in Irian Jaya. Japanese releases up to 1987, mostly in the area 14-21°N, 131-144°E, produced 4 recoveries, as opposed to 56 in the Philippines (Ganaden, 1987). SPC SSAP releases over the western Pacific (150,000 total) resulted in only 31 recoveries in Indonesian waters, and mostly in eastern high seas areas by the international purse seine and pole-and-line fleet.

The RTTP releases outside Indonesia have however already produced a large number of recaptures (166 total - 119 skipjack, 43 yellowfin and 4 bigeye tuna) in Indonesian waters, both in internal waters, by pole-and-line (78) and handline (17) vessels, and in high seas by purse seiners (70). Most recoveries have come from releases in Papua New Guinea (109) and Palau (49), but also in smaller numbers from FSM (5) and the Philippines (3). There have been no recaptures from releases further East than 155°E. Movements into Indonesian waters from PNG seem to be linked to the strong seasonal north-westerly setting Southeast Monsoon current coursing along the northern coast of New Guinea during the second and third quarters of the year.

The above results from other tagging experiments, especially the recent RTTP results in the western Pacific, are thus indicative of regular two-way exchange of tunas between eastern Indonesia and a wide area of the western Pacific, although primarily involving the adjacent waters of Palau, FSM and PNG. There are

indications that these movements are not random, with most influx from the PNG area, and most outward movement to areas North of the Equator, rather than back towards PNG.

3.2.14. Conclusions

Despite access to the optimal fishing gear for tuna tagging (pole-and-line), careful planning, and a favourable situation for the return of tags by a cooperative, well structured domestic fishery, the initial results of the national programme were disappointing. It is still not entirely clear why this was so, although tagging procedures, constrained by the compensation arrangement on relatively small commercial vessels, were not ideal. This seems to be borne out by the improvement seen recently in return rates with improved handling methods (covered foam pads). There are also indirect indications that greater publicity efforts and more attractive rewards could have resulted in greater return rates.

The Indonesian experiments have however generated some useful data, demonstrating for the first time the outward movement of skipjack and small yellowfin from eastern Indonesia to the western Pacific. Given the favourable experience of the most recent experiments and lessons learned from the RTTP experience, BPPL is well placed to undertake successful experiments in selected areas in the future.

3.3. MALAYSIA

3.3.1. Relevant background

Tuna fisheries occupy a relatively minor place in the Malaysian fisheries sector, contributing only 2% of the total annual catch of 1 million tonnes, which is dominated by small pelagics and trawl species. The Malaysian EEZ is mostly continental shelf, with the exception of offshore waters in East Malaysia (Sabah, Sarawak, Labuan) - see Figure 2 - and tuna catches are comprised primarily of neritic species -longtail tuna (*Thunnus tonggol*) and kawakawa (*Euthynnus affinis*).

Catches increased during the 1980s, following the declaration of Malaysia's EEZ in 1980 (Kamarrudin and Raja Bidin, 1990), to 29,000t in 1987. Troll/handline, purse seine and gillnet catches on the East coast of peninsular Malaya provided 65% of this total, i.e. 18,700t. Much more dramatic has been the increase in catches by Thailand, initially in the Gulf of Thailand and more recently in the South China Sea, from 13,000t in 1980 to 131,00t in 1989 (Yesaki, 1991). This has resulted from the development of the purse seine fishery to supply the growing Thai tuna canning industry.

Since 1987, however, catches in the Malaysian fishery have declined markedly, to 17,000t in 1990. The initial decline was seen in East coast landings, to 10,000t, and during 1990, in Sabah landings as well, although the latter may reflect diversion of the catch (skipjack and yellowfin) elsewhere. Thai purse seine catches and catch rates have continued to increase, and it seems that the catch of these vessels fishing offshore has had a direct effect on small tuna catches in coastal waters.

Reasons for the decline were however not certain, prompting the need to better understand population dynamics and movement of the major species. Tagging experiments were a logical starting point.

3.3.2. Objectives

The primary objective of the tagging programme, on the East coast of peninsular Malaysia, was to "study the migration pattern of longtail tuna and kawakawa in the Malaysian EEZ", with secondary objectives of estimating "the population parameters such as growth and mortality, and to assist in assessment of tuna stocks, and the extent of interaction between the tuna species in the region" (Raja Bidin, 1990).

3.3.3. Planning

Planning for the project was initiated in early 1990 by the Fisheries Marine Resources Research Centre (FMRRC), Kuala Terengganu, in close consultation with IPTP staff (see INT/86/016/TR/90/03). Options for the capture and release of the target species were restricted to troll, purse seine and possibly handline gear. The traditional troll vessels based in Kuala Terengganu were selected for the programme.

Longtail tuna were the priority species for tagging, with kawakawa also to be tagged. Frigate tuna (*Auxis thazard*, with an unknown amount of *Auxis rochei*), often caught in association with those species, were not to be tagged. A nominal target of 5,000 fish was established.

All tagging materials were supplied by IPTP (tags, applicators, data forms, posters); IPTP also provided funding to enable collaboration by scientists from adjacent Thailand, and support by IPTP staff. All operational costs (vessel charter etc.) were met by the Malaysian Government.

The programme was to be based out of Kuala Terengganu, the site of the main landing points (Pulau Kambing, Chendering, KT Central Market), where close and regular contact with the fishery could be maintained from FMRRC.

3.3.4. Design of the tagging experiment

As productive fishing grounds are often located 80 or more miles offshore, operations were based on the charter of two 20 GT trolling vessels and a larger trawler as a support vessel, given the lack of space for additional personnel on the trollers. This approach enabled trips of 3 to 5 days duration to be undertaken, over an area of 3,600 square nautical miles. Respective daily charter costs were M$160 and M$700 for trollers and trawler, with the vessels retaining all fish not tagged.

The initial experiment was scheduled for the June-July period, when the best weather is usually experienced. Catches however normally peak in October-November when fish are more readily available closer inshore, despite the monsoon weather.

Fish were trolled from around payaos (runjangs) set by purse seine vessels, from free schools located by visual search, and in the vicinity of oil platforms, some eight to nine hours steaming offshore. The usual strategy on trips was to first fish the payaos three to four hours from port, then search for schools towards the oil rigs, fish in that area, then return.

Both single and multiple troll gear was used, the former usually around payaos or when steaming, and the latter, with up to 30 jigs on droppers from the main line and known as an "apollo", on surface schools. Handlines jigged in midwater around payaos are also used, but not during the present work.

Although tunas, particularly kawakawa, up to 50cm LCF are taken, the majority of the catch is much smaller, typically less than 30cm. The intention on

each trip was to tag as many fish as possible, without any firm size preference, but with longtail tuna as priority.

Where two troll vessels were involved, six FMRRC personnel and collaborators were usually involved.

No biological sampling was undertaken on board, other than measurement of the catch not tagged.

3.3.5. Tagging methods

Methods are described in Raja Bidin (1990), and only briefly elaborated here. A team of three persons was generally used - a fish handler, a tagger, and a recorder.

All fish tagged were caught by troll gear, with the standard lure or jig used being a 4/0 hook, with a fibre or raffia skirt attached; troll lines were approximately 20 m in length. Trolling speed was typically 4-5 knots, with the vessel slowing down when a fish was hooked. Fish were hauled steadily and carefully, grasped as they crossed the transom, and unhooked before sliding along the bare deck to the tagger. Unhooking occasionally took some time, as barbed hooks were used.

After checking for injury (eyes, bleeding, level of activity), fish were tagged on a measuring board, then dropped over the adjacent gunwale. Fish hooked in the upper jaw or near the nostrils were not tagged. It was noted that longtail tuna were more active than kawakawa, and had to be restrained by the handler to enable tagging.

No information was available on the typical time taken to tag fish after their arrival on deck. The feeling of FMRRC staff was that 30 seconds would be a maximum, but usually much less than that. A total time, including hauling the troll line, may well approach 3 minutes.

Yellow 'Hallprint' tags 10cm by 1.5mm were used, and were stored in holders carrying 100 tags in numerical sequence. It was felt that these tags were probably too large for fish less than 20cm in length, and possibly too small for fish over 40cm in length. Tag placement was intended to be just below the second dorsal fin, to a depth of 1cm. Intending taggers were provided with demonstrations of tagging technique onshore, prior to the beginning of the project. Individual lengths were recorded to the nearest cm and noted by the recorder. Tagging and associated data were recorded and stored on standard forms designed for the programme.

Although tagging methods could not be actually observed in the available time, it was possible and very helpful to observe video footage of the tagging operation. Some possible problems were identified, at least in the situation viewed, as follows:-

(1) Fish arriving onboard were in good condition, despite their very small size (15cm) in some cases. However, the unhooking was often done by holding the fish across the nape, with index finger and thumb on the opercula. Whilst offering best purchase on the fish, this does run the risk of damage to the gills when fingers enter the gill cavity accidentally.

(2) Sliding the fish along the deck may have resulted in some damage to the fish, and certainly some mucus loss.

(3) Many of the tags were applied too low on the side of the fish, almost along the mid-lateral line, and very close to the subcutaneous red

muscle mass. Such placement not only runs the risk of damage to the fish, via the vital red muscle, but provides no internal anchorage for the dart tag. Tags placed higher up, under the second dorsal fin, can be securely anchored behind the pterygiophores (fin ray supports).

3.3.6. Publicity

Posters publicizing the programme were prepared and widely distributed throughout Malaysia, radio coverage given on the East coast by FMRRC personnel, and direct contact established at landing points. Publicity was extended to East Malaysia and more importantly to Thailand, in view of quantities of the target species taken by Thai vessels, in adjoining Thai waters, in the Malaysian EEZ under joint venture agreements, and in the South China Sea. Through cooperation with Thai collaborators, publicity at the large Thai landing points (Pattani, Songkhla) was arranged.

It is understood that little or publicity was provided in Cambodia (Kampuchea) or Vietnam, contiguous areas where tunas are taken. Limited publicity was undertaken in Indonesia, where large quantities of neritic tunas are also taken in the Java Sea and the South China Sea. As Figure 2 shows, the vast shelf area of the Java Sea/South China Sea/Gulf of Thailand provides an uninterrupted productive realm for the neritic tunas and, for the purposes of tagging programme publicity, it should be assumed, *a priori*, that movement can occur across the entire area.

A reward of M$5.00 was offered for the return of tags, with the tag needed to be handed in to obtain the reward. This reward was recently increased to M$7.00, and a new poster prepared for a further round of tagging tunas and squid.

3.3.7. Releases

During 5 trips between June 3rd and July 3st 1990, 3,803 releases were made, at an average of 760 fish per trip, and 215 fish per day. On the final two day trip, 1,800 fish, or 47% of the total, were tagged and released (Table 7).

Kawakawa proved more abundant than the preferred longtail, and accounted for 2,208 of the releases, or 58%. Fish were tagged in five 30 mile by 30 mile grid squares, as in Figure 5, but 2,024 of the releases (53%) were made in a single square, near the offshore oil rigs.

The size distribution of the releases by trip or by area was not available, but the total size distribution by species (Figure 6) shows that the size range of longtail and kawakawa tagged was respectively 14-45cm, and 15-49cm. The majority of the longtail were however less than 20cm (82%), whereas 61% of the kawakawa were of this small size. This size distribution is smaller than that recorded in port sampling of commercial vessels (Yesaki, 1991). All fish were single tagged.

The information from the tagging experiments are currently entered and stored on a stop-gap dBase IV database, which is rudimentary, of limited value and could be readily improved.

3.3.8. Recoveries

A total of 52 recoveries (1.36%) had been received, with some interesting features, as follows:-

- 50 of the 52 recoveries were kawakawa, at a return rate of 2.3%. The two longtail recoveries (0.1%) were both made by purse seine vessels.
- 50 of the 52 recoveries were from releases in the one grid square, near the oil rigs, which provided 53% of the releases.
- 41 of the recaptures were made within 8 days of release, with the longest period at liberty 132 days (kawakawa).
- 32 of these 41 recaptures were made on the same day, all by handline, and possibly on the same payao.
- recoveries by gear type were as follows: handline - 36; trolling - 8; purse seine - 8.
- all recaptures after 30 days at liberty (9 kawakawa, 1 longtail) were of fish 27cm or larger at release, even though fish of this size only made up 18% of kawakawa and 16% of longtail releases. The return rate for kawakawa of this larger size was thus 4%, all after 30 days, as opposed to 2.3% for fish less than 27cm.
- two recoveries were made by Thai purse seiners fishing in Malaysian waters, and one was received from a Thai port with no recapture data.

Movement would appear to be relatively limited, with nearly all recaptures within 60 miles of release. However, in the absence of detailed data on the distribution of catch and effort directed at the two species, both inside and outside the EEZ, and uncertainty regarding the level of awareness of, or cooperation with the programme in nearby countries, this cannot be ascertained.

The limited data are insufficient for preliminary analysis of growth, as many of the longer term recoveries show no incremental growth, and recapture data are often incomplete.

3.3.9. Analysis and reporting

No analysis of the data has been carried out, in view of the limited nature of the work so far. Examination of the pattern of recaptures by species and size at release has provided insights which should usefully guide future work.

The tagging work to date has been reported in some detail in Raja Bidin, 1990.

3.3.10. International cooperation

The involvement in the tagging itself of colleagues from Thailand, with IPTP support, and in the recovery of tags from Thailand has been noted, as has the need to possibly broaden the scope of the publicity for any further tagging work.

Involvement with other ASEAN countries with large fisheries for neritic tunas, other than Thailand, notably Indonesia and Philippines, has been limited. There has been, as noted, no contact at all with Cambodia and Vietnam. Even in the case of Thailand, there has been a reluctance to become involved in any joint tagging work, and some doubt must remain about the return of all tags by Thai vessels, given the amount of illegal fishing which occurs in Malaysian waters, and the regular apprehension and confiscation of Thai vessels which occurs. The sheer volume of the Thai catch in contiguous waters alone would make full Thai cooperation essential to the achievement of programme objectives.

3.3.11. Results of other tagging work in the same area

There has been no other tagging of neritic tunas elsewhere in Southeast Asia, other than the release of a small number of longtail tuna by the SPC RTTP in Philippines (8) and Indonesia (74), and during the 1970s in nearby Papua New Guinea (441 between 1972 and 1975). These have involved much larger adult fish (> 50cm).

Given the great importance of these neritic species to ASEAN fisheries (over 150,000t of longtail and 300,000t of kawakawa/*Auxis* were taken in Area 71 alone in 1990), there remains a need to gain some understanding, in at least one representative area, of the extent of movement of these species throughout their life history. This is at present totally unknown. In the case of kawakawa, where most sizes of fish, from juveniles to large adults can be found in the same area (such as the Malaysian East coast), movement may prove to be relatively limited. With longtail however, where the distribution of both larger and smaller fish tends to be separate and restricted, and there is some suggestion of size segregation by depth, there may well be significant movement over the life history. In the case of *Auxis*, the South China Sea fisheries seem to provide an interesting example of possible replacement of longtail tuna under heavy exploitation by *Auxis* which, unlike longtail, also occur in oceanic areas where exploitation levels are much lower.

3.3.12. Conclusions

The tagging experiments conducted to date in eastern peninsular Malaysia have been limited in scope, and of more recent origin than the other larger scale work reviewed in Indonesia and the Philippines. The results obtained have gone only a small way to meeting the stated objectives, but there are some prospects of improving this situation.

As noted above, the trolling vessels available are providing fish in suitable condition for tagging, and there additionally exists the possibility of obtaining fish in even better condition from handlining/jigging around payaos. Several means of improving the handling of fish and the placement of tags have already been identified, and hopefully are being implemented on tagging work now in progress. Other aspects are recommended for investigation as additional means of improving tagging methods with these very small fish, as below:-

(1) Experiment with the use of barbless hooks, which should reduce fish damage and unhooking time, albeit at probably a slight increase in drop-off initially. Under charter conditions, this is however not an issue.

(2) Investigate the use of a small cradle into which fish could be lowered and unhooked; this would be particularly efficient with barbless hooks. A sample design for such a cradle 80cm in maximum dimension was left with FMRRC, along with suitable cradle cover material purchased locally.

(3) Restrict tagging of troll-caught fish to medium size fish 25cm and above; this may be reduced to 20cm if the improved tagging methods result in increased return rates, and if the present tags were trimmed to perhaps 7.5cm in length for fish < 25cm.

(4) Investigate the use of handline fishing around payaos for tagging smaller fish. Handline fishing reportedly produces 40% of the catch from troll vessels, with fish of a smaller average size usually taken.

(5) Elevate the actual tagging operation to a specialist task, rather than rotated amongst personnel. There is ample evidence from other tagging

programmes of increased return rates from dedicated taggers with practised tagging skills. On some cruises in the programme, vessel crew were tagging fish on occasions.

(6) Keep tagging applicators sharp, especially for tagging longtail tuna with their thicker skin, and use cotton gloves for all handling of fish during tagging.

These improvements to the operational aspects of the tagging programme, as suggested, should prove achievable and provide a measurable impact on return rates.

Two other areas present more difficulty, as noted in the review.

The publicity/information campaign to achieve the necessary level of awareness and cooperation amongst the countries and fleets potentially involved over the target species' range, particularly the mobile Thai fleets, will need to be large relative to the size and value of the Malaysian fishery involved. This may well best be done on a larger cooperative scale in, for example, the South China Sea, to the benefit of more countries, if this is possible. Certainly if the programme is to continue even in its present form, publicity efforts will have to be upgraded and cooperation assured if objectives are to be met.

The situation with catch and effort data necessary for the interpretation of tagging data is currently not satisfactory, despite the good progress of the IPTP sampling programmes on the South China Sea coasts of Thailand and Malaysia. With the small scale artisanal nature of most coastal fisheries for neritic tunas, this may not reasonably be expected to improve much beyond estimates of total landings by species by port. Data on industrial scale fisheries, in this case purse seine vessels, has becoming increasingly the more important. In the case of Malaysia, these vessels are required to supply log sheet data when fishing in offshore areas (zone C). Data are difficult to obtain, and are subject to special request from Kuala Lumpur. In the case of Thai purse seine vessels which provide most of the total catch of neritic species, the situation is compounded by apparent discrepancies between official statistics and port sampling data with regard to areas fished.

The Kuala Terengganu-based programme does however offer a good opportunity to acquire much needed information on an important species pair, and with the prospects for improved results available, should be pursued at least on the present scale.

3.4. MALDIVES

The tagging experiments carried out with IPTP assistance in the Maldives during 1990 were also subject to desk review, because of their apparent success and to provide useful contrast with the South East Asian experiments. Reports by Rochepeau (SEAC/90/23), Yesaki and Waheed (MS), and various internal documents were consulted at IPTP Colombo, and discussions entered with IPTP staff.

A total of 9,941 tunas (81% skipjack) were tagged on eight cruises during the period January -November 1990, from traditional Maldivian pole-and-line vessels (mas dhoni). Most fish were captured with pole-and-line gear, but a small percentage (nearly all yellowfin) with baited handlines. Fish were released from a variety of atolls, during both monsoon seasons, but with most fish released in the northern Maldives. The tagged fish were mostly of medium size (70% of skipjack over 49cm; 77% of yellowfin in the 40-69cm range - see Figure 7).

As at 29/2/1992, 1,535 tagged fish had been recovered, at an overall return rate of 15.4% (skipjack 17.5%, yellowfin 6.7%). Most returns were made within the Maldives, where the rather intensive domestic fishery landed 61,400t of skipjack and 5,434t of yellowfin during 1990, from a fishing area of approximately 126,000 km² i.e. 0.5 mt/km² (Yesaki and Waheed, MS). Thirty three skipjack and 18 yellowfin recaptures were made outside the Maldives, 23 in Sri Lanka, 2 in the neighbouring Lakshwadeep Islands, and 26 in the western Indian Ocean.

Analysis of the results are continuing, particularly as the comprehensive catch and effort data available for the Maldives should facilitate some analysis of the dynamics of tuna populations, initially using attrition models. It is clear however that the programme has been a very successful one, and it is instructive to examine why this has been so.

3.4.1. Planning, objectives and design

Plans for the programme were made in June 1989, with objectives, target numbers and broad operational details, with respect to seasonality of the fishery, defined, and an indicative budget prepared (US$ 65,000). An IPTP consultant was identified to work with Maldives Marine Research Section and IPTP staff for the first month. The project was intended to be part of a wider Indian Ocean Tuna Fisheries Interaction Programme, of which only the Maldives component was ever successfully executed.

With tuna fishing constituting a central point of Maldivian life on most atolls, the project enjoyed full support from local fishermen keenly interested in the results. Tagging was carried out on cooperating vessels by paying compensation for fish tagged and released, at a price of roughly three times the market value of the fish (as opposed to approximately market price paid in the Indonesian and Philippines experiments).

3.4.2. Tagging methods and releases

Tagging was undertaken by 2-3 man teams, with fish tagged on measuring boards and released generally within 10-15 seconds of being hooked. This was greatly assisted by the skill of the fishermen in delivering fish to the tagging team. There was insufficient space on the narrow 10-15m long vessels to use cradles. Standard yellow 10cm by 1.5mm 'Hallprint' dart tags were used.

Viewing of a video of the tagging operation confirmed the soundness of the tagging techniques. The tagging operation was direct and rapid, tag placement appeared good, and even the handline caught fish looked to be in good condition with the short lines used. A deck covering might have reduced surface abrasion to the fish, and grabbing fish by the tail should have been avoided, but these are relatively minor concerns.

3.4.3. Publicity and tag recovery

Radio coverage, posters and regular personal contact with atoll leaders ensured that the programme enjoyed a very high profile and excellent rapport within the Maldives. An attractive reward for the fishermen of three pole-and-line hooks was offered. With nearly all the catch coming from mas dhonis, the catch was individually examined and it seems certain that non-reporting in the Maldives was minimal. Regular follow-up and feedback of tagging information was also carried out.

Publicity on an international scale was also pursued, in Sri Lanka and through the Seychelles and Mauritius, for the Indian Ocean purse seine fleet. Some publicity was also done in the neighbouring Lakshwadeep Islands.

3.4.4. Results, analysis and reporting

The results as broadly outlined above speak for themselves, with the large number of returns already having provided much useful information on local and wider scale movements, as per programme objectives. Preliminary attrition rates can also be estimated.

The quality of the return data is variable in terms of length at recapture, limiting its value for growth estimates, and it is clear that the use of return forms and the issue of measuring boards or sticks to landing points would have been useful.

There is also perhaps a question mark regarding possible non-reporting of international recaptures, particularly in the case of the Lakshwadeep Islands, where a 6,400t skipjack fishery provided only two recaptures.

Basic analyses and reports have already been carried out, and plans have been made to apply an attrition model approach to the data, to obtain estimates of exploitation rate and potential yield.

3.4.5. Conclusions

The Maldives programme no doubt enjoyed some in-built advantages in terms of the high awareness of the population, the likelihood that the atolls function to some extent as aggregation devices to retain fish in their vicinity and increase the probability of recapture, and the ready availability of skilled fisherman using a technique requiring little or no modification to release numbers of tunas in excellent condition. Nonetheless, the programme capitalized on these advantages to deliver a well planned and executed project which achieved all its objectives. Key factors were probably the cooperation generated by the generous fish compensation, and the intensive initial and follow-up publicity, as well as feedback to tag finders.

4. SUMMARY OF FINDINGS ON NATIONAL TAGGING EXPERIMENTS

Table 8 summarizes the essential characteristics of the three national programmes reviewed, plus the Maldives, and the results obtained.

Of the four tagging programmes, only the Maldives can claim to have achieved most of the stated objectives. This is despite all national programmes having been subject to careful planning, having received considerable technical input from IPTP staff or consultants, and having well trained and committed field staff.

Possible causes of this have been discussed in preceding sections, but to summarize, difficulties were identified to varying extents in three main areas of the national programmes, as follows :-

4.1. Tagging methodology

Although constrained in some situations by lack of access to optimal vessels for tagging tunas, insufficient attention was paid to minimizing tag-related mortality by careful handling, paying due attention to correct tag placement, and keeping time out of water to a minimum. In several cases, this has or is being improved, and future work should achieve better results. There is a general need to elevate the

importance of good quality tagging to a recognized specialist skill, rather than a routine field task. Quality control and tagging time benchmarks could usefully be established in most cases as operating standards.

4.2. Publicity and tag recovery

While considerable time and resources were devoted to planning and execution of field operations, much less effort was directed to the shore-based support activities - planning the publicity coverage needed, optimizing rewards and tag recovery procedures, and follow-up activity associated with verification of recapture data, timely payment of rewards and feedback of information to finders, and periodic review of tag return patterns relative to distribution of catch and effort, to detect any anomalies.

Budgetary and manpower allocation for these all-important activities in all cases, including the Maldives, has certainly been insufficient and non-reporting in some situations has probably been considerable. IPTP could play a useful role in the planning stage of this activity, and ensuring that sufficient resources had been allocated to this area.

4.3. Catch and effort data

All programmes reviewed had modest objectives in terms of analytical output, and successfully executed tagging programmes could have provided much of the required preliminary information on growth, broad movement patterns and possibly some understanding of stock structure. To progress beyond this to estimates of population size, yield, extent of fishery interaction etc., all situations except the Maldives would require a considerable improvement in the coverage and quality of catch and effort data for the fisheries under consideration. In cases where the fisheries are multi-gear, multi-species, this will clearly not be an easy task, but this requirement should be accepted in principle if tagging experiments are to serve in an assessment role.

5. RECOMMENDATIONS FOR FUTURE TUNA TAGGING EXPERIMENTS IN PHILIPPINES, INDONESIA AND MALAYSIA

Future needs of the three national programmes are based on the assumptions that (a) there is a continuing priority need for the type of information that will be generated by tagging programmes, that (b) the existing identified deficiencies in past programmes will be rectified, and that (c) funding and technical support at national and regional level will continue to be available.

In the case of the oceanic tropical tunas (skipjack, yellowfin and bigeye), national plans will need to be meshed with the activities of international/regional agencies involved in tuna research and monitoring. In the ASEAN area, these include IPTP, FAO regional programmes, SEAFDEC, and in recent times, SPC and FFA. There may thus be merit in looking initially at needs on a national basis, separately for oceanic and neritic tunas.

5.1. PHILIPPINES

5.1.1. Oceanic species

Increasing involvement of the Philippines with the Pacific Island nations in oceanic tuna matters of mutual interest appears set to take another step with the

involvement of the SPC/TBAP later this year with BFAR, in a two-year cooperative tagging-based stock assessment of Philippines oceanic tuna stocks. This work, planned to start in late July of this year, may seem to obviate the need in the short to medium term for further tagging experiments at the national level.

The assessment will exclude, however, the South China Sea portion of the Philippines EEZ, given conflicting claims and political complications. This area is supplying an increasing proportion of the Philippines industrial tuna catch, and remains an unknown area in terms of stock relationships. It is deserving of further study in the future, including tagging, preferably on an international scale.

With priorities changing at the national level away from the collection of detailed fisheries statistics, including tuna fisheries, the current coverage of domestic tuna fisheries is probably inadequate for analysis of tagging data to provide population estimates of any kind.

5.1.2. Neritic species

Increasing catches of neritic species (*Auxis, Euthynnus*) continue to provide 60% of Philippines tuna landings, yet the extent of movement between areas, and the dynamics of exploited populations remain very poorly understood. This is true of the ASEAN area generally, and there is a need to undertake a well-designed tagging experiment in a representative area to generate this much-needed information. Such a situation would need to be carefully chosen, but the Philippines would clearly be a suitable location.

5.2. INDONESIA

5.2.1. Oceanic species

Before undertaking any further work in Indonesian waters, a recommended first step would be the thorough analysis, jointly by BPPL and SPC, of the large amount of data generated by the 1991 RTTP visit, particularly from the viewpoint of identifying how this experiment, at face value a rather successful one, might be improved, and what limitations exist on the interpretation of the data.

There is an obvious need for further tagging work in the large fisheries of South Sulawesi (Kendari, Kolaka), if one of the original objectives of the tagging work - to understand the relationship between Indian Ocean and western Pacific fish, across the Banda Sea - is to be pursued. Such tagging could be extended to Maumere/Larantuka (Nusa Tenggara) and other southern areas. Linkage with IPTP or its successor, which is likely to be increasingly Indian Ocean-focussed, could be maintained on this basis.

Any further work should be well funded in terms of compensation arrangements for tagging fish - the Maldives model of three times market value is a good example - and for publicity and follow-up.

5.2.2. Neritic species

Despite the relative lack of interest in neritic tunas in Indonesia, and the suspicion in some quarters that some of the reported catch of these tunas is probably small skipjack, their importance to artisanal fisheries is great, and there may be a role for Indonesian involvement in any future work involving the stocks distributed over the wide shelf area of the South China Sea and environs (see later), particularly as it is believed that Thai purse seine vessels have been directing

increasing effort to the Indonesian portion of the South China Sea shelf (Natuna Is.).

5.3. MALAYSIA

5.3.1. Oceanic species

The oceanic tuna species, occurring only in any quantity in East Malaysia, have not been investigated at all in Malaysia, and even though potential for increased exploitation exists, any involvement in tagging programmes would logically be as part of an international South China Sea initiative. Efforts to improve the coverage of catches taken in the East Malaysian area by joint venture operations, but landed elsewhere, could be encouraged.

5.3.2. Neritic species

Further tagging work on the neritic species off the Malaysian East coast, other than to improve techniques and provide information on a local scale, is probably of limited value unless the cooperation and involvement of Thailand, whose fishery in neighbouring waters dwarfs that of Malaysia, can be assured. By extension, the cooperation of Vietnam, whose marine fisheries catch is estimated at 500,000t (FAO Statistics, 1989) and surely includes significant quantities of neritic tunas, would also be needed, as would that of Indonesia. International borders for these shelf areas are in most cases well defined and not disputed, as opposed to the oceanic areas further North.

This suggests that an international tagging programme with support of all the above countries would be desirable, in terms of elucidating neritic tuna stock structure and movement, provided the political support could be assured. In this case, IPTP may not be the logical coordinating body, with SEAFDEC, from its base in Kuala Terengganu, an ideal alternative if the present non-membership of Indonesia could be overcame, and if international cooperation could be assured. An FAO role is also possible.

Similar work on the oceanic species, more contentious because of conflicting claims to various offshore islands and associated waters, could then be addressed at a later stage.

Table 1. Guidelines for the evaluation of tagging programmes

A. Origins, background
- history of fishery, need for study

B. Statement of objectives
- movement, stock definition, assessment, interaction

C. Planning
- previous experience, advice
- budget, funding source
- staffing, training

D. Experimental design
- characteristics of the fishery (season, area, catch etc.)
- selection of vessel type, gear
- source of fish (charter, compensation, own catch)
- industry support (know the industry)
- target numbers (simulation) and time frame
- assess feasibility

E. Tagging methods
- fishing gear specifics for tagging
- tagging gear (tag type and size)
- on-deck procedures (team size, handling, cradle)
- tag placement
- size measurement
- quality control, tagging time, fish condition
- double tagging? tag seeding?

F. Publicity
- initial campaign (research to gauge coverage needed)
- periodic reinforcement of publicity
- rewards, lotteries
- feedback to finders

G. Tag release details
- numbers,size, species, time/area strata
- recording, storage and retrieval of data
- collection of biological data

H. Tag recovery mechanisms
- return of tags and data (return forms, contact points)
- reward payment (tag itself)
- entry and retrieval of data
- feedback to finders

J. Results
- recapture rates (by release set, fleet, species etc.)
- pattern in time/space
- effect of variables at release e.g size, condition, gear
- estimate non-reporting
- biological parameters e.g growth, mortality

K. Data analysis
- verification of tag data
- assembly of catch/effort data
- hypothesis testing

L. Write-up, reporting

M. International cooperation

N. Results of other tagging work in the same area

O. Final appraisal/conclusions regarding present work

Table 2. Philippines tag releases, by gear type

	SJ	YF	BE	
PURSE SEINE	3738	3576	211	7525
RING NET	2141	1027	30	3198
TOTAL	**5879**	**4603**	**241**	**10723**

Table 3. Summary of Philippines tag releases by cruise, 1988-1991

CRUISE	DATES	LOCATION	No. TAGGED			GEAR
			SJ	YF	BE	
1	27-30/09/1988	Moro Gulf	567	626	68	Purse Seine (PS)
2	29-30/11/1988	""	319	968	35	PS, Ring Net
3	16-29/04/1989	""	1 121	330	50	PS, Ring Net
4	02-03/06/1989	""	868	410	7	Ring Net
5	18-19/10/1989	""	10	37	1	Ring Net
6	06-08/04/1990	West of Palawan	4	239	8	PS
7	28/10-01/11/1990	Moro Gulf	2 833	1 795		PS (2 teams)
8	04-07/5/1991	""	157	198	116	Ring Net
					1	
		TOTAL	**5 879**	**4 603**	**241**	

Table 4. Philippines tag returns, by gear type, for each species

GEAR	YF	SJ	BE	UNSP.	TOTAL
Handline	15	10	2		27
Hook and Line	3	3			6
Purse-Seine	8	27			35
(Ps) Ring Net	1	5			6
No Record	55	65	2	1	123
TOTAL	**82**	**110**	**4**	**1**	**197**

Table 5. Summary of Indonesian tag releases, by species and area, 1983-1991

AREA	DATES	No. OF RELEASES (RECAPTURES)	
		SJ	YF
SORONG	12/1983	2 722	272
	4-5/1984	(9)	(2)
AMBON	4-5/1984	1 695	302
		(0)	(0)
BITUNG	4-5/1984	2 642	210
	1-2/1986	(73)	(3)
LABUHA	11/1990	1 926	105
(BACAN)	10/1991	(283)	(6)
	11/1990	370	3
LUWUK		(11)	(0)
TOTAL RELEASES		**9 355**	**892**
		(376)	**(11)**
		10,247	

Table 6. Indonesian tag returns, by vessel type and source

A. SKIPJACK

AREA OF RECAPTURE	TYPE OF FISHING GEAR USED			TOTAL
	PS	P/L	HL	
1. SORONG*	--	3	--	3
2. TERNATE	--	5	--	5
3. BITUNG*	--	72	--	72
4. BACAN*	--	271	--	271
5. BIAK	5	--	--	5
6. GORONTALO	--	--	7	7
7. MANOKWARI	--	--	2	2
8. LUWUK*	--	11	--	11
9. JAPAN (Pacific Ocean)	4	--	--	4
TOTAL	**9**	**362**	**9**	**380**

B. YELLOWFIN

AREA OF RECAPTURE	TYPE OF FISHING GEAR USED			TOTAL
	PS	P/L	HL	
1. SORONG*	--	2	--	2
2. BITUNG*	--	2	--	2
3. BACAN*	--	4	2	6
4. GORONTALO	--	--	3	3
TOTAL	**--**	**8**	**5**	**13**

NOTE: * State Enterprise
Small Scale
Private Company
Japan: Research Institute
PS: purse seine
P/L: pole-and-line
HL: hand line

Table 7. Fishing trips and numbers of fish tagged by species, Malaysia

TRIPS	LOT	KAW	TOTAL	LOT (%)	KAW (%)
1st (3-7/6)	71	111	182	39.01	60.9
	151	143	294	51.36	48.6
2nd (10-14/6)	19	372	391	4.86	95.1
	37	421	458	8.08	91.9
3rd (19-21/6)	79	6	85	92.94	7.0
4th (08-10/7)	46	883	929	4.95	95.0
5th (30-31/7)	606	160	766	79.11	20.8
	586	112	698	83.95	16.0
TOTAL	**1,595**	**2,208**	**3,803**	**41.9**	**58**

Table 8. Summary of national tagging programme characteristics, and results

	PHILIPPINES	INDONESIA	MALAYSIA	MALDIVES
Objectives	Stock identity, migration	Limits of stock, population parameters	Migration, population parameters	Movements; estimate growth, standing stock, turnover and throughput
Plan	5 year plan	Year-by-year planning	One year initially (5,000 target)	One year, all areas and seasons (10,000 target)
Start date	October 1988 - May 1991	December 1983 - October 1991	June 1990 - Ongoing	January 1990 - November 1990
Target fishery	Domestic multigear	Eastern Indonesia pole-and-line	East coast troll/purse seine/handline	Domestic skipjack (pole-and-line, handline)
Species	Skipjack, yellowfin, bigeye	Skipjack, yellowfin	Longtail, kawakawa	Skipjack, yellowfin
Gear, vessel type	Purse seine, ring net	Pole-and-line (30 GT)	Troll vessel (20 GT)	Mas dhoni (traditional pole-and-line)
Vessel arrangement	Compensation (market price)	Compensation (market price)	Charter	Compensation (market price x 3)
Tagging method	Scoop net, sorting, carry to cradle	Pole on deck, cradle	Lower to deck, tag on measuring board	Pole on deck, tag on measuring board
Tag type	Hallprint 10 cm x 1.5 mm	A. Japan 14 cm x 3 mm B. Floy 11.5 cm x 2 mm C. Hallprint 10 cm x 1.5 mm	Hallprint 10 cm x 1.5 mm	Hallprint 10 cm x 1.5 mm
Tagging time	20-30 seconds from net? (7-16 seconds, Nov. 1989)	Up to one minute?	Less than 30 seconds on deck	Less than 15 seconds total
Recording	Manual recorders from early 1990	Manual	Manual	Manual
No. of releases	10,723 (5,879 SJ)	10,247 (9,355 SJ)	3,803 (1,595 LOT)	9,941 (8,033 SJ)
Release area	Mostly 3°-6°N, 121°-124°E	0°-4°S, 128°-132°E	5°-6°N, 103°-105°E	0°-7°N, 72°-74°E
Fish size	25-30 cm	45-55 cm	15-25 cm	45-60 cm
Overall return rate	2.0%	3.8%	1.4%	15.4%
Movement	Internal waters	Local, and 5 international	Local	Local, and 51 international
Publicity, reward	Posters; T-shirt	Posters; T-shirt/towel	Poster, radio; M$5	Poster, radio; fishing hooks
Follow-up tag recovery	Limited	Limited (?)	Limited externally	Active
Achievement of objectives	Limited	Partial	Partial, but ongoing	Complete

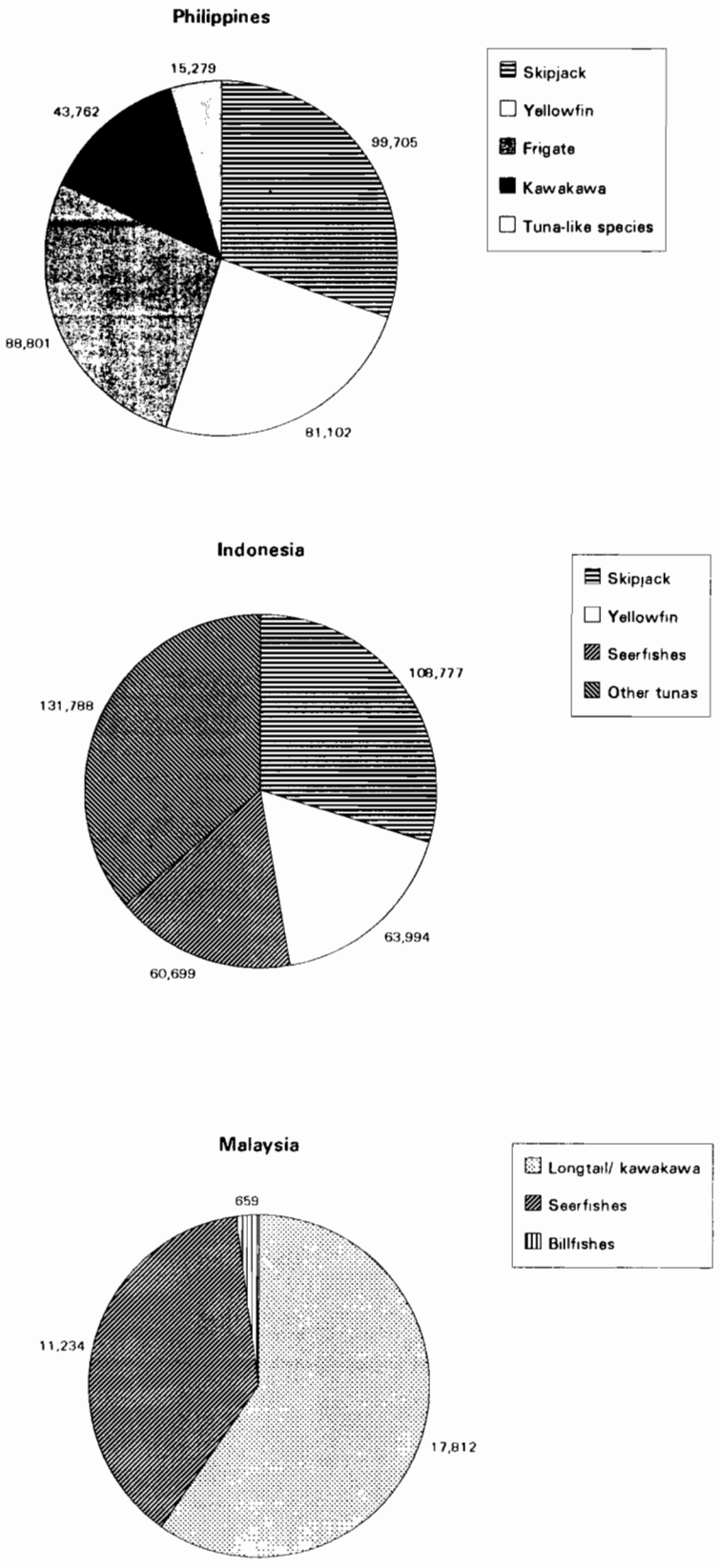


Figure 1. National catches of tuna and tuna-like species, 1990

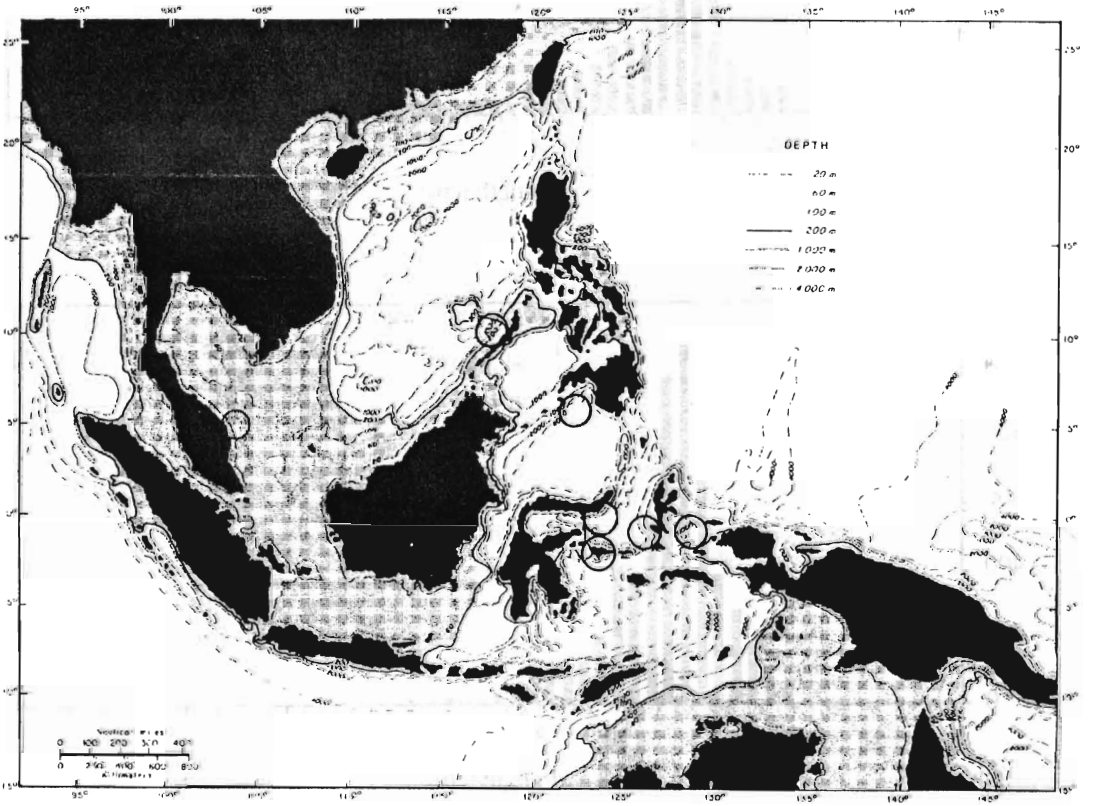
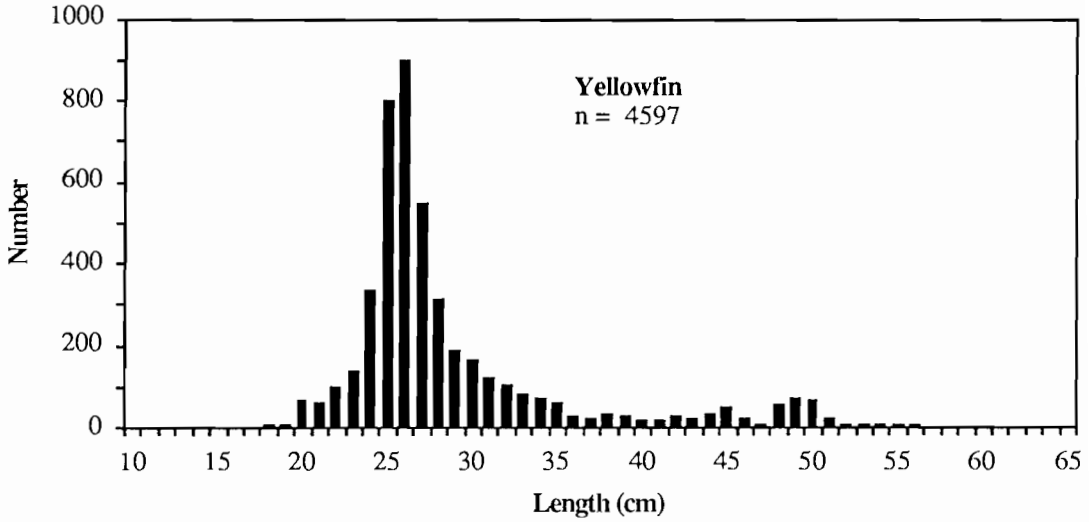
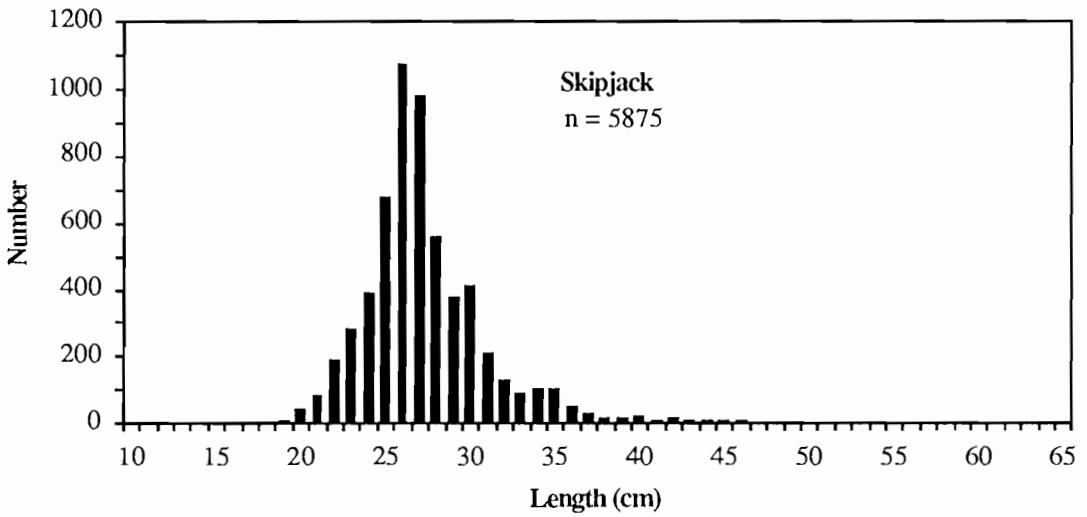


Figure 2. The Southeast Asian region, showing bathymetry and the areas of national tagging operations. (From Chullasorn and Martosubroto, 1986)

Figure 3. Size distribution of Philippines tagged tuna releases, by species





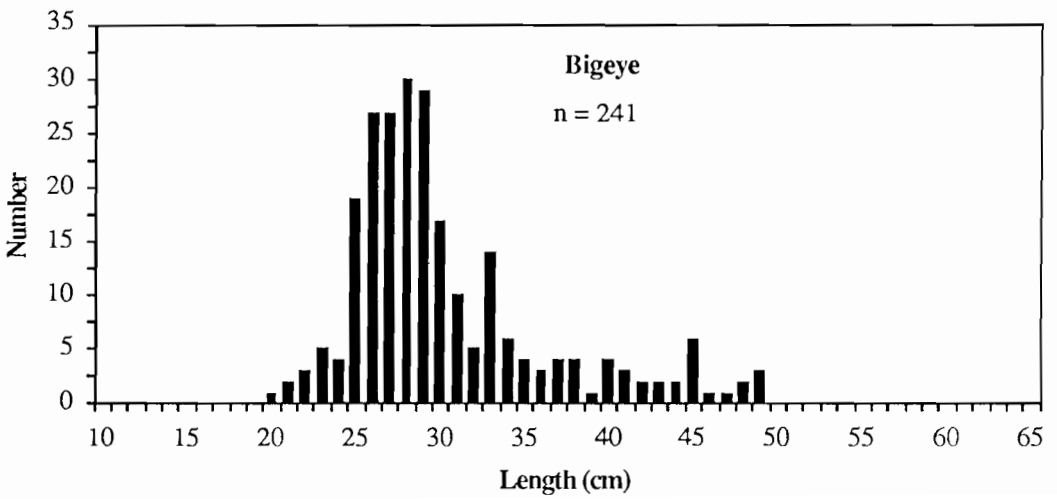
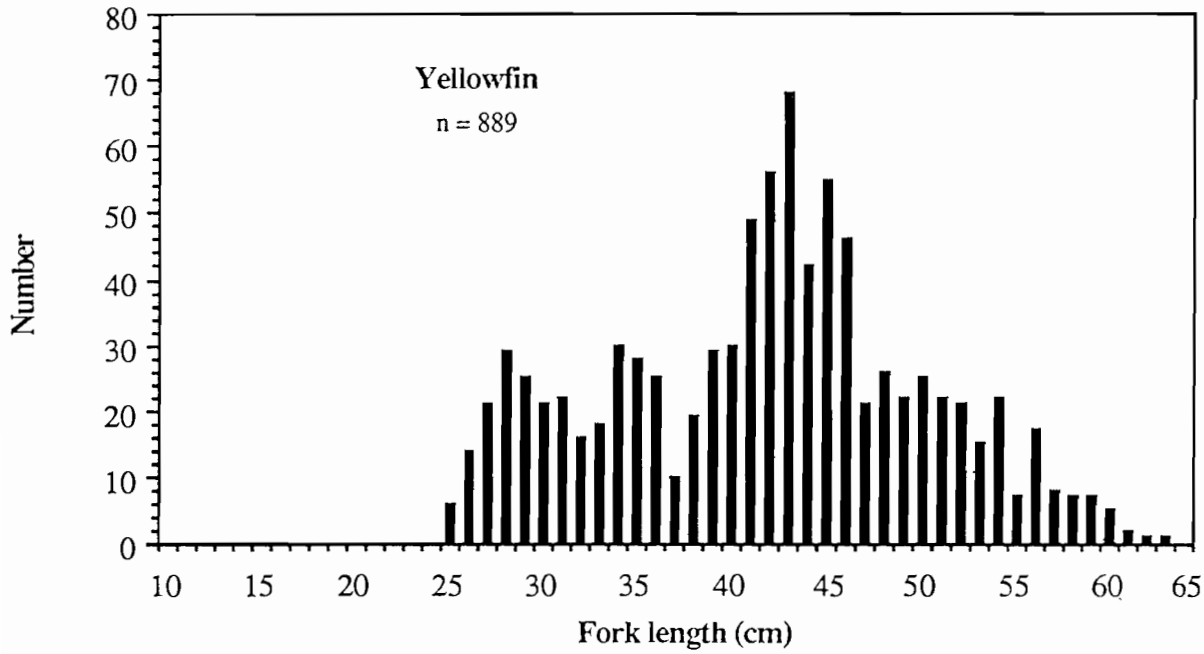


Figure 4. Size distribution of Indonesian tagged tuna releases, by species



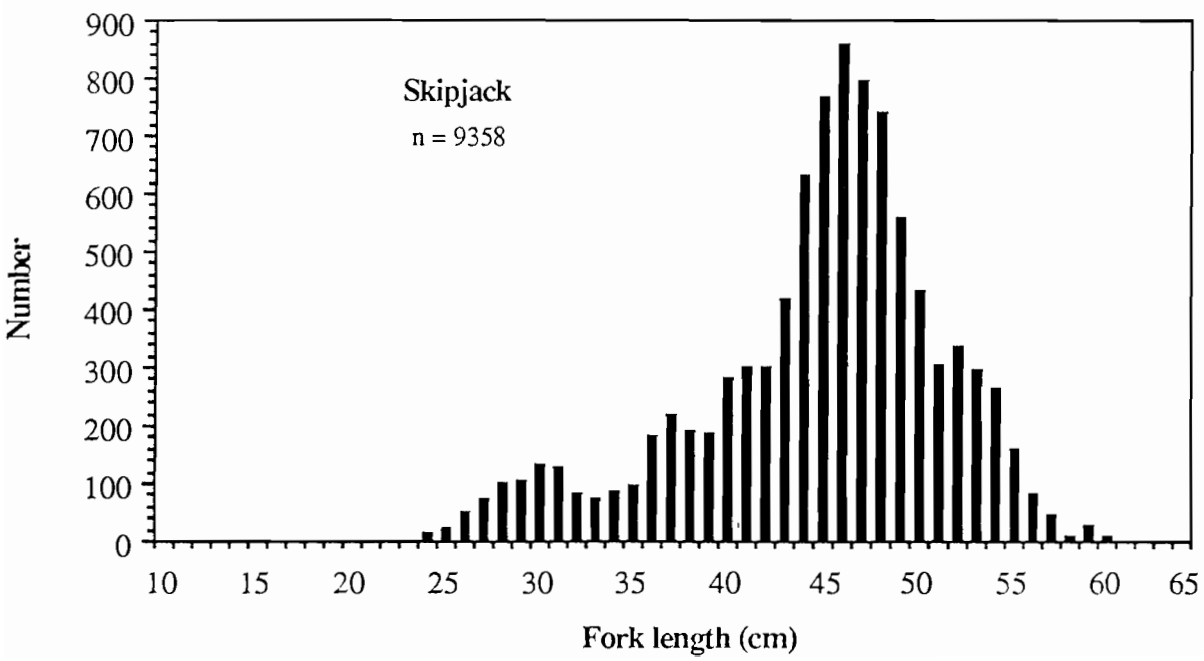


Figure 5. **Distribution of Malaysian tag releases, by half degree squares. Recapture numbers are given in brackets.**

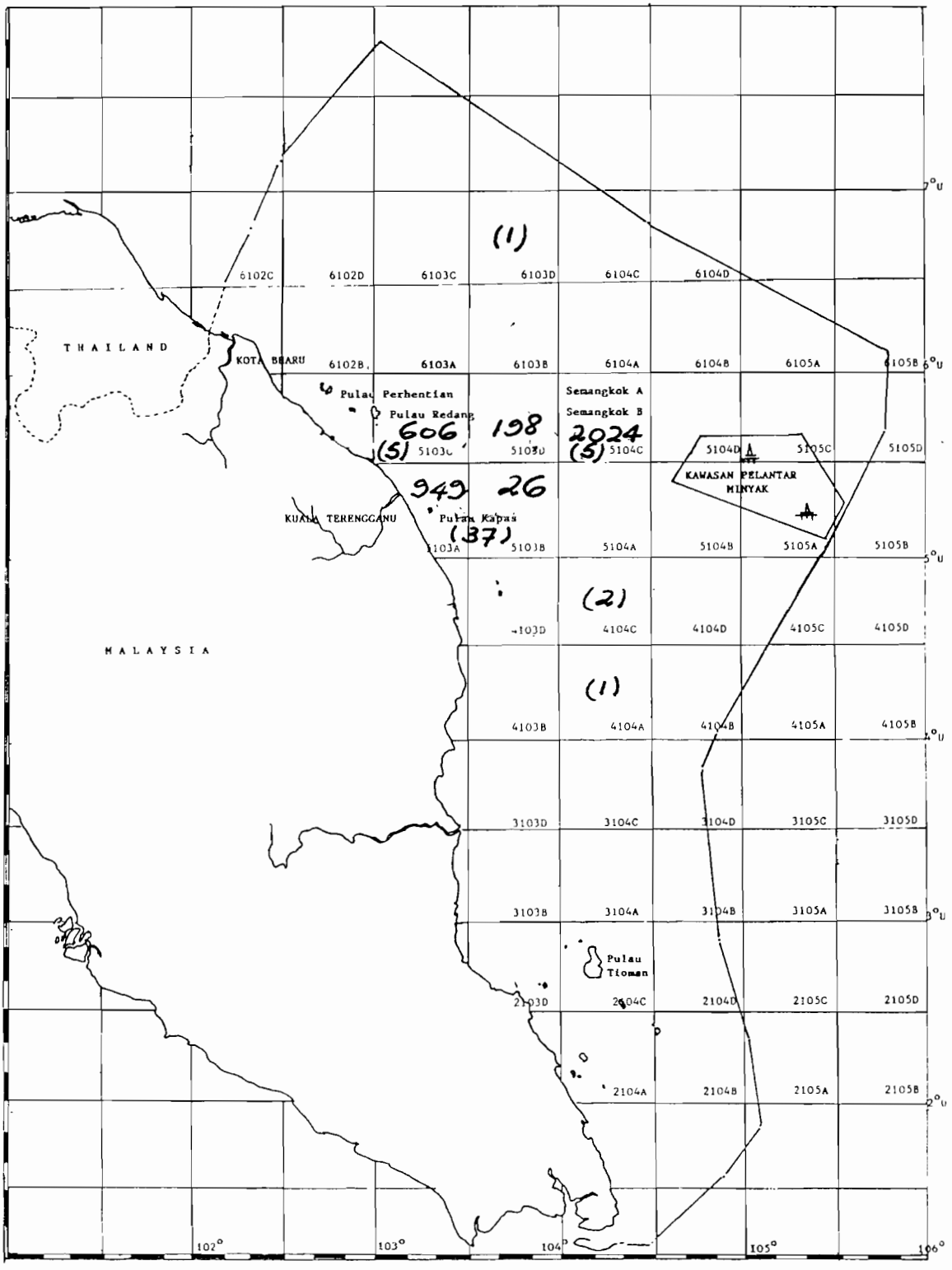
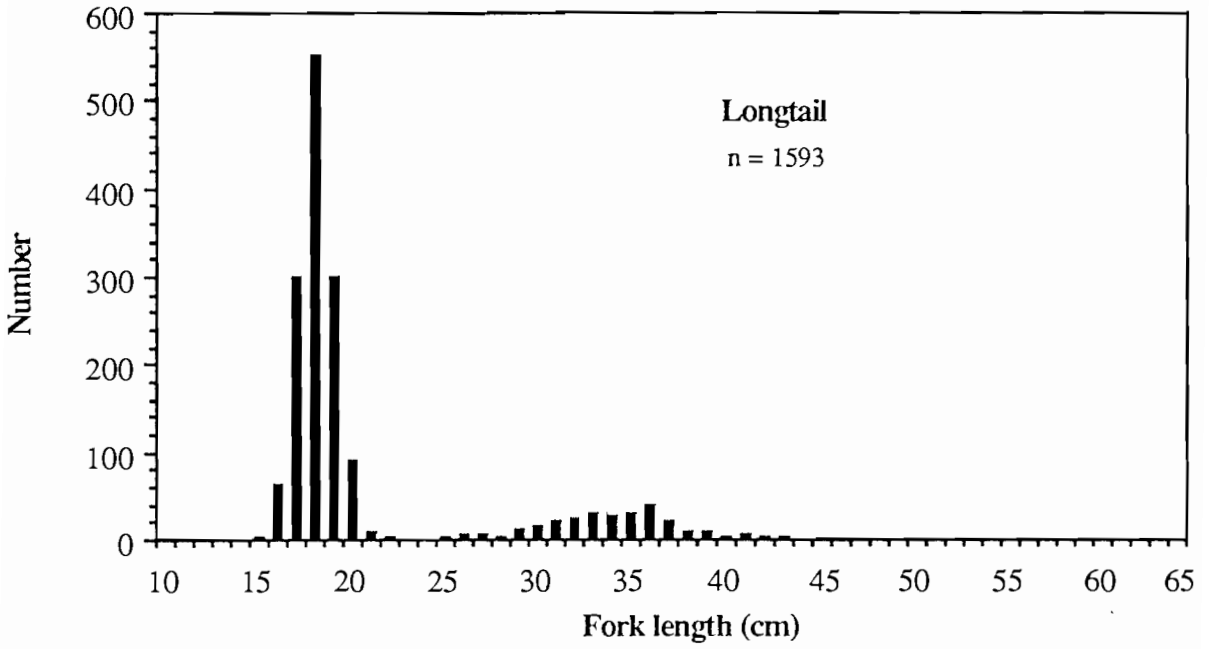


Figure 6. Size distribution of Malaysian tagged tuna releases, by species



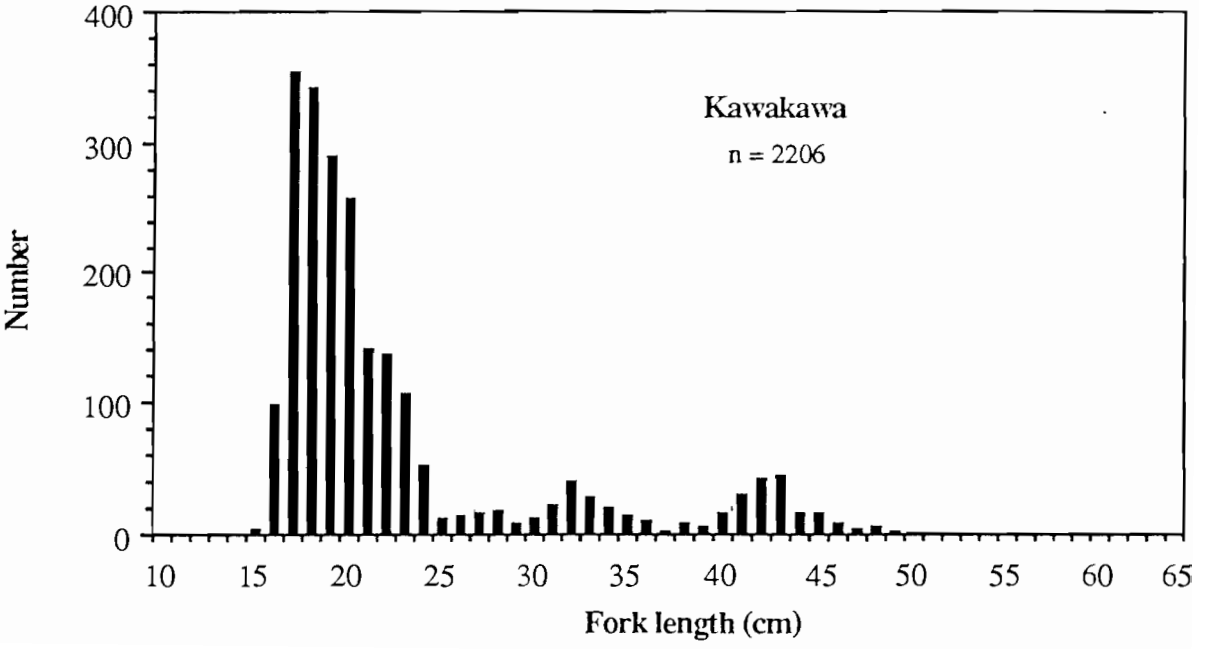
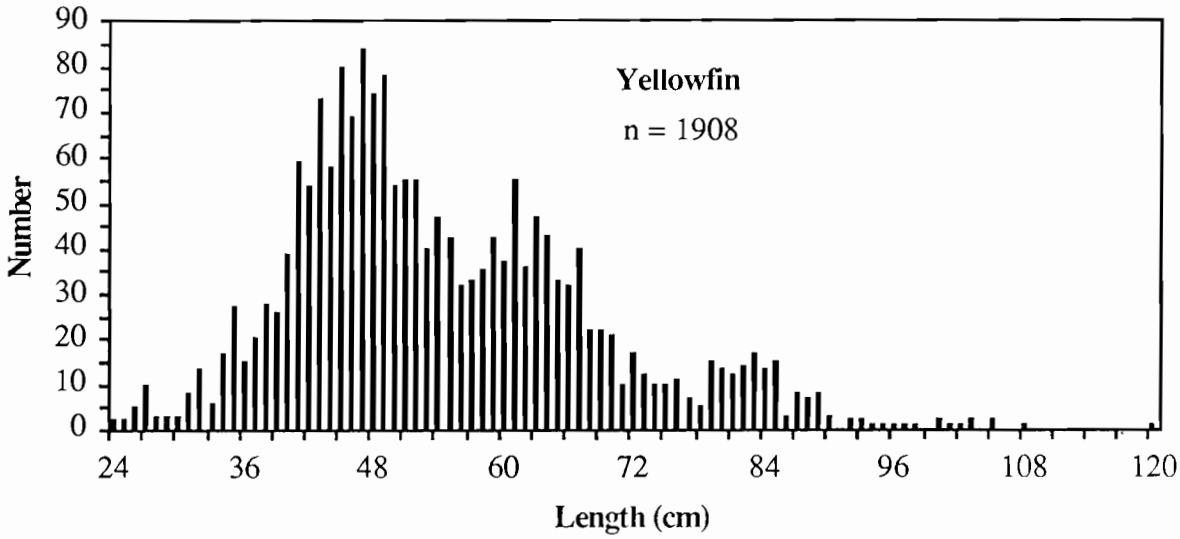
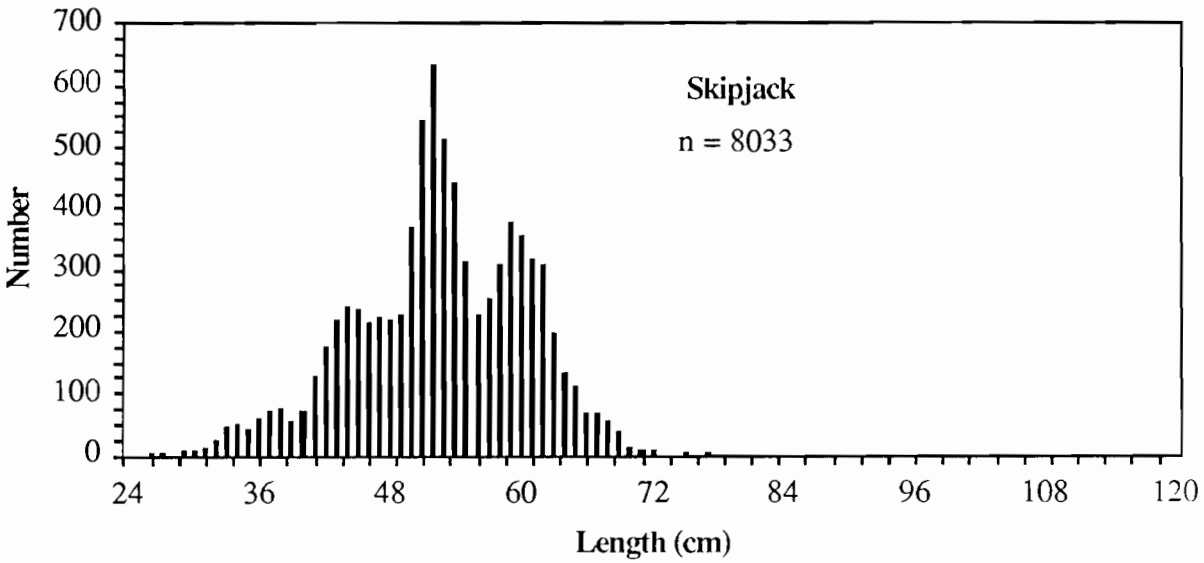


Figure 7. Size distribution of Maldives tagged tuna releases, by species





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ANNEX 1

ITINERARY OF THE STUDY

Sunday April 26	Noumea - Brisbane - Sydney
Monday April 27	Sydney - Manila ETA 1730 hrs. Initial contact and discussions with BFAR staff.
Tuesday April 28	Manila - Cebu - General Santos Discussions with BFAR staff re tagging work.
Wednesday April 29	General Santos BFAR/Industry meeting to discuss tagging results, future needs and planning for 5th SEATC. Return to Manila.
Thursday April 30	AM - further discussions of Philippines work. Manila - Jakarta ETA 1730 hrs .
Friday May 1	All day at RIMF, Jakarta Utara. Discussions with Tuna Section staff on Indonesian tagging experiments.
Saturday May 2	Presented seminar on Status of Tuna Stocks and Fisheries in the WTP to RIMF staff; further discussion of tagging experiments.
Sunday May 3	Jakarta - Kuala Lumpur ETA 1200 hrs PM - writing up trip notes.
Monday May 4	Visit to DOF (Jabatan Perikanan); Ms Rabihah Mahmood on leave, but had brief discussion with Mr. Tan and arranged meeting for Friday 8 May. Kuala Lumpur - Kuala Terengganu ETA 2010 hrs
Tuesday May 5	All day at Research Centre, with Mr. Lui, newly appointed Director, Raja Bidin and Raja Noordin. Thorough review of tagging work and data.
Wednesday May 6	Visit to Chendering and Pulau Kambing markets, to examine tuna catches, and inspect trolling vessels and their gear. Continuing review at FMRRC.
Thursday May 7	Presented seminar on tagging experiments and their design, results from the WTP and ASEAN, and a review of recent developments in tuna fisheries. Reviewed video of tagging, and as a result, gave tagging demonstration, designed cradle, and purchased materials. PM - working on report.

Friday May 8	Kuala Terengganu - Kuala Lumpur ETA 0930 hrs . Meeting PM with DOF staff in KL (Tan, Wahab) about national statistics and developments plans.
Saturday May 9	Report writing.
Sunday May 10	Kuala Lumpur - Colombo ETA 2235 hrs .
Monday May 11 - Thursday 14	Discussions with IPTP staff (M. Yesaki, D. Ardill); Review of findings and consideration of future tagging work; Review of Maldives tagging programme and analysis of results.
Friday May 15	Working on report. Colombo - Sydney ETA 1300 hrs Saturday
Saturday May 16	Sydney - Noumea ETA 2100 hrs.

ONE WEEK INTERMISSION

Monday May 25 - Sunday 31	Preparing report and comparative analysis of tagging data from other experiments.
Friday June 5	Submission of final report.

ANNEX 2

LIST OF PERSONS CONTACTED

PHILIPPINES

Atty. Reuben Ganaden	}	
Ms Flerida Arce	}	BFAR, Quezon City
Mr. Noel Barut	}	

Ms Elvira Baluyut, WPFCC Coordinator
Mr. Mike Lopez, PRIMEX Consultant
Mrs. Tabinga, FAO Office, Makati, Manila

Various General Santos-based industry and DA/BFAR persons, including Purefoods, RMF, etc.

INDONESIA

Dr. Nurzali Naamin	}	
Dr. Gede S. Merta	}	
Mr. Jacobus Uktolseja	}	RIMF, Jakarta Utara
Mr. Bachtiar Gafa	}	
Mr. Sofri Bahar	}	
Mr. Kusno Susanto	}	

MALAYSIA

Mr. Nik Wahab	}	
Mr. Tan, Cheng Kiat	}	Jabatan Perikanan, Kuala Lumpur
Mr. Lui, Pong Yean	}	
Mr. Raja Bidin	}	Kuala Terengganu Fisheries Marine Resource Research Centre.
Mr. Raja M. Noordin	}	Chendering
Mr. Abdul Hamid	}	

COLOMBO

Mr. David Ardill, Programme Coordinator, IPTP
Dr. Mitsuo Yesaki, IPTP.

ANNEX 3

OVERALL WORK PLAN FOR GCP/RAS/099/JPN

In close coordination with the existing international organizations including the South Pacific Commission (SPC) and Forum Fisheries Agency (FFA), and the FAO regional projects in the Western Pacific and Indian Oceans (i.e. ASEAN Small-Scale Fisheries, Bay of Bengal and Fisheries Development Programme and Southwest Indian Ocean Programme (SWIOP), the project will in general carry out the following work:

(i) Provide assistance to government research organizations in the initial design and implementation or improvement of data on catch, effort, species composition, length frequency and other biological characteristics.

(2) Conduct pilot activities to determine possible tagging and sample techniques for small tunas including in-depth evaluation of the fishing techniques used in the artisanal fisheries in selected areas of the IPFC/ IOFC area using, when necessary, locally chartered vessels which can be funded by national governments.

(3) Provide assistance to government and other research organizations in the design and implementation of relevant biological studies such as maturity and spawning juvenile development, feeding habits, etc.

(4) Make preliminary evaluation of:

   (a) surface tuna availability and seasonality, including studies of the migratory pattern of both tuna and tuna-like species;

   (b) fishing gear requirements for future tuna survey and assessment activities.

(5) Review information on the distribution and abundance of the various tuna stocks especially from the activities of this and related projects and identify necessary changes in the project including timing and location of the work.

ANNEX 4

Master plan of tuna and skipjack tagging in the Philippines
by the Bureau of Fisheries and Aquatic Resources (BFAR)

BFAR FORM 1: PROJECT PROPOSAL

Date Submitted : .....

Project code No.: .....
Support to Research

I. TITLE: Tuna and Skipjack Tagging

II. PROJECT LEADER: Reuben A. Ganaden
STUDY LEADER: Noel C. Barut

III. COOPERATOR/COOPERATING AGENCY:
Indo-Pacific Tuna Development and Management Programme, DA-Regional Office, Private Sector

IV. BACKGROUND/SIGNIFICANCE:

The project deals with the collection of information on stock identity and migration pattern of tunas present in Philippine waters necessary for resource assessment studies.

In order to make the best of the skipjack and tuna resources in Philippine waters, it is necessary to know whether the species are local stocks or part of the major stocks inhabiting the Western Pacific. To determine this it is imperative to have information on their migration. To assist in this stock identity, data information on their size and age composition, growth and maturity are needed. This project will aim to provide or supply this information.

This objective will be attained by tagging tuna at the variety of position throughout the Philippine waters within a 5-year period.

V. OBJECTIVE:

To gather information on stock identity, migration growth, food habit and maturity of skipjack and other tunas present in Philippine waters for management and development of the resource.

VI. DESCRIPTION OF THE PROJECT (METHODOLOGY):

Tagging will be done at the variety of position in Southern Philippine waters with priority given to the skipjack but yellowfin and bigeye tunas will also be tagged whenever practicable.

Tagging will be continued at intervals over a 5-year period to release tagged fish in the same position at different seasons.

Samples of skipjack, yellowfin and bigeye tunas will be obtained at intervals throughout the 5-year period from commercial and municipal fishing at a variety of location throughout the Philippine waters for size composition, maturity and food habit determination.

A system will be developed for publishing the tagging programme, recovery of tagged fish and tags and giving of rewards.

VII. DURATION OF THE PROJECT: 1988-1992

1st year - Moro Gulf, Davao Gulf and Mindanao Sea

2nd year - East, West and South Sulu Sea and Bohol Sea

3rd year - South China Sea, Luzon Sea

4th year - North Philippine Sea, Pacific Ocean

5th year - South Philippine Sea, Pacific Ocean.

VIII. TIMETABLE OF ACTIVITIES:

Duration of Activities	Detailed timetable of activities
1. January-December 1988 200 days per year	Tagging of tuna and skipjack onboard a ring net vessel
2. January-December 1988 200 days per year	Collection of biological parameters: a) Analysis of stomach content b) Collection of blood samples c) Analysis of samples for sex and maturity determination
3. December 1988	Collation of collected data and preparation of report

IX. BUDGETARY REQUIREMENT:

A. OBJECT OF EXPENDITURE

1. Travel .....P 120,000
2. Equipment outlay 50,000
3. Supplies and Materials 800,000
4. Sundries 50,000

P 1,020,000

X. PERSONNEL INVOLVED:

Name of Personnel	% of involvement to Project
1. Reuben A. Ganaden Supervising Fishery Biologist	50%
2. Noel C. Barut Senior Fishery Biologist	40%
3. Edwin Rome Fishery Technologist	40%
4. Nixon L. Java Junior Fishery Biologist	50%
5. Gregorio Garceron, Jr. Junior Fishery Biologist	50%
6. Alex Mole Junior Fishery Biologist	40%
7. Cesar Garcia Junior Fishery Biologist	40%
8. Homerto Riomalos Junior Fishery Biologist	40%

RECOMMENDED BY:

JOSE A. ORDONEZ
Division Chief

SUBMITTED BY:

REUBEN A. GANADEN
Project Leader

APPROVED:

JUANITO B. MALIG
Director

Date Project Actually Started:..... Date Approved:.....

PUBLICATIONS OF THE INDO-PACIFIC TUNA DEVELOPMENT AND MANAGEMENT PROGRAMME

WORKING PAPERS

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