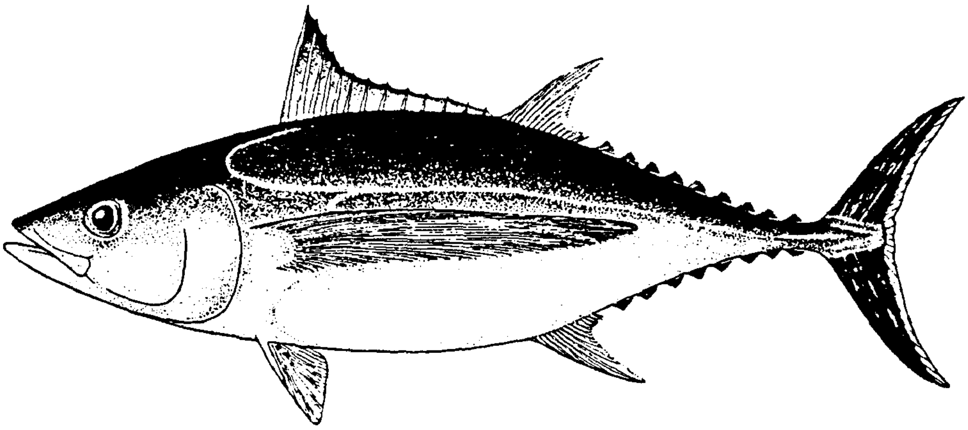
South Pacific Albacore Tagging Programme

Summary Report 1990-1991

Marc Labelle and Peter Sharples



Fourth South Pacific Albacore Research Workshop
Working Paper No. 2

National Taiwan University
Taipei, Republic of China
November 4-8, 1991

1. BACKGROUND

The Tuna and Billfish Assessment Programme (TBAP) of the South Pacific Commission (SPC) conducts biological research on exploited pelagic fish stocks on a regional basis. The two primary responsibilities of the TBAP are the compilation, maintenance and analysis of a regional data base on commercial tuna fishing, and the assessment of the stocks supporting these fisheries. One of its primary aims is to provide a scientific information base for the assessment of tuna resources of the region, upon which regional groupings and individual island countries could base their plans and decisions regarding the development of their fisheries resources.

The TBAP's involvement in South Pacific albacore research began in 1988, and was catalyzed mainly by the rapid developments in this fishery. Since 1952, albacore stocks have been exploited in the South Pacific by longliners from Japan, Korea and Taiwan. Catches have fluctuated between 25,000 t and 40,000 t since 1960, and production model estimates of maximum sustainable yield for the longline fishery were about 35,000 t, with 2,000 t taken by surface fisheries (Wetherall and Yong 1984, Wang 1988). Although the longline effort has remained relatively stable, a seasonal surface fishery for primarily sub-adult albacore developed during the mid-1980's, involving driftnet vessels of Japan, Taiwan and Korea, and a trolling fleet of U.S., Canadian, French Polynesian and Fijian vessels. The estimated catch of the 1988-89 surface fishery alone reached about 33,000 tonnes. Such rapid developments in the surface fisheries led South Pacific nations to express concerns about the potential for overfishing, and about potential impacts upon the local economies. In response to such concerns, the TBAP initiated the South Pacific Albacore Research Project, which included the development of a catch and effort data base, and several other programmes for the coordination of catch sampling, fishery monitoring and albacore tagging activities.

Lewis (1990) summarized the South Pacific albacore tagging activities conducted during the 1986-90 period by scientific organizations from Australia, New Zealand, France and the U.S. As of June 1990, about 7000 albacore had been tagged and released in the South Pacific, but only seven tagged fish have been recaptured and returned so far to the tagging organizations. In view of the necessity to obtain more release-recovery data for stock assessment purposes, a continuation of the mark-recapture operations was considered essential.

A South Pacific albacore tagging programme was initiated by the TBAP during 1990-91 with funding from the Fifth European Development Fund. The overall goal of the tagging programme was to provide scientific information required to (i) estimate vital stock parameters such as abundance, mortality and growth rates, movement and exploitation patterns, (ii) formulate biologically rational options to determine sustainable yields for each gear type, and (iii) determine the extent of interactions between surface and longline fisheries at current exploitation levels and for projected future developments. The present report summarizes the activities conducted under this programme during the 1990-91 season, and provides an overview of the mark-recapture data on South Pacific albacore.

2. SPECIFIC OBJECTIVES OF THE TAGGING PROGRAMME

The specific objectives of the 1990-91 tagging programme were;

(a) To tag and release a total of ~5000 albacore in the major troll fishing areas, namely, the Tasman Sea, the coastal waters of New Zealand, and the Subtropical Convergence Zone (STCZ: 35-40°S, 170-130°W);

(b) To monitor the prevailing oceanographic conditions, and collect data on the associated catch rates and catch composition;

(c) To assess the use of pole-and-line gear for purposes of tagging albacore, and the feasibility of catching sufficient bait supplies in the STCZ for this purposes. This objective stemmed from the hypothesis that pole-and-line gear would be more suitable for tagging albacore since it subjects the fish to less stress than troll gear.

(d) To monitor driftnet and troll fishing activities of commercial fleets primarily for the purpose of assessing general conditions and trends in these fisheries;

3. GENERAL STRATEGY AND METHODOLOGY

3.1 Allocation of tagging effort

The South Pacific albacore surface fishery is now mainly composed of troll vessels. However, albacore have been caught in the North Pacific and in New Zealand waters by means of baitboats equipped with traditional pole and line gear. It is a well known fact that albacore brought on board with poles are generally more vigorous than those hauled in while trolling. In order to maximize the probability of post-tagging survival, it was decided to use pole and line gear as often as possible. For this purpose, the dual purpose pole-and-line/troll-fishing vessel *Solander 3* was chartered by the SPC from Solander Pacific Ltd. (in Fiji), and was used to assess the feasibility of tagging large numbers of albacore with pole-and-line gear (vessel/gear described in Appendix). The general strategy was to maintain a good supply of bait in the vessel's four tanks (total capacity ~30 m^3), which would be used to 'chum' albacore during good fishing periods to lure them to the surface waters in the hope that pole and line gear could be used. Bait would be collected with a combination of *bouki ami* nets, *Lampara* nets and small seines whenever opportunities presented themselves. This course of action also dictated that the vessel be in the vicinity of good bait grounds to resupply itself when reserves were low. When bait was not being used and/or conditions were not ideal, fishing was conducted with troll gear as on other troll fishing vessels (see Dotson 1980).

In order to assist the SPC with tagging operations, the NZ Ministry of Fisheries and Agriculture (NZ MAF) assigned the research vessel *Kaharoa* to participate in the tagging programme, and provided about one month of vessel time for this purpose. This small trawl fishing vessel had previously been modified with the addition of troll fishing gear, which had been shown to be adequate for tagging purposes during previous tagging cruises conducted with this vessel. The initial plan was to use the *Kaharoa* to cover areas primarily along the coast of New Zealand, while the Solander *3* would cover the Tasman Sea initially and then the STCZ. In order to cope with potentially poor catch rates, each vessel was allowed to alter the planned itinerary slightly to maximize the number of tags released. This approach would ensure that tags would be roughly distributed over most of the area where surface fisheries operate.

3.2 Tagging gear

The tagging equipment used on board these vessels consisted of the same gear as used on board the other SPC chartered tagging vessel *F.V. Te Tautai.*, which is used primarily for yellowfin and skipjack tagging in tropical waters. The cradles used resembled those described by Kearney *et al.* (1972) and Kearney and Gillett (1982). The cradles are composed of a soft, plasticized, concave, half-funnel shaped tarp, which is hung over a metallic structure of galvanized steel pipes secured onto the deck. A spongy, plastic covered, foam block is located at the funnel end to prevent albacore from injuring their nose while sliding into the cradle. Each tarp is graduated so that albacore can be measured while being tagged. The cradles are sufficiently large so that one or two fish could be landed, unhooked and held by an assistant, while the other is examined, measured and tagged at the opposite end.

The tags used were identical to those used in SPC's tropical Regional Tuna Tagging Project. These were 13 cm yellow plastic tags with a single barbed nylon head, which were obtained from Hallprint Propriety Ltd. from Adelaide, Australia. They were numbered with an 'A' followed by a five digit number, starting at 'A00001'. Applicators were made of stainless steel tubing, slightly longer and slightly greater in diameter than the tags, cut obliquely at one end to produce the sharpened, indented conformation required to aid insertion of the tag and to accommodate the barb of the tag so that it is less likely to be severed from the shaft of the tag during insertion. These were kept arranged in groups of one hundred applicators standing in holes numbered '01' to '00' in wooden blocks. A block was placed, as required, handy to the tagger in the receptacle provided on the tagging cradle. The forward and outside walls of the tagging block receptacle are made higher than that of a standing applicator complete with tag. This prevents the tags from being inadvertently removed from their applicators by the movement of troll lines over the end of the cradle during fishing.

3.3 Tagging procedure

The tagging procedures used when troll and/or pole and line gears were used followed those described by Laurs *et al.* (1976) and Laurs and Nishimoto (1989). Immediately after a strike, the fishing line was hauled in manually, and the fish handled with cotton gloves until release. The fish was lifted by a crew member to the hands and arms of a waiting assistant (or catcher) who held it while the hook was removed. Fish exhibiting visible injuries and/or bleeding were not tagged. If such injuries were absent, and the fish was still vigorous, it was immediately placed on the cradle. While the fish settled down a bit, the mouth and gill parts were examined rapidly for subtle signs of injuries. If none were present, the tag was inserted in an oblique angle so that the barb would anchor itself among the pterygiophores of the second dorsal fin. A fork length measurement was taken while the albacore had its snout flush against the end of the cradle, and the fish was released head first into the water immediately after. The measurement taken was rounded down to the lowest centimeter, and was recorded along with the date, time and tag number on a small tape recorder hanging from the taggers neck. Additional information on the condition of the fish was also recorded at the same time if peculiar observations were made at the time of release. As a safeguard, data recorded each day was transcribed onto paper at the end of the same day along with information on fishing and oceanographic conditions.

Unlike previous tagging programmes on South Pacific albacore, none of the fish tagged were injected with tetracycline. This approach was opted for mainly because of logistic considerations. However, in order to provide insight on tag loss rates, ~20% of all fish handled were to be double tagged. In an attempt to accomplish this, double tags were to be applied on every fifth day. When applied, this second tag was placed on the opposite side of the first tag, and 2-3 cm forward to avoid entanglement of anchors.

3.4 Additional sampling and monitoring activities

During the 1988-89 troll fishing season, large numbers of troll caught albacore were found to exhibit distinct patterns of skin and scale loss (Hampton *et al.* 1989). Damage which appeared to be recent was frequently seen when troll and driftnet vessels were fishing in the same areas. These observations suggested that the damage was caused during escapement from a driftnet. Additional evidence has been obtained recently in support of this hypothesis (Hampton *et al.* 1991). Since then, efforts have been made to record the incidence of driftnet injuries in troll catches monitored during the observer and tagging programmes. For this purpose, the following categories of driftnet damage were established and used for classification while processing fish;

Damage Code 0: No evidence of skin loss or scale loss loss (recent or old);

Damage Code 1: Continuous multiple stripes appearing as slight skin discolorations running laterally along the thickest part of the body about 5-10 mm apart. On close examination the discolored striping results from skin loss. Large albacore previously assigned to category 4 during the 1988-89 season (see Hampton *et al.* 1989) are now included in this category;

Damage Code 2: Minor damage similar to the previous category, but the skin abrasion has brush-like patterns, which distinctively terminate at locations anterior to the point of maximum girth. This pattern suggests that the fish was not able to pass through the net;

Damage Code 3: The most serious category of net damage. Areas of exposed muscle are visible where the skin and scales have been scraped away. Exposed patches are typically 25-50 mm wide, 50-100 mm long, and are usually located within 30 mm of the dorsal or ventral mid-line in the area of maximum girth. Damage to the second dorsal, anal and caudal fins is common. The first dorsal and pectoral fins are also occasionally damaged;

Damage Code 4: Similar to first category except that the stripes are older, less distinct and are somewhat interrupted. These fish appear to have been damaged by a driftnet previously, and to have recovered after some time at liberty (possibly one year). This includes the unspecified 'aged marks' category used by observers during the 1989-90 season;

In addition to the above, taggers also checked the fish for the presence of small, round and concave holes induced by the mesopelagic shark (*Isitius brasiliensis*), large external cuts to the body caused by larger epipelagic sharks, and injuries to the mouth and surrounding tissues as typically caused by troll fishing gear. On the *Solander 3*, most of the the tunas which were not tagged and released were retained for sales and further sampling. Nearly all of these fish were measured for fork-length to the nearest whole centimeter below actual length. Other data collected included weight, sex, gonad maturity, otolith samples, stomach contents and a range of morphometric attributes. Records were also kept of the number and type of fish other than albacore that were captured while trolling (by-catch).

4. RESULTS

4.1 Cruise summary

Nine distinct cruises were conducted during the December-March period of 1990-91 (Table 1). Most of the tagged fish were released from the *Solander 3*, which conducted six tagging cruises spread over most of the troll fishing season (Table 2). During the first cruise of *Solander 3*, catch rates were lower than anticipated, and only 83 albacore and 19 skipjack were tagged. Bad weather conditions prevailed during the second cruise, which drove most fishing vessels to port, caused damage to *Solander 3*, and allowed for only 32 albacore and three skipjack to be tagged. The third cruise was delayed in order to conduct repairs to the ship, and supply the vessel with adequate bait. Given the poor fishing conditions encountered in the Tasman Sea, the third cruise was conducted on the east side of New Zealand, and 167 albacore were tagged before refuelling at Waitangi on the Chatham Islands. During the first three cruises, there were no good opportunities to conduct an assessment of the efficiency of pole-and-line gear for tagging purposes.

On the fourth cruise, *Solander 3* headed towards the principal albacore fishing fishing grounds in the STCZ to meet the bulk of the troll fleet. Catch rates during this cruise varied considerably (range: 0-337 fish$\cdot$d^{-1}), but on average were substantially greater than those encountered previously. In order to take advantage of such conditions, an additional tagger was placed on the *Daniel Solander* for six weeks to cover areas further east of the *Solander 3* during the peak fishing period. The two vessels often operated at considerable distances from each other (> 400 km) so each trip was considered as a distinct cruise. This approach allowed crews to tag 576 albacore from the *Daniel Solander,* and 1753 from the *Solander 3*, which accounted for >80% of all tags released during the season. The bulk of these were released within a area of 5^o x 5^o, located ~1100 km southwest of French Polynesia (Fig. 1). On February 22nd, 337 tagged albacore were released from *Solander 3*, of which 188 were captured and tagged using pole-and-line gear. This was the only instance where pole and line gear was used to tag a large number of albacore, mainly because large surface dwelling schools were not encountered at other times.

The *Solander 3* left the STCZ grounds around mid-March mainly because supplies were running low. The sixth cruise was essentially conducted along the east coast of New Zealand. During this period, 71 albacore were tagged, primarily in shallow waters (< 40 m) from mixed schools with kahawai (*Arripis trutta*) and kingfish (*Seriola grandis*). On the final cruise, bait-tanks were filled with small mullet (*Aldrichetta forsteri*) caught under a warf in Nelson while the vessel waited for repairs. Only 19 fish were tagged during the week, and the tagging season was terminated on March 26.

The two cruises of the *Kaharoa* took place in the Tasman Sea. During the first cruise in early January, only 128 tags were released, mainly because of bad weather which prevented it from reaching and assessing conditions in the western part of the Tasman Sea. The second cruise began ~mid-February, and 497 albacore were tagged in the Tasman Sea.

Overall, 3326 albacore and 22 skipjack were tagged and released during the season. About 12.5% of all albacore released had double tags. A composite map of all locations of tagging (Fig. 1) shows that releases were made over most of the area traditionally covered by the surface fishery. Due to the larger variation in catch rates, 70.2% of the tags were applied STCZ, with 24.2% in coastal waters of New Zealand, and 1.7% in the Tasman.

4.2 Size distribution of the tagged fish released

Tagged albacore released from the *Kaharoa* were, on average, ~20 cm smaller than those released from the *Solander 3* (Fig. 2). This can be attributed to the fact that the two vessels operated mainly in different areas, and that albacore in the STCZ are generally larger than those caught in coastal waters of New Zealand (Labelle and Murray 1991). The length frequency distribution of tagged fish released from the *Daniel Solander* were similar to that of tagged fish released from the *Kaharoa*, and no significant difference in the distributions was detected between the two groups of albacore (Kolmogorov Smirnov test, $P \approx 0.5$). It should be noted that only the small fish caught on board the *Daniel Solander* could be tagged during the cruise. Commercial fishermen operating in the STCZ often retain predominantly the larger albacore which are sold at a higher price per kg than the smaller ones, which are less in demand by canneries. Thus the similarity in the size frequency distributions of these two vessels is mainly attributed to the selective actions of the tagger, and is not a reflection of the level of similarity of albacore populations found in the two areas. No such selection was done on the *Solander 3*, so the length frequency distribution of the fish sampled on board this vessel is more representative of the actual size distribution of the albacore population in surface waters of the STCZ. A comparison of the size distributions of the *Kaharoa* and *Solander 3* releases clearly shows that the relative abundance of small albacore (~50 cm) is much greater in coastal waters of New Zealand where the *Kaharoa* operated, than in the STCZ where the *Solander 3* operated.

Length frequency distributions of albacore caught in the Tasman Sea, New Zealand coastal waters and the STCZ generally show modes at ~50, 58, 67 and 78 cm, which are hypothesized to correspond to the modal lengths of albacore from successive year classes (Labelle and Murray 1991). Length frequency data on commercial catches obtained during 1990-91 showed that the 58 cm mode was conspicuously absent in the STCZ catches (Fig. 3). Correspondingly, this mode was also absent from the size distributions of the tagged fish released. Thus, the majority of the tagged fish released on the *Kaharoa* and the *Daniel Solander* might be, on average, about 2 years younger than the bulk of those tagged and released from the *Solander 3*. The substantial overlap of the size distributions of albacore that were tagged and caught by commercial trollers indicates that the entire size range of albacore caught by trollers will be represented (although non-proportionally) by the tagged fish released. In fact, the degree of overlap is even greater than indicated by Fig. 3, since commercial fishermen catch fish in the 49-55 size range which are often rejected. This component of the commercial catch is not well represented by Fig. 3, since observers usually measured the fish that were retained on commercial vessels (Labelle and Murray 1991).

Laurs and Nishimoto (1989) provided details of the 1986-1989 tagging programs on South Pacific albacore. Tagged fish released from U.S. and New-Zealand vessels were mainly within the 43-85 cm size range, with about 55% of the tagged fish being within the 55-62 cm size range. Tagged fish released around New Zealand or west of 170°W tended to be smaller than those tagged further east in the STCZ (means ≈ 59.4 and 62.7 cm). Laurs and Nishimoto (1989) speculated that this difference was due to the fact that U.S. troll fishermen tend to seek fish >5 kg for the higher prices they command. The results of the present study suggest that their hypothesis is correct, but is not responsible for all the size difference observed between both areas. It should be noted that the tagged fish released by the French research vessel *Coriolis* during 1987 were also in the same size range as those tagged by U.S. and New Zealand vessels (Pianet and Grandperrin 1990). Thus, fish tagged prior to 1989 tended to be from younger age classes than those tagged during the 1990-91 season.

4.3 Temporal distribution of tagging effort

Cumulative distributions of the percentage of tagging effort over time for the previous tagging seasons indicate that tagging generally occurs between January 1 and mid-March. The temporal distribution of tagging effort for the 1990-91 season thus conforms to the general pattern observed during previous seasons (Fig. 4). During the 1990-91 season, only ~10% of all tags released had been applied by February 1, at which time, ~30-40% of the total commercial troll catch, and a small fraction of the longline catch of that season has already been taken. This means that not all tags released in a given season are available for recapture by all boats fishing each season, and the total troll catch for a given season cannot be considered as the associated recovery sample even if the entire catch is inspected for tagged albacore.

4.4 Albacore condition at release

Efforts were made to simplify tagging operations, and ensure that tagging would be conducted in such a fashion as to minimize the stress on the fish during and after tagging. The vast majority of fish tagged were generally brought on board within 30 seconds from striking the line. Once the fish was on board, the total time required to tag and release the fish was generally <12 seconds, and only in rare instances did it take longer than 20 seconds to process the fish. Taggers generally managed to place the tag in the ideal location, but owing to handling difficulties, about 1.7% of the tags applied were not implanted properly (Table 3). In such cases, the tags could not be anchored deep enough into the pterygiophores. Approximately 80% of the tagged fish exhibited no visible signs of excessive stress loads and/or injuries. About 18% of the tagged fish released had minor mouth injuries (torn lip, above average hook damage), but taggers generally assumed that such damage was not serious enough to cause mortality after release. This was by far the most common type of injury observed during tagging operations. Nearly all albacore tagged were easily released, but a minor fraction of these (<1%) could not be handled easily and hit the deck or the side of the vessel at release.

Estimates of the incidence of external injuries on troll caught albacore were based the *Solander 3* sampling records since they were more complete than those obtained on the other two vessels. The number of albacore that exhibited recent driftnet marks (<1 year old) accounted for <2% of those examined, which was less than the incidence observed during previous seasons, presumably due to the reduction in driftnet fishing activity (Labelle and Murray 1991). About 1% of all albacore examined exhibited old driftnet marks. The incidence of external injuries caused by previous encounters with troll gear was negligible (<0.1%), and only a small portion of the albacore sampled exhibited shark bites (<0.3%). As a result, ~97% of the fish examined exhibited no visible external injuries at capture which stemmed from previous encounters with fishing gear and sharks. Still, only ~48% of the albacore caught on board the *Solander 3* could be tagged and released because all other fish caught were too exhausted and/or had serious injuries caused by the fishing gear of that vessel.

4.5 Factors affecting tagging success

The hooks used on the *Kaharoa* and the *Solander 3* were regular commercial double barbless tuna troll hooks which had been cut down to singles. However, for a short period, a selection of smaller, single and double hooks were tested on the *Solander 3* to see if a greater fraction of the fish hooked could be tagged. Lines with different types of hooks were monitored during several hours each day and the number of strikes, drop-offs (fish that escaped after being hooked) and injured albacore were recorded.

The results obtained indicated that about 9% of the fish hooked with double barbless hooks managed to escape before being brought on board (Table 4). This fraction increased to ~52% when regular single hooks were used, which accounts for significant differences in the corresponding landed:drop-off ratios (χ^2 test, P≈0.0001). Changing from regular single hooks to small single hooks further increased the escapement rate to 55.7%, but no significant difference could be detected in the corresponding landed:drop-off ratios (χ^2 test, P≈0.64). The use of extra small single hooks did not result in a significant increase in this ratio, and extra small double hooks had comparable performance to that of regular single hooks. Both of the latter types of hooks were simply not suitable for extended use as they tended to straighten out after a short period due to the excessive stress load. Statistics for these two types of hooks were therefore omitted from further statistical comparisons.

Based on the above results, it might be tempting to use double hooks to minimize the escapement rate, but double hooks appeared to cause more injuries than single hooks. The fraction of the fish landed that were rejected because of mouth injuries was greater for regular double hooks than for regular single hooks (~57% against 44%), but no significant difference was detected between the corresponding suitable:reject ratios (χ^2 test, P≈0.94). Using small single hooks failed to further decrease the fraction rejected.

In order to maximize the number of tags released, it is necessary to use hooks which minimize the product of the escapement and rejection rates. The suitable:miss ratios (miss=strike-suitable) is a function of both processes, and statistical differences were detected between corresponding ratios of regular single and regular double hooks (χ^2 test, P≈0006). Thus, when double regular hooks were used, a greater fraction of all fish hooked were tagged and released (39.4%) than when regular single hooks were used (27.1%). An even smaller fraction was obtained when small single hooks were used (22.9%). Such results indicate that despite the prevailing assumption that single hooks are 'better' for tagging purposes, the use of double hooks allows the crew to tag a greater fraction of all fish that hit the lures. The differences between hook types is even greater than indicated by this test if one also takes into account that albacore tend to hit double hooks at a slightly greater rate than single hooks (strikes·hook h^{-1}, Table 4). In view of this, it would appear that tagging operations could be conducted from commercial troll fishing vessels without major modifications to the hooks used, since there is no apparent need to replace the double barbless hooks generally used by the other hooks tested.

One of the factors which apparently affected the escapement rate on the *Solander 3* was the height of its transom. Albacore caught on stern lines had to be lifted out of the water over a considerable height (2 m), and a highly variable fraction of the the fish handled each day were lost while lifting them on board. Therefore, attempts were made to tag albacore from the 5.5 m skiff equipped with four standard troll lines attached to the stern. On three distinct occasions (calm weather), the performance of the skiff was monitored at the same time as that of the *Solander 3*. Although the number of strikes per hook hour was ~20% lower for the skiff than for the main vessel, the escapement and rejection rates associated with the skiff operations was substantially lower than those associated with the main vessel. Still, the landed:drop-off ratio of the skiff was not statistically different than that of the main vessel (χ^2 test, $P \approx 0.108$), so the hypothesis of equal escapement rate cannot be rejected based on the available data. However, statistical differences were detected between the corresponding suitable:miss ratios (χ^2 test, $P \approx 0.001$), which supports the observation that proportionally fewer albacore are damaged when fishing and tagging from the skiff. This is mainly due to the fact that the skiff can be slowed down after a strike faster than the main vessel, so less strain is imposed on the mouth parts when pulling in the hooked fish. Taggers on board the skiff observed that fish were noticeably livelier than those off the lines of the *Solander 3*. Thus, despite the comparatively lower catch rates obtained on the skiff, there are definite advantages associated with tagging operations conducted from skiffs. It should be noted that the lower catch rates obtained during skiff operations seemed to be related to the general fishing conditions. The master fisherman on board the *Daniel Solander* noted that during periods of relatively low catch rates, the skiff occasionally had better catch rates than the mother vessel. Efforts will be made to test this hypothesis during the 1991-92 tagging cruises.

4.6 Information on tag recoveries.

Efforts are currently being made at the SPC to retrieve all historical tag release statistics associated with previous albacore tagging programmes in the South Pacific in order to complement those associated with the 1990-91 season. Efforts are also being made to retrieve and cross-validate all associated recovery statistics, so as to ensure that the resulting mark-recapture database will be sufficiently complete and accurate for analytical purposes. At the present time, the records available indicate that 11 tagged albacore have been recovered since tagging activities began in 1986. Four of these were recovered during 1991, of which two had been released during the 1990-91 tagging programme (Table 5). One of these two tagged fish recovered had been double tagged on the *Solander 3*, and both tags were present at recovery. Tagged fish recovered were at liberty from 2 to 30 months, with the average time being ~13 months. Nine tagged albacore were recovered from Asian longline vessels, and one from troll and driftnet vessels.

Further analysis of migration patterns, growth rates and mortality schedules based on the available records is underway. At this stage, the information on hand can only serve to conduct a preliminary assessment of the relative success of the 1990-91 tagging programme. For each tagging season, the corresponding number of recoveries made during the same (initial) year was determined. For the 1986-87, 1987-88 and 1990-91 seasons, these respectively added up to two, one and two (Table 5). No tags were recovered during the same year of release for the other tagging seasons. Statistical comparisons of the recovery rates across years based on the associated release:recapture ratios could not be made because of the high incidence of zeros in the cell frequencies (Zar 1984). The cell frequencies were collapsed into two groups: the 1990-91 season, and all previous tagging seasons. For these two groups, the proportion of all tags released that were recovered in the same year of tagging were ~0.03% (previous seasons), and 0.06% for the 1990-91 season. Thus the recovery rate of the 1990-91 tagging season so far appears to have been comparable to that of previous seasons, and no significant difference in the corresponding release:recapture ratios could be detected (χ^2 test, P≈0.471).

It should be noted that the above results are based on incomplete records, so the conclusions are tentative at best. Information obtained recently confirmed that at least one tag applied this year (Yellow SPC tag) had been recovered on an Asian longline vessel, but was lost before it would be returned to the SPC. There are undoubtedly other unreported instances were tags are lost or simply not returned, and efforts are currently being made to increase awareness of the tagging programme, as well as quantify the non-reporting rate.

5. SUMMARY

The major results of the 1990-91 tagging programme are as follows:

(a) Tagging was conducted in the Tasman Sea, the coastal waters of New Zealand, and the Subtropical Convergence Zone during the period of December 1990 to March 1991.

(b) Three troll fishing vessels were used to catch albacore for tagging purposes; the *Solander 3*, the *Kaharoa*, and the *Daniel Solander*. The total number tagged fish released from each of these vessels respectively amounted to 64%, 19% and 17% of the total tags applied. About 72% of all tags released were applied in the STCZ, and 25% in the coastal waters of new Zealand.

(c) Albacore tagged were predominantly within the 44-85 cm size range, with distinct size modes at ~50 cm and 70 cm. The size distribution of the albacore tagged was very similar to that of the albacore caught in the commercial troll fleet. The incidence of external injuries on albacore examined was negligible.

(d) Observations conducted during tagging cruises suggest that standard double barbless hooks commonly used by commercial fishermen are suitable for tagging purposes, and allow crews to tag a greater portion of all fish hooked than the smaller hook types tested. Albacore tagged and released from slower moving skiffs seemed to be in better condition at release than those processed from the mother ship. Albacore caught with pole and line fishing gear were in excellent condition at release, but it is doubtful that this fishing method can be relied upon to tag large numbers of albacore because surface dwelling schools are uncommon in the STCZ.

(e) Available records indicate that the recovery rate of albacore tagged and released this season is comparable to that of previous seasons. Some observations indicate that not all tags recovered by fishermen are submitted to the SPC, and further studies are needed to quantify the level of non-reporting.

6. ACKNOWLEDGEMENTS

The hardships associated with the duration and isolation of these tagging cruises demanded uncommon toil and perseverance of the men at sea striving to make it work. We wish to thank Captain David J. Williams, his mate Sam Ue and all the crew of the *Solander 3* for their considerable input in this respect. We are also grateful to the Captain and crews of the *Daniel Solander* and the *Kaharoa* for their timely and effective contributions. The shore staff of the New Zealand Ministry of Agriculture and Fisheries assisted with logistical support and liaison. Financial assistance for the programme was provided through the Fifth European Development Fund, and Canada's International Center for Ocean Development (ICOD).

7. LITERATURE CITED

Dotson, R.C. (1980). Fishing methods and equipment of the U.S. west coast albacore fleet. U.S. NOAA Tech. Memo. NMFS. 8. 126 p.

Hampton, J. (1990). Simulation of the South Pacific albacore population: Effects of rapid developments in the surface fishery. Third South Pacific Albacore Research Workshop. South Pacific Commission, Noumea, New Caledonia. 9-12 Oct. 1990. WP 1: 33 p.

Hampton, J., T. Murray and P. Sharples (1989). South Pacific albacore observer programme 1988-1989. South Pacific Commission. Tuna and Bill. Assess. Progr. Tech. Rep. 22: 22 p.

Hampton, J., T. Murray and K. Bailey (1991). South Pacific albacore observer programme 1989-1990. South Pacific Commission. Tuna and Bill. Assess. Progr. Tech. Rep. 25. 25 p.

Kearney, R. E., and R. D. Gillett. 1982. Methods used by the Skipjack Survey and Assessment Program for tagging skipjack and other tuna. Tech. Rep. Skip. Surv. Asses. Progr. South Pacific Commission. 7: 21-43.

Kearney, R. E., A. D. Lewis, and B. R. Smith. 1972. Cruise Report Tagula 71-1 survey of skipjack tuna and bait resources in Papua New Guinea waters. Res. Bull. Dep. Agric. Stock. Fish. Port Moresby. 8: 1-145.

Labelle, M., and T. Murray. 1991. South Pacific Albacore Observer Programme. Summary Report 1988-1991. Fourth South Pacific Albacore Research Workshop. South Pacific Commission. Noumea, New Caledonia. November 4-8, 1991. WP 3: 38 p.

Laurs, R. M., W. Lenarz, and R. Nishimoto. 1976. Estimates of rates of tag shedding by North Pacific Albacore, *Thunnus alalunga*. Fish. Bull. 74(3): 675-678.

Laurs, R. M., and R. Nishimoto. 1989. Summary of South Pacific albacore tagging conducted during 1986-1989. Second South Pacific Albacore Research Workshop. Suva, Fiji, June 1989. WP 13: 4 p.

Lewis, A. D. 1990. South Pacific albacore stock structure: A review of available information. Third South Pacific Albacore Research Workshop. South Pacific Commission, Noumea, New Caledonia. 9-12 October 1990. WP 5: 13 p.

Piannet, R., and R. Grandperrin. 1990. Prospection des resources en germons de surface dans le Pacifique Sud: Rapport de la campagne PROSGERMON 87 et évolution de la situation (1988-1990). Conv.: Sci. Mer : Biol. Mar. 4: 48 p.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191: 382 p.

Seber, G. A. F. 1982. The estimation of animal abundance and related parameters. Second Ed. Oxford University Press. New York, U.S.A. 654 p.

Wang, C-H. 1988. Seasonal changes in the distribution of South Pacific albacore based on Taiwan's tuna longline fisheries, 1971-1985. Twentieth Regional Technical Meeting on Fisheries. Info. Paper No 12. South Pacific Commission, Noumea, New Caledonia. 12 p.

Wetherall, J. A., and M. Y. Y. Yong. 1984. Assessment of South Pacific albacore stock based on changes in catch rates of Taiwanese longliners and estimates of total annual yield from 1964 to 1982. S-W Fish. Cent. Admin. Rep. H-84-11. 7 p.

Wetherall, J. A., and M. Y. Y. Yong. 1975. A cohort analysis of the North Pacific Albacore stock and an assessment of the yield-per-recruit in the American and Japanese fisheries. U.S. Nat. Mar. Fish. Serv. S-W. Fish. Center. Adm. Rep. 16H.

Zar, J. H. 1984. Biostatistical Analysis. Second edition. Prentice-Hall. New Jersey. 718 p.

8. TABLES

Table 1: Total duration and general area covered by each cruise conducted during the 1990-91 albacore tagging programme. The abbreviations used are New Zealand (NZ), Exclusive economic zone (EEC), Subtropical Convergence Zone (STCZ), West coast of the South Island (WCSI).

Cruise number vessel name	Start date	End date	General itinerary and area of activity
1-90 *Solander 3*	13 Dec. 90	24 Dec. 90	NZ - from Whangerei northwards on the east coast then down the west coast of the North Island, out to Viddi Canyons then ending in Nelson;
2-90 *Solander 3*	27 Dec. 90	10 Jan. 91	NZ - from Nelson down west coast of South Island, then west to the Gascoyne Seamount in the Tasman Sea, and then retraced back to Nelson;
3-91 *Solander 3*	13 Jan. 91	28 Jan. 91	NZ - from Nelson via Marlborough Sounds to the Wairarapa coast and Hawkes Bay east of the North Island, then out to the Chatham Islands;
4-91 *Solander 3*	29 Jan. 91	12 Mar. 91	STCZ - from Chathams east to 148°W, then back to the NZ EEC boundary east of Hawkes Bay;
5-91 *D. Solander*	5 Feb. 91	23 Mar. 91	STCZ - between 142°W and 160°W;
6-91 *Solander 3*	13 Mar. 91	18 Mar. 91	NZ - east coast of North Island mainly in Hawkes Bay, then onto Nelson via Marlborough Sounds;
7-91 *Solander 3*	19 Mar. 91	26 Mar. 91	NZ - from Nelson down the WCSI to Milford Sound, then retraced back to Nelson;
8-91 *Kaharoa*	01 Jan. 91	10 Jan. 91	NZ - from Wellington towards mid-Tasman Sea (~39°S), then back to west of Auckland, then south to the North Taranaki Bight, and back to New Plymouth;
9-91 *Kaharoa*	16 Feb. 91	10 Mar. 91	NZ - from Wellington to WCSI, then across the Tasman Sea to Gascoyne Seamount, then back to Taranaki, down WCSI and back to Wellington.

Table 2. Number of albacore and skipjack tagged and released during each cruise. Tag release statistics are stratified by gear type (troll, pole) and tag type (single, double) for each species.

Cruise Number	Albacore Single tag Troll	Albacore Single tag Pole & Line	Albacore Double tag Troll	Total Albacore released	Skipjack single tag Troll	Skipjack single tag Pole & line	Total skipjack released
01--90	64	3	16	83	14	5	19
02--90	32	-	-	32	3	-	3
03--91	92	3	72	167	-	-	-
04--91	1367[1]	198	188	1753	-	-	-
05--91	511	-	65	576	-	-	-
06--91	14	-	57	71	-	-	-
07--91	1	-	18	19	-	-	-
08--91	128	-	-	128	-	-	-
09--91	497	-	-	497	-	-	-
Total	2706	204	416	3326	17	5	22

1. Includes the 23 albacore tagged from the skiff.

Table 3. General condition of albacore tagged on board the *Solander 3* and *Daniel Solander* tagging cruises.

General Condition	Count	Quality of tagging	Count
Good condition	2098	Well placed tag	2579
Slight bleeding on release	24	Tag off ideal location	46
Minor mouth damage	471	Excessive time taken	3
Dropped on deck	14	Tagging record lost	73
Hit side of vessel on release	12		
Sluggish on release	3		
Miscellaneous external scrapes	3		
Condition record lost	76		

Table 4. Performance data for different hook types and fishing methods used during the *Solander 3* tagging cruises. Drop-off figures represent the number of fish that escaped after being hooked. Albacore brought on board were considered as rejects if mouth or gill injuries were present, and suitable if no injuries were visible. The figures in the lower box include only data from observations conducted concurrently.

Hook type	Hook brand & model	Survey period (h)	Strikes	Drop-offs	Landed	Rejects	Suitable	Strikes /hook.h
Regular double	Mustad 7-925-21-50	130.00	208	19	189	107	82	1.60
Regular single	Mustad 7-925-21-50	594.84	911	474	437	190	247	1.53
Small single	Mustad 1665-7/0*	38.49	70	39	31	15	16	1.82
Extra s. single	Mustad 1665-5/0*	25.50	27	16	11	9	2	1.06
Extra s. double	Mustad 1665-5/0	49.00	61	25	36	15	21	1.24
Skiff single		63.67	54	18	36	6	30	0.85
Vessel single		313.08	325	150	175	73	102	1.06

* These hooks had barbs crimped with pliers to make them barbless. The others were barbless by design.
Approximate hook sizes were: Regular = 2.5 cm gap x ~4 cm shank; Small = 2.0 x 3.7 cm; E. small = 1.5 x 3.2 cm.

Table 5. Summary of release and recovery statistics for South Pacific albacore. Statistics associated with tagged albacore recovered prior to 1990 were obtained from Lewis (1990).

Tag Code	Return Address	Tagging vessel	Release date	Lat.	Lon.	Size (cm)	Recapt. date	Vessel type	Lat.	Long.	Size (cm)	Days Free	Size diff	Growth / month	Comments
	Pago		28/02/86	40.3	150.4W	72	14/07/88	Asian L.	26.02	167.3W	88.0	867	16.0	0.56	
	Pago		09/03/86	40.2	145.5W	78	16/04/87	Asian L.	38.23	133.5W	86.0	403	8.0	0.60	
	Pago		30/01/87	37.4	153.4W	80	06/06/88	Asian L.	32.38	153.4W	92.0	493	12.0	0.74	
	Pago		27/02/87	40.4	177.0E	76	13/08/87	Asian L.	30.40	171.5E	80.0	167	4.0	0.73	
	Pago		28/02/87	39.4	151.0W	64	27/04/87	Asian L.	38.23	145.4W		58			
	Pago		25/02/87	40.2	177.1E	80	18/08/89	NZ Tr.	42.15	170.1E	96.5	905	16.5	0.55	
	Pago		01/02/88	38.2	173.0E	61	26/12/88	Jap. drif	38.47	158.3E		329			
A05720	Pago		n/a	n/a	n/a	n/a	18/05/91	Taiw L.	38.45	151.1W	70.7		70.7		
A00324	Pago	Kaharoa	02/02/90	39.0	172.3E	60	13/08/91	Jap. L.	33.22	174.4E	85.0	557	25.0	1.36	Est. FL from W
A00374	SPC	Solander 3	25/01/91	40.4	177.0E	82	24/07/91	Jap. L.	36.57	178.0E	89.9	180	7.9	1.33	Est. FL from W
A01889	SPC	Solander 3	22/02/91	41.2	151.3W	69	01/06/91	Taiw L.	39.00	146.5W	73.6	99	4.6	1.42	Est. FL from W

* All tags released prior to to Nov. 1990 were orange tags with Pago Pago printed as return address.
Fork lengths were estimated from weight using the equation proposed by Labelle & Murray (1991) for the STCZ 1989-90: $FL = 35.5386\ W^{0.33841}$

9. FIGURES

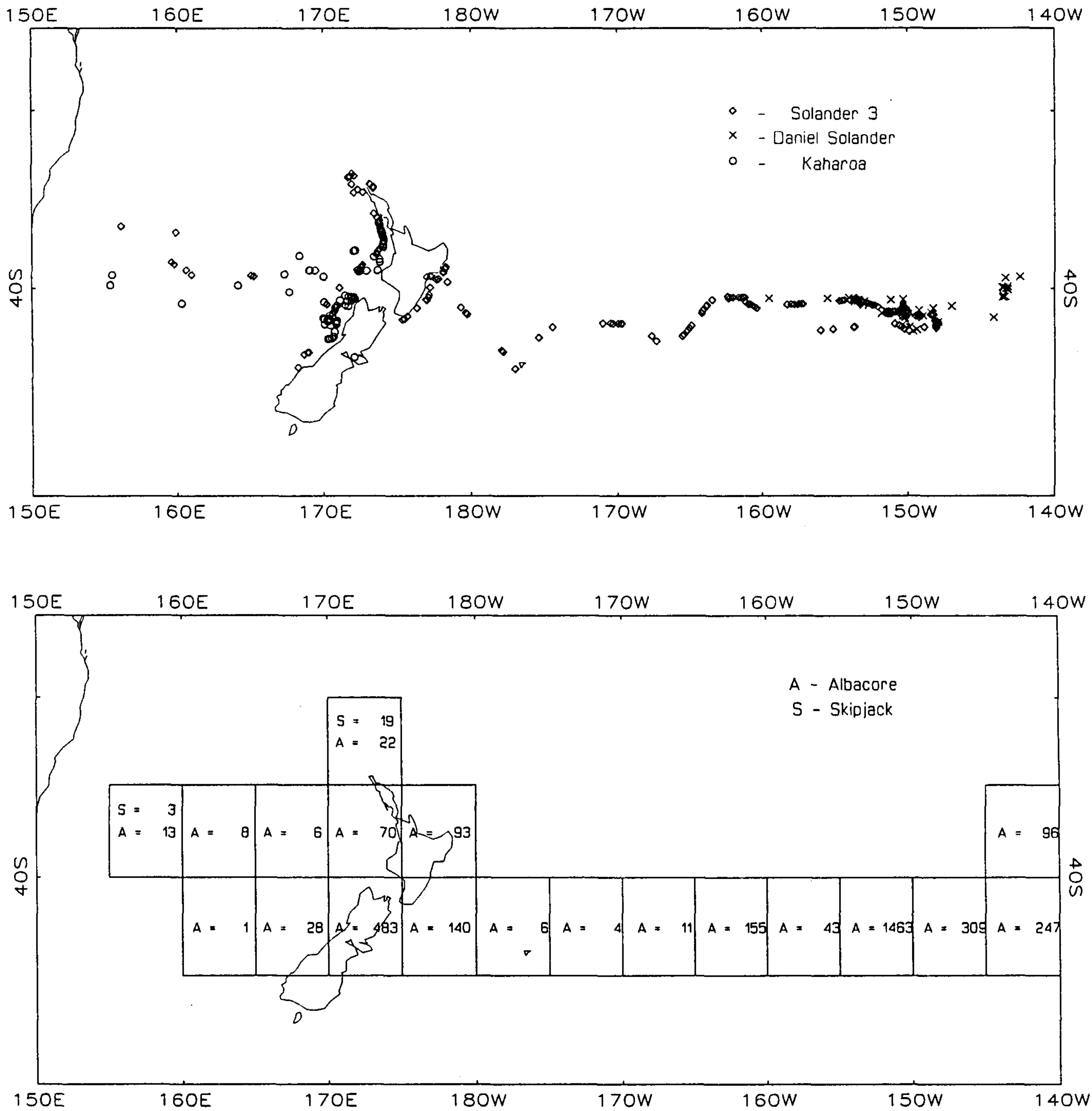


Figure 1. Location of tagging vessels on days where tagged fish were released (top), and actual distribution of tagging effort during the 1990-91 season (bottom). Each square in the lower chart corresponds to a 5° square area.

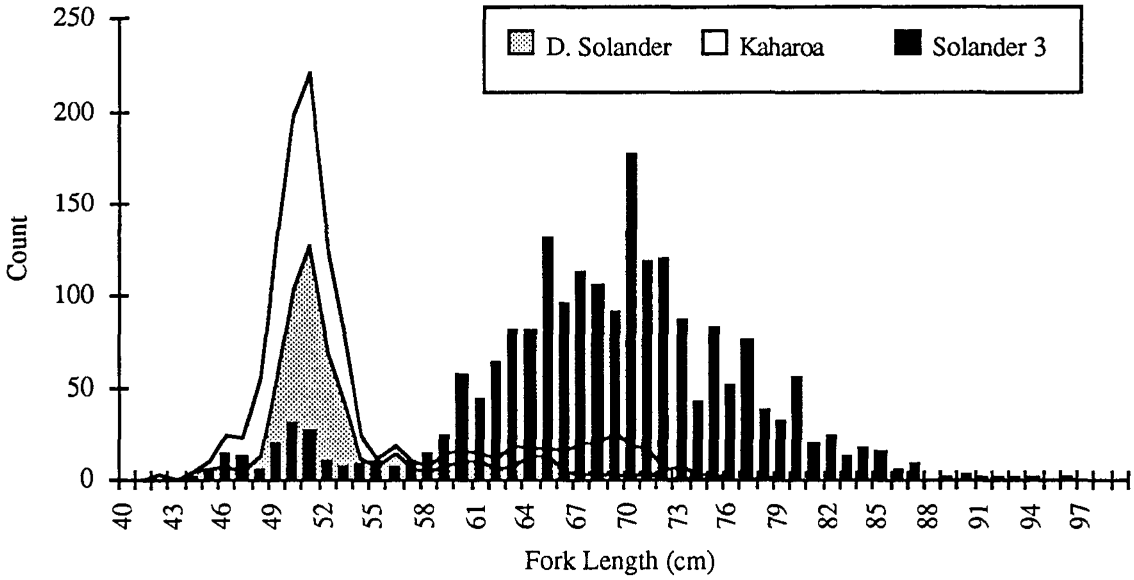


Figure 2. Size distribution of albacore tagged and released from each vessel, 1990-91.

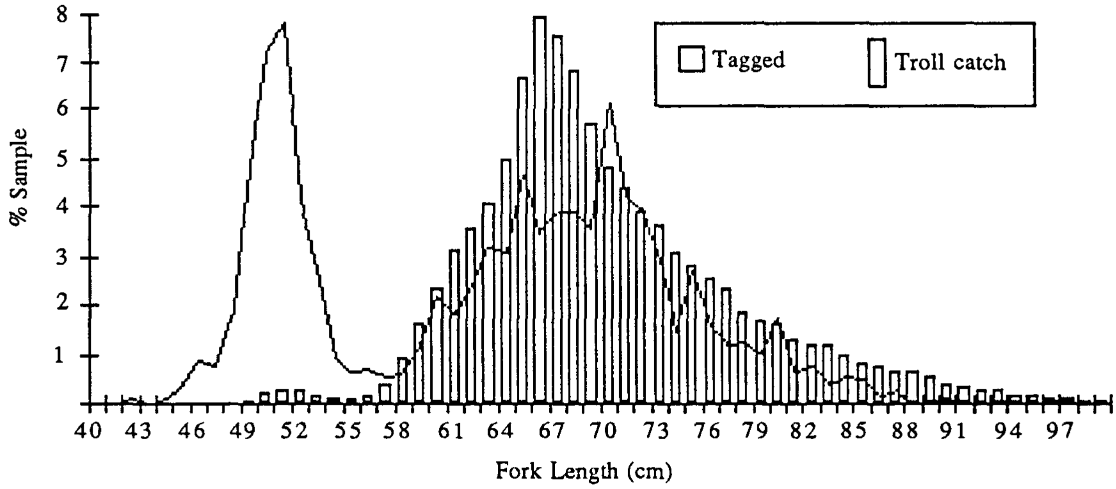


Figure 3. Size distribution of tagged albacore released during the 1990-91 season, versus that of albacore caught by commercial troll vessels during the same season. All size measurements used for the above chart were collected between January and mid-March, which corresponds to the principle period of of tagging activity. Length frequency data for troll catches were obtained from the 1990-91 SPC/MAF observer programme (see Labelle and Murray 1991).

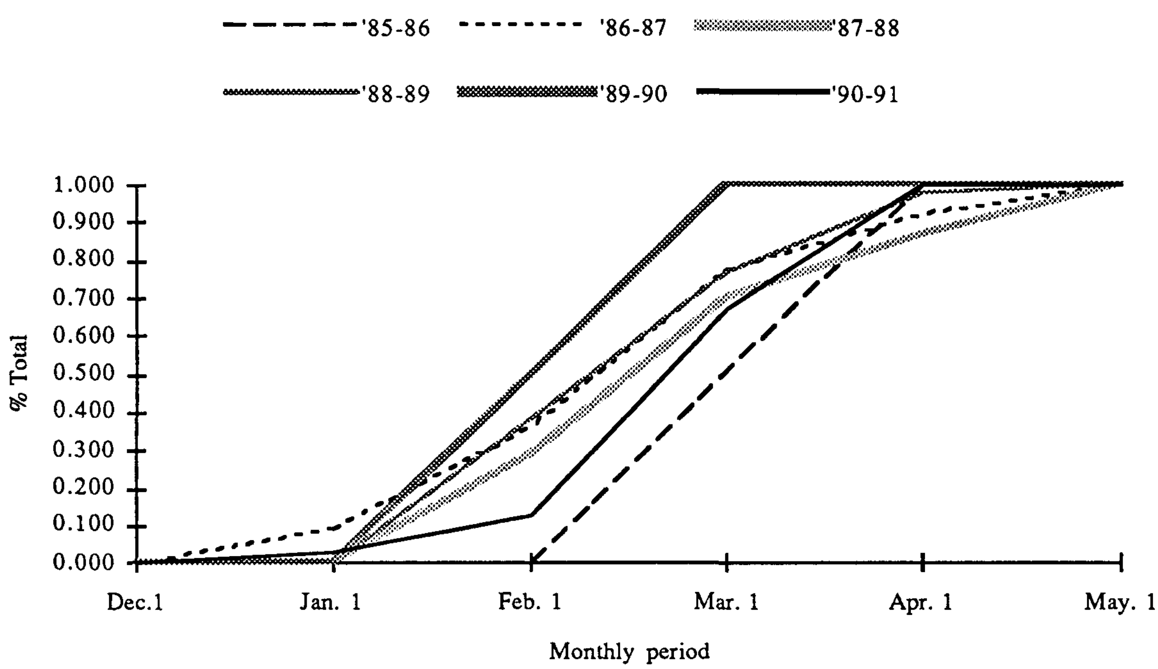


Figure 4. Temporal distribution of tagging effort for South Pacific albacore 1985-1991. Figures for the 1985-1990 period were derived from data presented by Lewis (1990). Estimates of the total number of tagged albacore released each season since 1985-86 were 723, 1456, 1402, 2410, 815 and 3326 respectively. The figures do not include tagged albacore released in Australian waters by the NSW Fisheries & Gamefish Tagging Program (~1900 for the 1981-90). Tagged fish released by the U.S. commercial trollers in 1989-90 are also excluded (not available).

10. APPENDIX

10.1 Characteristics of tagging vessels

Vessel name	Call Sign	Length (m)	GRT (t)	Hold (t)	Crew size	Lines used
Solander 3	3DQH	26.2	99	9.5	15-16	13-17[1]
Daniel Solander	ZMCH	53.6	345	300	10	24-36[2]
Kaharoa	ZM552	28.0	268	10	6	12-13

1. Maximum figure includes the four lines towed from the skiff when in use.
2. Maximum includes the six lines towed each skiff (2) on some occasions.

10.2 Description of fishing gear used

Solander 3

Pole and Line — Poles: '3M3H OFRO' Fiberglass 2.8 by 3.0 m..

Feather lures: 'TAN YARI', Sizes = 2.2, 2.5, 2.8, 3.0, 3.3 and 4.0.

Troll — Outriggers: 10m long x 100mm diam high-grade aluminium tubing, mounted port (4 lines) and starboard (3 lines), midships.

Attachment: Lines attached with elastic 'bungy' cord.

Mainline: 'Ashaway Line and Twine MFG Co.' Stretch cord.
This is tuna leader line solid braided cord tested to 130 kg;
Nylon 110 H braided.

Monofilament: 'New Chio' 80 x 100kg, blue-grey in color.

Lures: Two weights of hex heads were used, only one with ruby eyes.

Lure skirts: 'Yo-zuri' Size 4..

Hooks: 'Mustard' 7-925-21-50 - cut down to single hooks;
An assortment larger and smaller hooks for experimental use.

Crimps: 'Toyo' lock size No. C.

Skiff — Four lines were towed from the Solander 3's 5m Yamaha skiff. The two inner ones were ~10m of mainline plus 3m monofilament. The two outer lines were ~13m plus 2m monofilament.

Daniel Solander

Troll — 'Mustard' 7-925-21-50 - double, barbless. Remaining gear as on *Solander 3*;

Skiffs — Two heavy duty aluminium tender boats each capable of towing six lines. No tagging was undertaken from these craft.

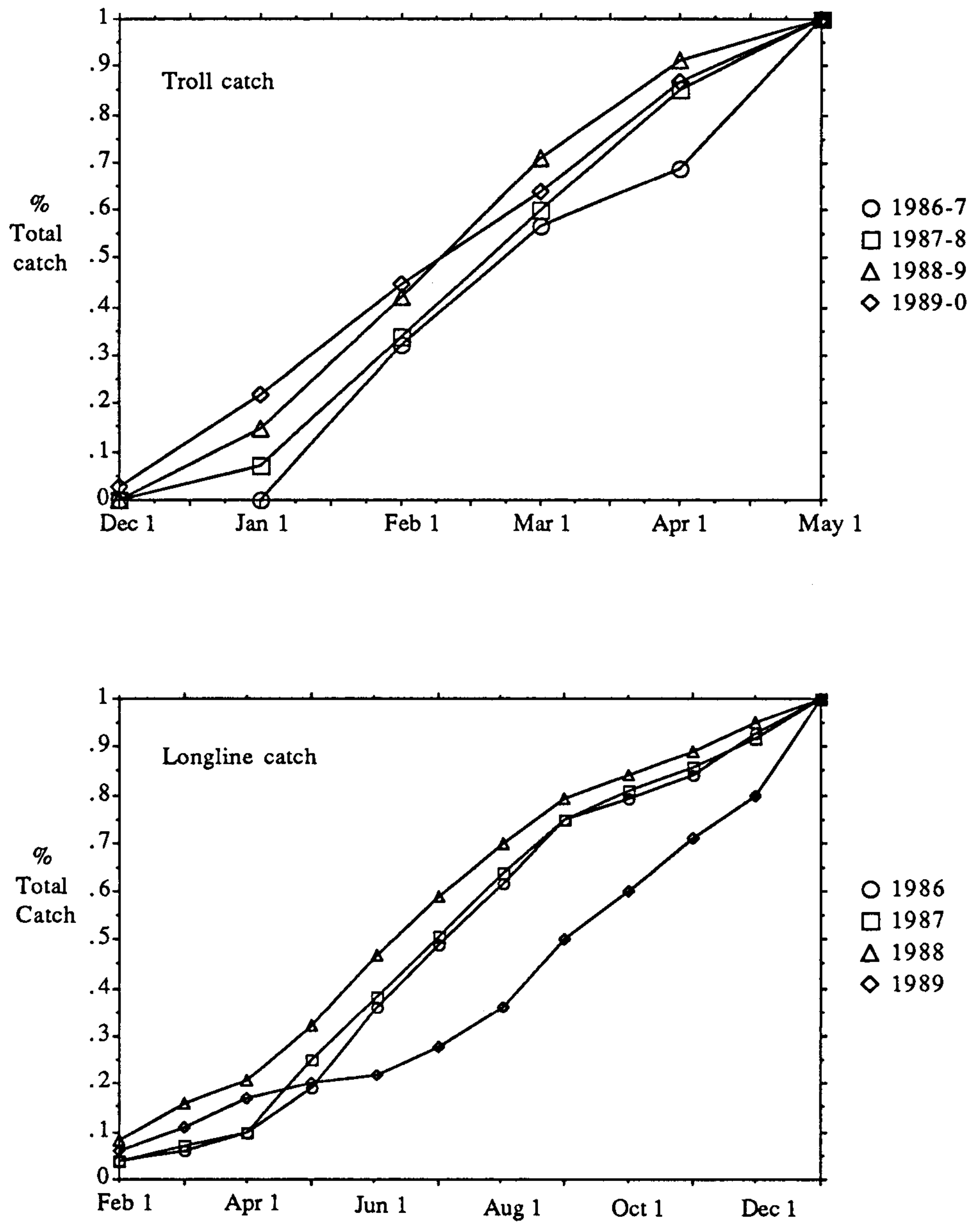


Figure 5. Cumulative fractions of total catch against time by gear type for 1986-1989. Catch data source: SPAR database.