SOUTH PACIFIC COMMISSION

A REVIEW OF ALBACORE TAGGING IN THE SOUTH PACIFIC

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ABSTRACT

Tagging programmes have been conducted in the South Pacific since the early 1960s by various fishery agencies to obtain information on the demographic traits of South Pacific albacore. A total of over 20,000 albacore was tagged and released. Less than 3,000 of these were tagged in the recreational fishery along the south-east coast of Australia. Over 17,000 albacore were tagged from commercial troll fishing vessels, mainly along the New Zealand coast and in the Sub-Tropical Convergence Zone. Less than one per cent of all tags released have been recovered so far. Tagged albacore were recovered primarily in the longline fishery, after a period at large that ranged from one month to 4.9 years. Tag loss during the period at large was estimated at ~16 per cent. Albacore tagged in areas east of 155°W were usually recovered at locations to the east and north of the release site. By contrast, albacore tagged in areas west of 155°W were usually recovered at locations to the west and north of the release site. Growth rates during the period at large averaged about 0.8 cm per month for 68—70 cm albacore.

RÉSUMÉ

Des programmes de marquage ont été conduits par divers organismes halieutiques depuis le début des années 1960 pour obtenir des informations sur les traits démographiques de la population de germons du Pacifique Sud. Plus de 20.000 germons ont été marqués et relâchés. Moins de 3.000 germons ont été marqués par des pêcheurs sportifs sur la côte sud-est de l'Australie. Plus de 17.000 germons ont été marqués à bord de ligneurs commerciaux sur les côtes de la Nouvelle-Zélande, et dans la zone de convergence du Pacifique Sud. Moins de un pour cent des germons marqués ont été recapturés par la suite. Ceux-ci ont été capturés principalement par des palangriers, après une période variant de un mois à cinq ans. Le taux de perte de marques a été estimé à seize pour cent. Les germons marqués en mer à l'est de 155°W ont généralement été recapturés en des points situés plus à l'est et plus au nord de la région de marquage. Les germons marqués en mer à l'ouest de 155°W ont généralement été recapturés plus à l'ouest et plus au nord de la région de marquage. Le taux moyen de croissance durant la période de liberté a été estimé à 0,8 cm par mois pour des germons de 68 à 70 cm.

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1. INTRODUCTION

Since the mid-1960s, there have been several investigations focusing on the demographic traits of South Pacific albacore (Labelle 1993). In particular, tagging programmes have been conducted by various agencies to estimate growth, distribution, migration and fishery interception patterns. Albacore were first tagged during the initial southern bluefin tuna tagging programme conducted by the Commonwealth Scientific and Industrial Research Organization (CSIRO) during the early 1960s (Pepperell 1991). Between 1960 and 1968, 65 albacore caught incidentally with troll gear were tagged and released (Caton and Ward 1991). Since 1974, some of the albacore caught by recreational fishermen along the south-east coast of Australia have been tagged and released as part of the New South Wales Game Fish Tagging Programme (Matthews and Deguara 1992). Albacore were also tagged along the New Zealand coast by scientists from the Ministry of Agriculture and Fisheries (MAF) during troll fishing surveys in the early 1970s (Roberts 1974), and during tagging surveys conducted since 1986 (Bailey 1989). Between 1986 and 1989, a high-seas tagging programme was carried out on the principal albacore fishing grounds of the Subtropical Convergence Zone (STCZ) (Knox 1970), mainly within the area bounded by 35—47°S and 170—130°W (Laurs and Nishimoto 1989). This zone extends across the South Pacific, and is analogous to the North Pacific Transition Zone, which also supports large surface fisheries for albacore (Laurs and Lynn 1991). Most of the tagging in the STCZ was done by commercial troll fishermen, with the assistance of scientists from the US National Marine Fisheries Service (NMFS) and the Institut français de recherche scientifique pour le développement en coopération (ORSTOM).

By March 1988, only seven of the albacore tagged from troll vessels since 1986 had been reported to the Tuna and Billfish Assessment Programme (TBAP) of the South Pacific Commission (SPC) (Lewis 1990). In view of the concerns expressed by Pacific Islanders over the effects of expanding surface fisheries, and the need for additional data on stock structure, scientists from MAF and TBAP initiated an albacore tagging and fishery observer programme (Labelle and Murray 1992). During 1990—91, tagging operations were conducted simultaneously from chartered vessels in the STCZ and the Tasman Sea (Labelle and Sharples 1991). During 1991—92, tagging was conducted by six trained technicians who worked on board several commercial troll fishing vessels interspersed throughout the fishing grounds.

Tag release records associated with each programme were supplied by the co-ordinating agencies, and included in the TBAP's regional tagging database (SPC 1992). Tag recovery data were supplied to TBAP through voluntary returns by fishermen and fishing companies, and through systematic catch sampling programmes at canneries and landing sites throughout the South Pacific. This report summarises the tagging methods used, tagging effort distribution, and tag recovery patterns associated with albacore tagging programmes conducted primarily from research and commercial fishing vessels since 1986. Albacore tag release-recapture activities associated with the CSIRO and NSW programmes are not covered in detail because of the relatively small numbers of releases and the highly localised nature of such activities.

2. TAGGING PROCEDURES

Most of the tagging was conducted on the principal troll fishing grounds during the commercial fishing season because this was where pre-juvenile albacore could be collected most easily. Albacore tagged and released each season were caught mainly with troll gear as found on commercial vessels (see Dotson 1980). The general approach consisted of applying tags to as many uninjured albacore as possible. No efforts were made to select albacore of certain sizes. However, efforts were made to intersperse tagging effort throughout the fishing grounds and the fishing season, because the main objective of this programme was to obtain information on spatial and temporal patterns of albacore movement.

The tags applied to albacore were similar to those used for the SPC Regional Tuna Tagging Project. Most of the tags used were obtained from Hallprint Proprietary Ltd. of Adelaide,

Australia. These were 11 or 13 cm yellow plastic tags with a single barbed nylon head. Tag identities were provided by a combination of tag colour (yellow, red or orange), a capital letter (A, S or _), a five-digit tag number, and a return address (Pago Pago, Wellington, Noumea, La Jolla or Cronulla).

The tagging method was similar to that described by Laurs et al. (1976). Immediately after a strike, the fishing line was hauled in manually. Once on board, the hook was removed, and the albacore inspected for injuries to the gills, eyes, mouth and palate. Albacore that were visibly uninjured and vigorous were usually placed on a cradle similar to that described by Kearney and Gillett (1982). Albacore were then tagged as rapidly as possible using a stainless steel tube applicator. Tags were inserted at an oblique angle to anchor the barbs among the pterygiophores of the second dorsal fin. Albacore were thrown head-first into the water after tagging. The fork length measurement to the nearest lower centimetre was recorded with the associated date, time, tag number and information on the fish's condition at release.

To validate ageing estimates obtained from the examination of growth increments on bony tissues (see Laurs et al. 1985), albacore tagged before 1990 were usually injected intramuscularly with 1.5 ml of 100 mg/ml of oxytetracycline hydrochloride before release. To estimate tag rejection rates during the period at large, up to 20 per cent of the albacore tagged each day during 1990—91 and 1991—92 were double-tagged. The second tag was inserted on the opposite side of the first one, 2—3 cm forward to avoid entanglement of anchors. The total time required to haul, tag and release albacore (handling time) ranged from ~20—90 seconds, and averaged about 40 seconds.

To minimise handling time, tagging was conducted as often as possible from skiffs towed behind the fishing vessel. The shorter lines trolled and the lower transom height of the skiff allowed taggers to haul in albacore more rapidly. During 1990—91 and 1991—92, pole-and-line gear was also used to catch and tag albacore to determine if recovery rates would increase if fish suffered less stress. When troll catch rates were higher than average, the lines were hauled in while the vessel circled the area and live bait (mainly *Sardinops neopilchardus* and *Aldrichetta forsteri*) was thrown overboard to lure albacore to the surface. This technique could not be used regularly because live bait was usually in short supply, but in one instance, 188 albacore were captured with the poles, tagged and released.

3. RESULTS

3.1 Distribution of tagging effort

By the end of 1992, 17,231 albacore had been tagged and released from 38 troll fishing vessels in the STCZ, along the New Zealand coast, and in the Tasman Sea (Table 1). Another 3,646 albacore had been tagged and released by recreational fishermen in coastal waters of Australia (Matthews and Deguara 1992). Details on tag releases in the recreational fishery were not available when this report was prepared, so only the commercial release records have been summarised. Between 1986 and 1990, less than 2500 albacore were tagged each year (Table 2). Only single tags were applied during this period, and 47 per cent of the albacore tagged were injected with tetracycline. Over 60 per cent of all tagging from troll vessels was conducted during 1990—92 through the joint SPC—MAF tagging programme. The latest increase in tagging effort allowed taggers to release albacore over a wider area (Fig. 1). There was considerable year-to-year variation in the spatial distribution of tagging effort. Before 1990, tags were released mainly in narrow sections of the STCZ and along the NZ coast. Since then, tagged albacore have been released over larger areas which ranged from Tasmania (~148°E.) to Easter Island (~110°W.) within the latitudinal band of 30—47°S. On an overall basis, over 76 per cent of all albacore tagged from troll vessels were released in the STCZ. Tagging was conducted mainly between early December and late March (Fig. 2), which corresponds to the main period of commercial fishing activity in the STCZ (Labelle 1993).

Table 1. Summary of the TBAP albacore tagging database

Cruise number	Tagging region	Agency +colour	Starting date	Ending date	Lowest tag #	Highest tag #	Tags released
DAT86-003	STCZ	NMFY	09-Feb-86	18-Mar-86	_03301	_23631	602
BAE86-001	STCZ	NMFY	15-Feb-86	12-Mar-86	_23401	_23500	100
CRO86-002	STCZ	NMFR	17-Feb-86	19-Feb-86	_03401	_03423	22
KAH86-014	NZ	NMFO	23-Nov-86	12-Dec-86	A03000	A03138	138
DEF87-001	STCZ	NMFO	09-Jan-87	21-Jan-87	A01300	A01399	100
JEA87-002	STCZ	NMFO	10-Jan-87	27-Feb-87	A01500	A01599	100
BAE87-013	STCZ	NMFO	14-Jan-87	07-Mar-87	A01600	A01650	51
COT87-005	AUNZ	NMFO	17-Jan-87	21-Jan-87	A04000	A04057	57
DAT87-012	STCZ	NMFO	17-Jan-87	01-Mar-87	A01400	A01499	95
CRO87-000	STCZ	NMFO	23-Jan-87	09-Feb-87	A00000	A00427	426
SAP87-006	AUNZ	NMFO	15-Feb-87	17-Feb-87	A04950	A04962	13
KAH87-004	NZ	NMFO	25-Feb-87	28-Feb-87	A03139	A03316	178
COR87-001	STCZ	NMFO	03-Mar-87	07-Mar-87	A02300	A02489	190
REB87-003	STCZ	NMFO	07-Apr-87	14-Apr-87	A01700	A01731	31
BEH87-010	STCZ	NMFO	23-Dec-87	28-Dec-87	A00850	A00899	49
FOC87-005	STCZ	NMFO	24-Dec-87	29-Dec-87	A00950	A01299	150
MIR87-006	STCZ	NMFO	26-Dec-87	31-Dec-87	A01900	A01949	50
ROA87-004	STCZ	NMFO	26-Dec-87	29-Dec-87	A00700	A00749	50
JUS87-009	STCZ	NMFO	28-Dec-87	30-Dec-87	A00750	A00799	50
MER87-008	STCZ	NMFO	28-Dec-87	28-Dec-87	A00500	A00503	4
NIG87-007	STCZ	NMFY	28-Dec-87	29-Dec-87	_22276	_22299	22
HEI87-011	STCZ	NMFO	29-Dec-87	31-Dec-87	A00900	A00940	41
NIG87-007	STCZ	NMFO	29-Dec-87	31-Dec-87	A01850	A01866	16
BEH87-010	STCZ	NMFY	30-Dec-87	31-Dec-87	_23655	_23670	15
DEF89-001	STCZ	NMFY	01-Jan-88	01-Jan-88	_23671	_23680	9
HEI88-006	STCZ	NMFO	01-Jan-88	01-Jan-88	A00941	A00949	9
BAH88-001	STCZ	NMFO	04-Jan-88	30-Jan-88	A05050	A05094	44
NOR88-002	STCZ	NMFO	04-Jan-88	05-Jan-88	A00650	A00655	6
NIG88-008	STCZ	NMFO	06-Jan-88	18-Mar-88	A01867	A01885	19
DAT88-004	STCZ	NMFO	07-Jan-88	15-Feb-88	A00550	A00599	50
NOP88-003	STCZ	NMFO	16-Jan-88	05-Feb-88	A01800	A01849	50
DEF88-005	STCZ	NMFO	20-Jan-88	20-Jan-88	A01100	A01166	67
KAH88-002	NZ	NMFO	23-Jan-88	05-Feb-88	A03317	A03898	581
REB88-009	STCZ	NMFO	23-Jan-88	21-Mar-88	A05000	A05049	48
MER88-007	STCZ	NMFO	24-Jan-88	26-Mar-88	A00504	A00516	13
CAB88-004	NZ	NMFO	01-Feb-88	04-Feb-88	A04701	A04720	19
KAH88-003	NZ	NMFO	28-Feb-88	11-Mar-88	A03899	A03942	44
ROA89-003	STCZ	NMFO	21-Dec-88	06-Jan-89	A05100	A05749	500
DEF89-001	STCZ	NMFO	24-Dec-88	14-Mar-89	A05750	A06249	500
MIR89-002	STCZ	NMFO	24-Dec-88	27-Mar-89	A00428	A05299	498
KAH89-002	AUNZ	NMFO	26-Jan-89	11-Feb-89	A03943	A04885	855
KAH89-003	NZ	NMFO	05-Apr-89	10-Apr-89	A04886	A04941	56
KAH89-007	NZ	NMFO	13-Jun-89	18-Jun-89	A04942	A04944	3
MIR90-004	STCZ	NMFO	31-Dec-89	29-Dec-90	A00656	A06749	394
KAH90-000	AUNZ	NMFO	20-Jan-90	26-Jan-90	A04945	A07499	235
KAH90-000	AUNZ	MAFY	26-Jan-90	05-Feb-90	_00009	_00589	580
JUS90-003	STCZ	NMFO	09-Feb-90	10-Feb-90	A01050	A01078	29
PHA90-001	STCZ	NMFO	06-Mar-90	11-Mar-90	A06250	A06299	50
HEI90-002	STCZ	NMFO	08-Mar-90	11-Mar-90	A06400	A06416	17
SO390-001	NZ	SPCY	15-Dec-90	22-Dec-90	A00001	A00407	83
SO390-002	NZ	SPCY	29-Dec-90	10-Jan-91	A00113	A00147	32
KAH91-008	NZ	SPCY	01-Jan-91	10-Jan-91	A09001	A09128	128
MIR91-001	STCZ	NMFO	01-Jan-91	04-Mar-91	A06750	A06899	150

Cruise numbers are unique references to vessel and period combinations. Tagging regions are: Australian coast (AUST), and Tasman Sea (AUNZ), New Zealand coast (NZ), and STCZ. Agency & colour refer to the co-ordinating fishery agency (SPC, NMFS, MAF) and tag colour used (orange, yellow, red).

Table 1. Summary of the TBAP albacore tagging database (cont.)

Cruise number	Tagging region	Agency +colour	Starting date	Ending date	Lowest tag #	Highest tag #	Tags released
SO391-003	NZ	SPCY	15-Jan-91	28-Jan-91	A00148	A00386	167
SO391-004	STCZ	SPCY	30-Jan-91	08-Mar-91	A00387	A08100	1753
DAS91-005	STCZ	SPCY	05-Feb-91	23-Mar-91	A00801	A03242	576
KAH91-009	STCZ	SPCY	17-Feb-91	09-Mar-91	A09129	A09627	497
SO391-006	NZ	SPCY	14-Mar-91	16-Mar-91	A02642	A02769	71
SO391-007	NZ	SPCY	20-Mar-91	23-Mar-91	A02770	A02806	19
DAS92-003	STCZ	SPCY	17-Dec-91	23-Mar-92	A00551	A05523	2202
KAR92-004	STCZ	SPCY	18-Dec-91	25-Jan-92	A13001	A13618	548
ATU92-005	STCZ	SPCY	28-Dec-91	23-Feb-92	A16001	A18600	1098
MAV92-	STCZ	SPCY	28-Dec-91	23-Feb-92	A19001	A20312	1134
KAH92-014	STCZ	SPCY	03-Jan-92	29-Jan-92	A09628	A09691	53
ARI92-002	STCZ	SPCY	25-Jan-92	11-Feb-92	A07001	A07061	59
NOE92-007	STCZ	SPCY	30-Jan-92	06-Mar-92	A11001	A11545	524
PAC92-001	STCZ	SPCY	01-Feb-92	19-Feb-92	A06001	A06050	47
ROY92-008	STCZ	SPCY	24-Feb-92	08-Mar-92	A20313	A20442	118
FAI92-009	STCZ	SPCY	27-Feb-92	29-Apr-92	A17207	A17446	200
KAY92-012	STCZ	SPCY	04-Mar-92	07-Mar-92	A07062	A07100	39
ANA92-010	STCZ	SPCY	07-Mar-92	14-Apr-92	A11546	A11907	292
EIL92-017	AUST	SPCY	07-Mar-92	08-Mar-92	A08101	A08131	31
PUR92-011	STCZ	SPCY	10-Mar-92	11-Apr-92	A20443	A20561	111
KAY92-013	STCZ	SPCY	25-Mar-92	28-Mar-92	A07101	A07129	29
EIL92-015	AUST	SPCY	29-Mar-92	30-Mar-92	A08132	A08143	12
OCE92-016	AUST	SPCY	02-Apr-92	04-Apr-92	A08144	A08156	13
OCE92-018	AUST	SPCY	06-Apr-92	25-Apr-92	A08157	A08165	8

Notes as per previous table section

Table 2. Number and condition of albacore tagged each season

Tagging season	Total tagged	Double tagged	Tetracycline injected	Mean FL	Cond. #1	Cond. #2	Ideal position	Non-ideal position
1985-86	724	0	199	72.0	-	-	-	-
1986-87	1379	0	1370	65.2	-	-	-	-
1987-88	1407	0	637	58.8	-	-	-	-
1988-89	2412	0	705	57.4	-	-	-	-
1989-90	1160	0	430	57.2	-	-	-	-
1990-91	3625	416	0	61.1	2098	24	2576	46
1991-92	6524	800	0	61.7	5665	54	6348	106

Figures in the last four categories are the numbers of albacore in excellent condition, with bleeding mouth, and tagged in the ideal or non-ideal position on the body.

On an overall basis, ~15 per cent of the albacore caught during the cruises were tagged and released (range: 6—39%). About 11 per cent of the tagged albacore released during the last two seasons had double tags, but none were injected with tetracycline since past experience had shown that the bony structures were rarely returned with the tags. Detailed information on tagging operations was obtained during 1990—91 to assess the quality of tagging. Over 97 per cent of the albacore were tagged in the ideal position, with the barb anchored among the pterygiophores, and 80 per cent of those tagged exhibited no visible signs of excessive stress or injuries (Table 3). About 18 per cent had minor injuries (torn lip or skin) at release; ~5 per cent of those injured were bleeding slightly around the mouth (Table 3).

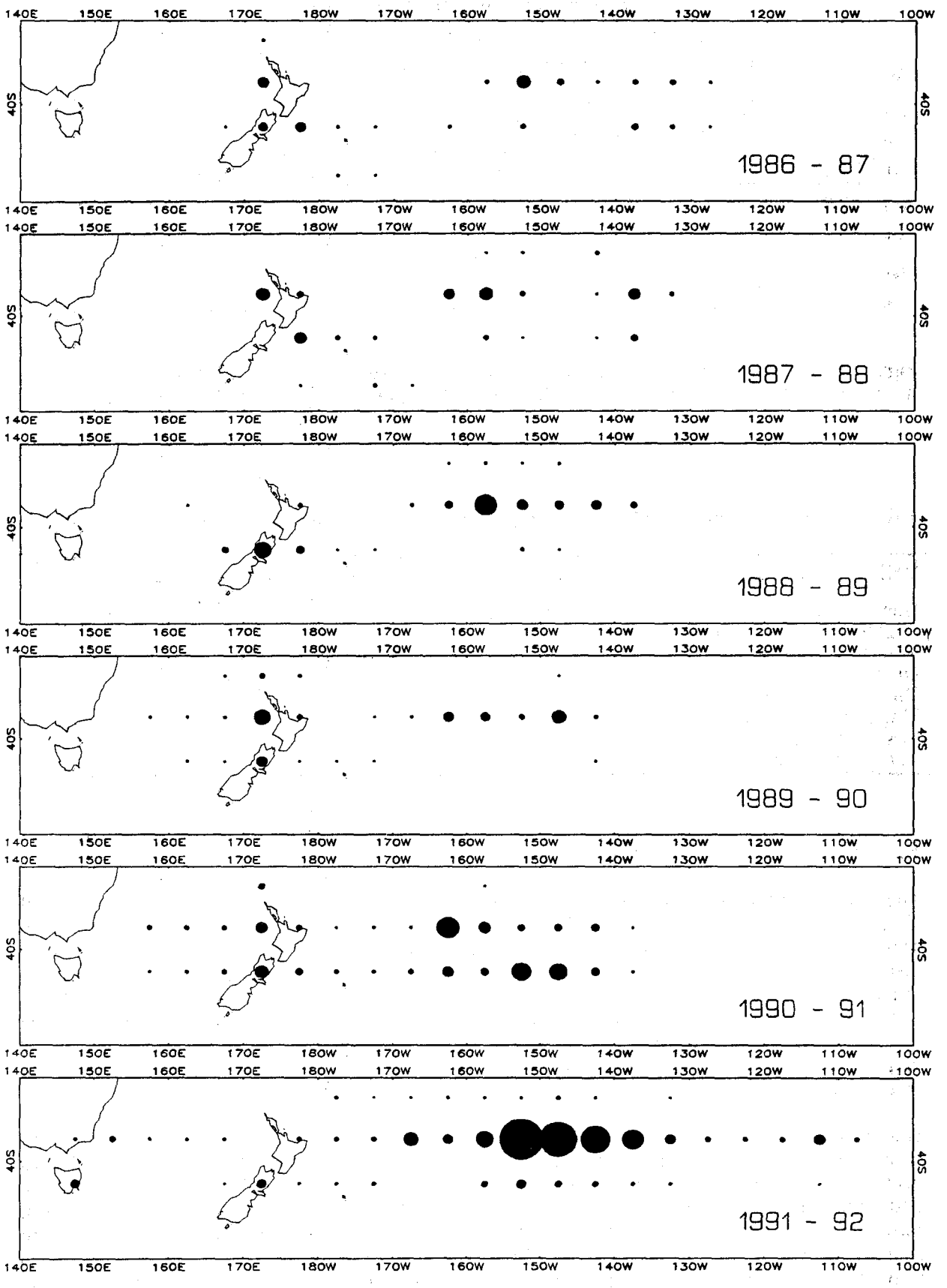

Figure 1. Distribution of tagging effort, 1986—92. Dot sizes are proportional to the tagging effort within each 5° by 5° area.

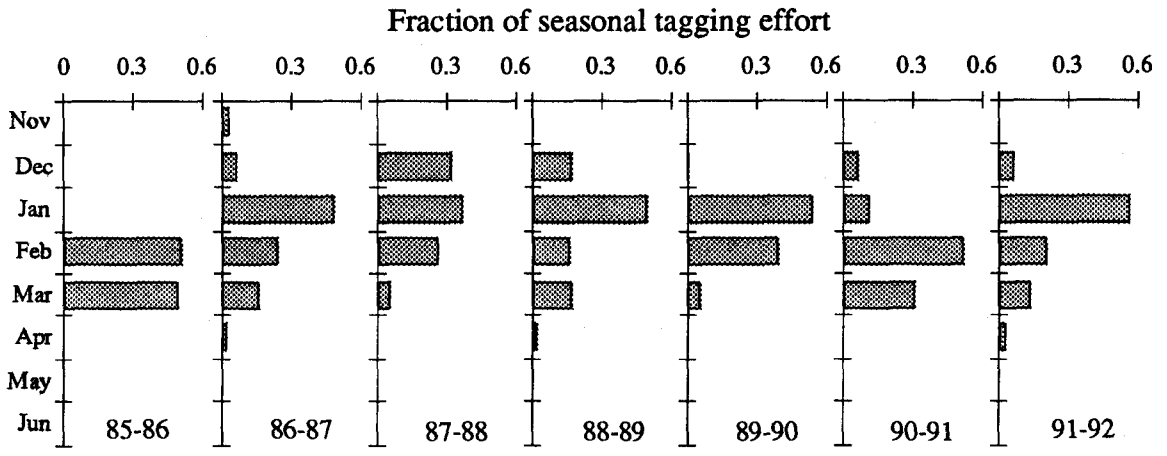

Figure 2. Distribution of tagging effort within each season. Effort values correspond to the total number of tagged albacore released in all regions where tagging was conducted.

Table 3. General condition of albacore tagged during two cruises conducted in 1990—91

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		

3.2 Size distribution of the tagged albacore

The size distribution of the albacore tagged varied from year to year (Fig. 3). The average size of albacore tagged was largest in 1985—86, and decreased progressively during the next two seasons. Without sampling data from commercial catches, it could not be determined if the size distribution of the tagged group was comparable to that of the commercial catch during 1985—88, but no evidence was found to indicate that taggers selected albacore of certain sizes. Sampling of commercial catches in 1988—89 and 1989—90 showed that medium-sized albacore were usually selected for tagging. Taggers reported that small albacore were rarely tagged since they were often damaged, and larger albacore were usually retained by fishermen and sold to the canneries at a higher price per kg.

During the 1990—91 season, an unusually large fraction of small albacore was tagged, which led to marked differences in the size distributions of the tagged group and the catch. This was because much of the tagging was done along the NZ coast that year (Labelle and Murray 1992), and albacore caught there tend to be smaller than those in the STCZ (Labelle 1993). Furthermore, taggers had been instructed to take greater care while hauling lines so that more small albacore could be tagged. During 1991—92, greater efforts were made to disperse taggers throughout the fleet and tag albacore in a non-selective manner. As a result, the size distribution of the tagged group was the closest ever to that of the commercial catch (Fig. 3).

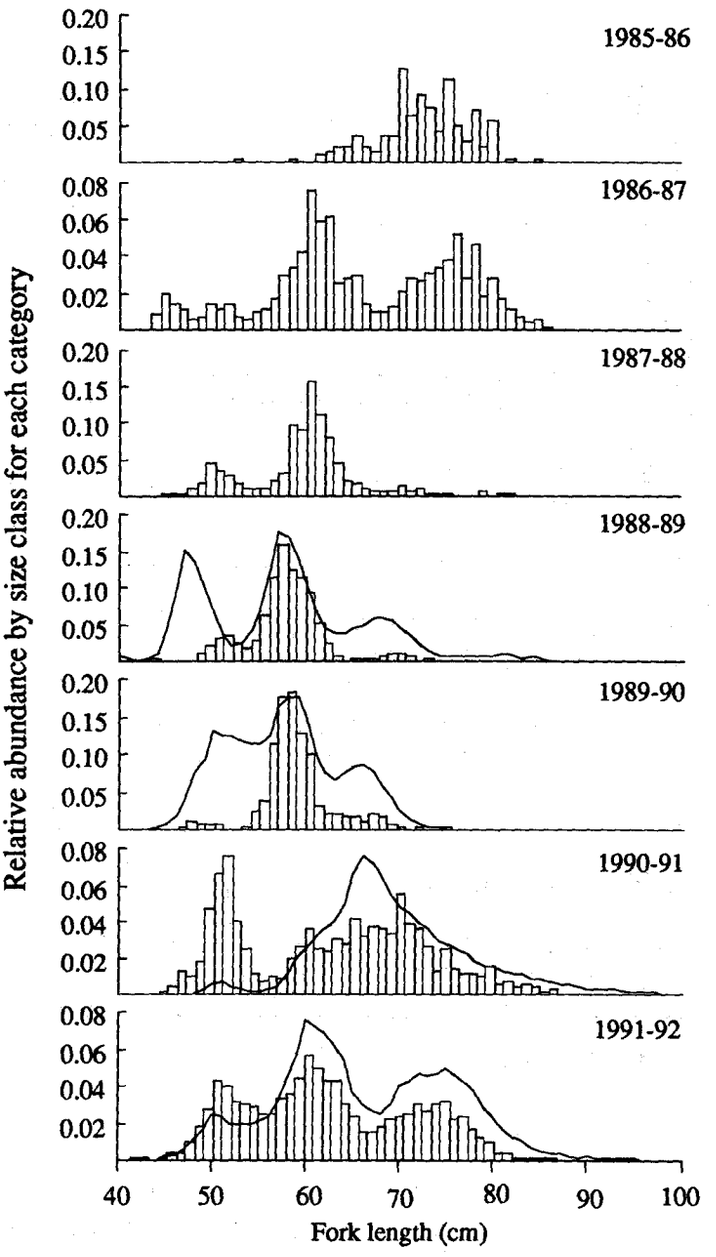

Figure 3. Size distribution of tagged albacore released (vertical bars) and albacore caught (solid lines) by commercial troll vessels during the same season. Size measurements for the latter group are based on observer samples of troll fishery catches (see Labelle 1993).

3.3 Tag recovery patterns

As of January 1993, a total of 65 tag recoveries had been reported to TBAP either directly or through the collaborating agencies. Of these, 46 stemmed from the NMFS—MAF—SPC tagging programme, and 19 from the NSW Game Fish Tagging Programme (Table 4). The tag recovery patterns provided the information used to determine movements, tag recovery rates, fishery interceptions, reporting rates and growth.

Table 4a. South Pacific albacore tag recaptures from recreational fishery releases

Tag code	Agency +colour	Vessel type	Release date	Lat.	Lon.	E-W	Size (cm)	Recapt. date	Vessel type	Lat.	Lon.	E-W	Size (cm)	Days free	Size diff.	Mid-size	Growth /month
-	FRIY	Sport	09/06/83	35.45'	150.20'	E	72	25/05/84	_____L.	36.04'	150.08'	E	-	351	-	-	-
-	FRIY	Sport	27/10/81	33.50'	151.18'	E	50	21/09/86	Aust. L.	35.08'	150.45'	E	87.0	1790	37.0	68.5	0.63
-	FRIY	Sport	25/04/87	36.25'	150.08'	E	91	02/12/88	Aust. S.	36.25'	150.08'	E	-	587	-	-	-
-	FRIY	Sport	15/11/86	34.22'	151.17'	E	50	22/05/89	_____L.	37.34'	149.55'	E	-	919	-	-	-
-	FRIY	Sport	12/05/86	36.25'	150.08'	E	45	15/05/89	Aust. S.	36.25'	150.08'	E	-	1099	-	-	-
-	FRIY	Sport	04/11/90	33.50'	151.17'	E	-	15/03/91	_____L.	36.25'	150.08'	E	60.0	131	-	-	-
-	FRIY	Sport	04/11/90	33.50'	151.17'	E	-	21/05/91	_____L.	37.16'	150.03'	E	61.0	198	-	-	-
-	FRIY	Sport	04/11/90	33.50'	151.17'	E	-	21/05/91	_____L.	37.30'	150.00'	E	45.0	198	-	-	-
-	FRIY	Sport	13/01/90	35.45'	150.20'	E	75	26/05/91	_____L.	37.05'	150.00'	E	-	498	-	-	-
-	FRIY	Sport	09/01/90	36.15'	150.15'	E	60	18/11/91	_____L.	35.08'	150.45'	E	78.9	678	18.9	69.5	0.85
-	FRIY	Sport	04/11/90	33.50'	151.17'	E	-	21/12/91	_____T.	35.08'	150.45'	E	-	412	-	-	-
S59530	FRIY	Sport	07/10/91	34.02'	151.17'	E	-	07/03/92	Aust. T.	42.20'	148.35'	E	65.0	152	-	-	-
-	FRIY	Sport	12/10/91	33.50'	151.17'	E	-	29/05/92	_____L.	43.02'	147.48'	E	69.0	230	-	-	-
-	FRIY	Sport	06/10/91	34.05'	151.18'	E	-	15/06/92	_____L.	36.25'	150.08'	E	74.0	253	-	-	-
-	FRIY	Sport	25/05/92	36.25'	150.08'	E	-	15/06/92	_____L.	36.25'	150.08'	E	72.0	21	-	-	-
-	FRIY	Sport	07/10/91	34.05'	151.18'	E	-	17/07/92	_____L.	36.25'	150.17'	E	59.0	284	-	-	-
-	FRIY	Sport	05/10/91	34.05'	151.18'	E	-	17/06/92	Aust. S.	36.25'	150.08'	E	-	256	-	-	-
-	FRIY	Sport	07/06/92	36.33'	150.15'	E	-	13/10/92	_____L.	35.00'	151.08'	E	-	128	-	-	-
	FRIY	Sport	05/10/91	34.02'	151.39'	E	59	24/04/92	_____L.	36.15'	150.03'	E	63.2	202	4.2	61.1	0.63

The gear types abbreviations are longline (L.), troll (T.), sport (S.) and driftnet (D.). Days free are the number of days between release and recapture. Mid-size is the median size between release and recapture. Growth rates correspond to the growth increment during the period at large divided by the number of months at liberty. Dashes (-) indicate that no information was reported, and an underline (_) indicates that vessel nationality was not released.

Table 4b. South Pacific albacore tag recaptures from troll fishery releases

Tag code	Agency +colour	Vessel type	Release date	Lat.	Lon.	E-W	Size (cm)	Recapt. date	Vessel type	Lat.	Lon.	E-W	Size (cm)	Days free	Size diff.	Mid-size	Growth /month
_23267	NMFY	Troll	13/02/86	38.37'	141.46'	W	70	30/12/90	Taiwan L.	18.10'	126.30'	W	-	1781	-	-	-
20344	NMFY	Troll	28/02/86	40.32'	150.36'	W	72	14/07/88	Taiwan L.	26.02'	167.28'	W	88.0	867	16.0	80.0	0.56
_03362	NMFR	Troll	09/03/86	40.20'	145.50'	W	78	16/04/87	Korean L.	38.23'	133.45'	W	86.0	403	8.0	82.0	0.60
A00084	NMFO	Troll	25/01/87	37.38'	151.35'	W	60	01/07/90	-	-	-	-	-	-	-	-	-
A00287	NMFO	Troll	30/01/87	37.42'	153.37'	W	80	06/06/88	Taiwan L.	32.38'	153.21'	W	92.0	493	12.0	86.0	0.74
A00324	NMFO	Troll	31/01/87	37.46'	155.12'	W	76	13/08/91	Japan L.	33.22'	174.36'	E	85.0	1655	9.0	80.5	0.17
A03207	NMFO	Troll	27/02/87	40.39'	177.01'	E	76	13/08/87	Japan L.	30.40'	171.45'	E	80.0	167	4.0	78.0	0.73
A01473	NMFO	Troll	28/02/87	39.43'	151.04'	W	64	26/04/87	Taiwan L.	38.23'	145.38'	W	-	57	-	-	-
A03148	NMFO	Troll	25/02/87	40.21'	177.11'	E	80	18/08/89	NZ T.	42.15'	170.05'	E	96.5	905	16.5	88.3	0.55
A00850	NMFO	Troll	23/12/87	35.59'	150.25'	W	60	24/09/91	Taiwan L.	-	-	-	>60	1371	-	-	-
A00710	NMFO	Troll	28/12/87	39.46'	159.56'	W	59	29/08/92	US L.	28.23'	175.50'	E	-	1706	-	-	-
A01036	NMFO	Troll	28/12/87	37.20'	157.10'	W	58	17/10/91	Taiwan L.	-	-	-	72.7	1389	14.7	65.4	0.32
A03623	NMFO	Troll	01/02/88	38.24'	172.57'	E	63	15/05/91	Taiwan L.	38.40'	146.30'	W	83.3	1199	20.3	73.2	0.51
A03669	NMFO	Troll	01/02/88	38.25'	172.56'	E	60	17/02/91	Taiwan L.	14.15	170.40	W	72.1	1112	12.1	66.1	0.33
A03599	NMFO	Troll	01/02/88	38.25'	172.59'	E	61	26/12/88	Japan D.	38.47'	158.33'	E	-	329	-	-	-
A03662	NMFO	Troll	01/02/88	38.24'	173.00'	E	61	26/12/88	Japan D.	38.47'	158.33'	E	-	329	-	-	-
A05658	NMFO	Troll	05/01/89	36.58'	158.15'	W	55	01/08/92	Taiwan L.	12.00'	160.00'	W	-	1304	-	-	-
A05720	NMFO	Troll	06/01/89	36.58'	158.17'	W	56	18/05/91	Taiwan L.	38.45'	151.05'	W	70.7	862	14.7	63.4	0.52
A04644	NMFO	Troll	05/02/89	42.01'	170.40'	E	59	25/04/92	Taiwan L.	36.15'	164.13	E	79.0	1175	20.0	69.0	0.52
A04791	NMFO	Troll	09/02/89	41.40'	170.39	E	60	21/09/91	Taiwan L.	-	-	-	50.8	954	-	-	-
A07328	NMFO	Troll	21/01/90	40.41'	170.57'	E	69	17/05/91	Japan L.	36.35'	160.15'	E	80.0	481	11.0	74.5	0.70
A07384	NMFO	Troll	23/01/90	38.03'	173.58'	E	49	02/01/92	NZ T.	42.05'	170.40'	E	61.0	709	12.0	55.0	0.51
_00127	MAFY	Troll	29/01/90	42.19'	170.25'	E	62	18/05/92	Austr. T.	36.42'	150.23'	E	86.5	840	24.5	74.3	0.89
00546	MAFY	Troll	05/02/90	39.02'	172.28'	E	58	16/06/92	Japan L.	35.00'	158.00'	E	80.0	862	22.0	69.0	0.78
A00665	NMFO	Troll	16/12/90	36.26'	160.20'	W	52	01/06/92	Taiwan L.	39.15'	142.00'	W	-	533	-	-	-
A00356	SPCY	Troll	21/01/91	40.38'	177.01'	E	79	26/06/92	Japan L.	36.57'	178.35'	E	90.0	522	11.0	84.5	0.64
A00374	SPCY	Troll	25/01/91	40.40'	177.01'	E	82	24/07/91	Japan L.	36.57'	178.02'	E	89.6	180	7.6	85.8	1.28
A00439	SPCY	Troll	04/02/91	40.25'	162.24'	W	61	29/02/92	US T.	40.05'	143.09'	W	75.0	390	14.0	68.0	1.09
A00652	SPCY	Troll	08/02/91	40.50'	157.18'	W	62	25/04/92	Taiwan L.	40.05'	148.47'	W	75.7	442	13.7	68.9	0.94
A01390	SPCY	Troll	15/02/91	40.51'	153.13'	W	65	07/05/92	Taiwan L.	27.30'	172.30'	E	73.6	447	8.6	69.3	0.59
A01536	SPCY	Troll	20/02/91	41.07'	150.17'	W	75	15/06/92	Taiwan L.	38.00'	153.00'	W	79.3	481	4.3	77.2	0.27
A01788	SPCY	Troll	22/02/91	41.20'	151.20'	W	67	16/06/92	Taiwan L.	38.00'	147.00'	W	75.0	480	8.0	71.0	0.51
A01889	SPCY	Troll	22/02/91	41.20'	151.30'	W	69	01/06/91	Taiwan L.	39.00'	146.50'	W	72.2	99	3.2	70.6	0.98
A01817	SPCY	Troll	22/02/91	41.20'	151.20'	W	63	07/01/92	US T.	38.06'	150.02'	W	74.9	319	11.9	69.0	1.13
A02539	SPCY	Troll	02/03/91	41.59	148.06'	W	68	04/12/92	Taiwan L.	-	-	-	-	-	-	-	-
A19182	SPCY	Troll	06/01/92	38.00'	152.32'	W	70	01/06/92	Taiwan L.	38.50'	143.20'	W	-	147	-	-	-
A19219	SPCY	Troll	08/01/92	37.59'	152.12'	W	75	10/02/92	Taiwan L.	39.05'	149.04'	W	-	33	-	-	-
A03970	SPCY	Troll	15/01/92	38.02'	152.19'	W	72	15/04/92	Taiwan L.	39.53'	148.59'	W	74.5	91	2.5	73.3	0.84
A04035	SPCY	Troll	16/01/92	38.23'	152.50'	W	73	10/03/92	Taiwan L.	37.51'	147.37'	W	74.0	54	1.0	73.5	0.56
A19505	SPCY	Troll	16/01/92	39.09'	150.46'	W	61	10/02/92	Taiwan L.	42.00'	100.00'	W	-	25	-	-	-
A16384	SPCY	Troll	18/01/92	38.15'	151.05'	W	77	01/06/92	Taiwan L.	31.00'	158.00'	W	78.8	135	1.8	77.9	0.41
A19585	SPCY	Troll	18/01/92	38.16'	150.44'	W	77	01/08/92	Taiwan L.	30.00'	150.00'	W	-	196	-	-	-
A04331	SPCY	Troll	22/01/92	38.49'	150.10'	W	75	07/05/92	Taiwan L.	37.30'	150.16'	W	-	106	-	-	-
A16824	SPCY	Troll	24/01/92	39.27'	150.21'	W	60	16/06/92	Taiwan L.	38.00'	147.00'	W	61.9	144	1.9	61.0	0.40
A04587	SPCY	Troll	28/01/92	39.09'	149.37'	W	76	07/05/92	Taiwan L.	27.30'	172.30'	E	-	100	-	-	-
A11897	SPCY	Troll	12/04/92	37.12'	141.24'	W	83	16/06/92	Taiwan L.	38.00'	147.00'	W	83.4	65	0.4	83.2	0.19

3.3.1 Movements

Tagged albacore released in the NSW recreational fishery were recaptured at locations within 9 degrees in latitude and 3.5 degrees in longitude from the tagging location (Fig. 4). The average distance between the tagging and recovery locations was approximately 280 km, even though some of the tagged albacore were at large for several years before recapture. This suggests that at least some of the albacore caught in this coastal region do not migrate extensively but remain close to the coast for a considerable portion of their life.

By contrast, albacore tagged from troll fishing vessels in the STCZ and along the NZ coast were recaptured at locations up to 24 degrees in latitude and 50 degrees in longitude from the tagging location (Fig. 4). The average distance between the tagging and recovery locations for this group was ~1000 km. Albacore released at locations east of 155°W tended to be recaptured at locations to the east of the point of release, while those released at locations west of 155°W tended to be recaptured at locations west of the point of release.

Note that on both sides of 155°W, tagged albacore that exhibited extensive movements were generally recaptured further north of the point of release. This suggests that albacore moved northward as they got older. This hypothesis is supported by the observation that tagged albacore recovered within the latitudinal band of 30—35°S averaged 83.2 cm in fork length, while those caught within the bands of 35—40°S and 40—45°S averaged 78.5 and 70.2 cm respectively.

While extensive eastward, westward and northward movements were exhibited by tagged albacore released at locations between Australia and Easter Island, none were ever recaptured in the North Pacific. Furthermore, none of the tagged albacore released in the North Pacific were ever recaptured in the South Pacific. These observations support the popular notion that there is very limited exchange between the North Pacific and South Pacific populations (Lewis 1990).

3.3.2 Recovery rates

Tagged albacore released in the recreational and commercial fisheries were at large for periods ranging from as little as 3 weeks to as much as 4.9 years before recapture. The average time at large was 605 days (median = 480 d) for commercial releases, and 441 days (median = 256 d) for recreational releases. No significant difference in the distribution of recoveries against time was detected between the two groups (Kolmogorov-Smirnov test, $P = 0.353$). In view of the temporal pattern of tag recovery, the overall recovery rates can only be estimated with certainty several years after the tagging experiments. The overall recovery rates associated with the earlier recreational fishery releases could not be estimated because of insufficient tag release data. However, the long-term recovery rates for two commercial fishery tagging experiments conducted five or more years ago (1985—86 and 1986—87) were ~0.4 per cent of the total release (Table 5). The relative success of the most recent and largest tagging experiment can be assessed on the basis of recovery rates within the first 12 months. This shows that the recovery rate for the 1991—92 tagging experiment (0.17%) was the highest obtained since tagging began in 1986.

Only one of the tagged albacore caught with pole-and-line gear has so far been recaptured. This sample was not considered sufficiently large to compare the associated recovery rate with that obtained by means of troll gear and skiffs. Seven albacore that had been double-tagged were recaptured after periods ranging from 33 to 522 days at liberty. Two of these had lost one tag by the time of recapture some 100 and 180 days respectively after tagging. None of the double-tagged albacore recovered after longer periods had lost a tag. Letting n_1 represent the number of double-tagged albacore recovered with one tag, and n_2 represent the number of double-tagged albacore recovered with two tags, tag shedding rates are given by $n_1 \cdot (n_1+2n_2)^{-1}$. These estimates were 8.3 per cent after three months and 16.7 per cent after six months. These figures suggest that tag retention decreases during the first six months to stabilise at ~84 per cent, but more recoveries are needed to provide a more accurate picture of this process.

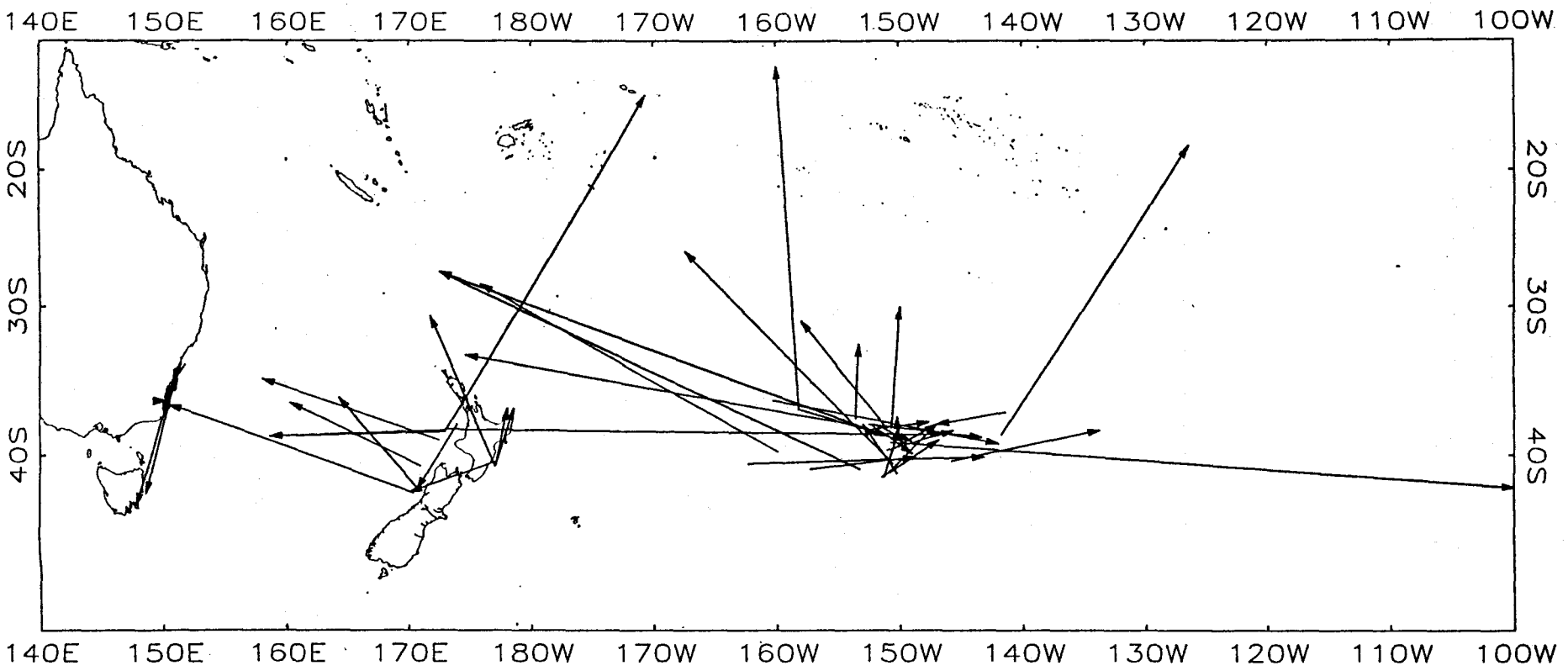

Figure 4. Locations of release and recapture of tagged albacore recovered. Arrowheads show the recapture locations.

Table 5. Number of tagged albacore released and recaptured each season (recreational releases not included)

Recapture season	Tagging season 1985—86	1986—87	1987—88	1988—89	89—90	1990—91	1991—92
1985—86							
1986—87	2	2					
1987—88		1					
1988—89		1	2				
1989—90		1					
1990—91	1	1	2	1	1	2	
1991—92			3	3	3	9	11
Tags rec.	3	6	7	4	4	11	11
Tags rel.	724	1379	1407	2412	1160	3625	6524
Rec. (a)	0.0000	0.0015	0.0000	0.0000	0.0000	0.0006	0.0017
Rec. (b)	0.0041	0.0044	0.0050	0.0017	0.0034	0.0030	0.0017

Tag recoveries are tabulated by season of release (across).
(a) Fraction of tagged group recovered within the same fishing season.
(b) Fraction of tagged group recovered since tagging.

3.3.3 Fishery interception patterns

The vast majority of all tag recoveries from recreational releases was obtained in the longline fishery (74%). Only 16 per cent and 10 per cent of the recoveries from recreational releases came from the troll and sport fisheries respectively. One albacore was recovered in the longline fishery only 21 days after tagging. By contrast, another albacore was recovered in the recreational fishery almost three years after being tagged in the same fishery. The tag recovery pattern of commercial releases followed similar trends, with 85 per cent of recoveries obtained in the longline fishery. Only 11 per cent and 4 per cent of the recoveries from commercial releases came from the troll and drift gillnet fisheries. One albacore was tagged by a troller in the STCZ and recaptured only two months later in the longline fishery, while another was recaptured in the troll fishery 905 days later. These results indicate that segments of the population may contribute to the surface fisheries for several years, while others can move from the surface to deeper waters within a short time interval. Therefore, surface fisheries can potentially affect recruitment to the longline fishery and such interaction effects could begin within the same season.

3.3.4 Reporting rates

Estimation of mortality rates (particularly fishing mortality) from tagging data is possible if non-reporting can be quantified and accounted for. It is hypothesized that some non-reporting exists in the South Pacific albacore fisheries, as in many commercial and recreational fisheries of the world. During 1990—91 and 1991—92, a total of ~50 troll vessel skippers were interviewed either directly by observers while on board, or indirectly by collaborating investigators during port sampling operations. Only one of these skippers acknowledged that he had not reported the recapture of a tagged albacore. It should also be noted that while working on board troll vessels, observers and taggers witnessed the capture of ~170,000 albacore in 1990—91 and 200,000 albacore in 1991—92. None of the albacore caught during the monitoring period were tagged. The 1990—91 sample amounted to ~9% of the seasonal catch (in pieces) of the South Pacific troll fleet. This type of evidence supports the notions that tagged albacore are rarely captured in the troll fishery, and that non-reporting is not a major problem in this fishery.

No evidence of non-reporting has yet been obtained for the longline and driftnet fleets targeting albacore. No experiments have so far been conducted to quantify the level of non-reporting these

fisheries due to the logistic difficulties of conducting tag seeding experiments and other complementary tests on board vessels during the fishing period. However, about 33 per cent of the tag recoveries from longline vessels were reported by port samplers and cannery workers who found them during the unloading or processing stages. This suggests that some longline fishermen do not see the tags while handling the catch; unless the cannery workers participate in the tag recovery programme, a substantial portion of the tags recovered will not be reported.

Mis-reporting is also common in many fisheries, and generally takes the form of simple recording errors. Erroneous records can sometimes be identified, particularly when they are unrealistic (e.g. release size > recovery size). About 10 per cent of the albacore recapture records reported to TBAP fell into this category.

3.3.5 Growth rates

Most of the tagging records from the recreational fishery lacked information on the size at release or recapture, so growth rates could only be estimated for three of these. However, 29 tag release-recapture records from commercial releases were sufficiently complete to estimate growth rates. The estimates ranged from 0.17 to 1.28 cm·month^{-1}. A plot of growth rate against the mid-size indicated that growth rates peak at ~68 cm and decline progressively afterwards (Fig. 5). Too few recaptures were available for the 50—67 cm size interval to determine if the corresponding growth rate estimates are representative of albacore in this size range. If so, small albacore would grow more slowly than those in the 68—75 cm size range. This would suggest a Gompertz-like growth pattern (see Ricker 1979), as opposed to the standard von Bertalanffy growth model. Clearly, additional recoveries of relatively small albacore are needed to confirm this hypothesis.

Eleven tagged albacore recovered had been injected with oxytetracycline, but the bony structures of only three albacore were retrieved. Examination of one vertebra suggested an annulus deposition rate of ~0.9·year^{-1} (K. Bailey, pers. comm.). However, a thorough validation of the annulus deposition rate and the time of first annulus formation has not been conducted so far.

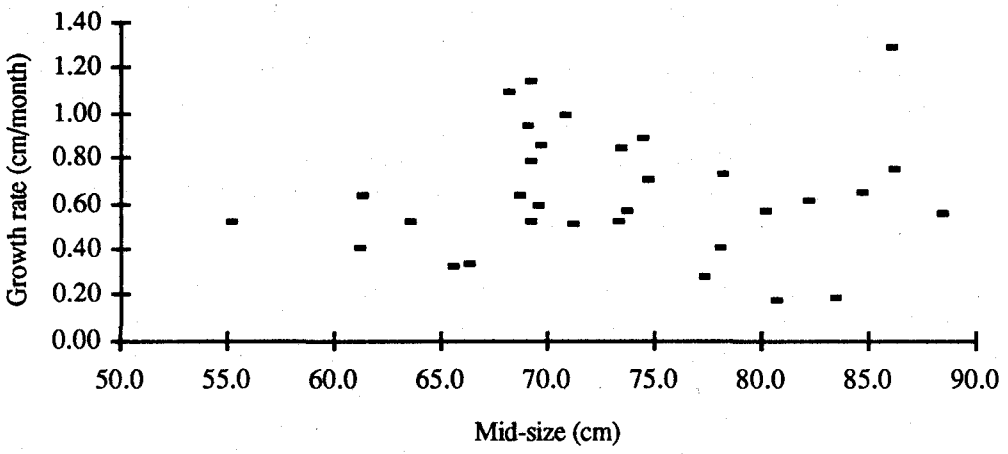

Figure 5. Estimates of growth rates of tagged albacore based on release-recapture records. Mid-size denotes the median fork length during the period at large.

4. DISCUSSION

The South Pacific albacore tagging programmes provided some insight into the movement patterns and growth rates of this species. Unfortunately, too few recaptures have been reported so far to estimate mortality rates and exploitation patterns. If the 1986—92 recovery rates associated

with the troll tagging programmes are indicative of future trends, 100,000 albacore would have to be tagged to get the 200—400 recaptures needed to provide a preliminary quantitative description of the stock-fishery dynamics. This would require a considerable investment since the cost of the 1991—92 tagging programme exceeded US$ 25 per albacore tagged. Even if sufficient funds were available for such purposes, efforts should be made to determine the factors responsible for the low recovery rates to maximise the cost-effectiveness of future tagging programmes.

Albacore tagging programmes were conducted in the North Pacific during 1971—74 with the same tagging methods as those described here. The recovery rates within the first year following tagging averaged about 1.2 per cent over the 1972—74 period (Laurs et al. 1976), which is ~10 times higher than the 1986—92 South Pacific albacore tag recovery rates within 12 months after tagging. During the North Pacific tagging experiments, most recoveries came from the surface fishery, and the size of the combined baitboat, jigboat and pole-and-line fleets targeting albacore exceeded 1000 vessels (M. Laurs, pers. comm.). This is at least an order of magnitude higher than the peak number of troll and driftnet vessels targeting South Pacific albacore during the late 1980s (SPC 1991). It could be hypothesized that the relatively low recovery rates observed so far are mainly due to the smaller number of vessels and the corresponding lower exploitation rates in the surface fishery.

Relatively low recovery rates might also be explained if a large fraction of the albacore tagged from troll vessels moved out of the fishing region after release. The patterns in Fig. 4 indicate that some of the albacore tagged in the STCZ were heading eastward towards Chile, or beyond the principal area fished by longliners, driftnetters and trollers. If so, a fraction of the tagged population could simply become unavailable for recapture soon after release. If this non-availability factor was partly responsible for the low recovery rates, then higher recovery rates should be obtained for tagged albacore released in areas west of 155°W. This hypothesis could not be tested since accurate information on the distribution of fishing effort was not available to adjust for the uneven effort levels directed at albacore in each region.

The programmes conducted so far have revealed that tagging albacore in the STCZ is logistically more difficult and more costly than in the AUNZ. The overall recovery rate of tagged albacore released from troll vessels in the AUNZ was 0.36 per cent, versus 0.24 per cent for STCZ releases, but no significant difference in the recapture to non-recapture ratios was detected between the two groups (Chi-square test, $P = 0.281$). These results indicate that tagging costs in the AUNZ would be lower than in the STCZ, but comparable (or higher) recovery rates could be expected under similar conditions of fleet distribution. The cost-effectiveness of the tagging programme could be improved by focusing future efforts in the AUNZ, although little information would be obtained on movement and interception patterns of albacore east of 180°.

The apparent movement patterns of tagged albacore released from troll vessels are undoubtedly a function of the distribution of longline, driftnet and troll fishing effort, which is mostly concentrated north of 40°S and west of 130°W (Ito and Yamasaki 1988, Labelle 1993). Negligible levels of fishing effort south of 40°S may explain why few of the tagged albacore recovered exhibited extensive southward migrations, but it does not explain the general eastward and westward movements of albacore released on each side of 155°W. The latter observation suggests the existence of different migration patterns, as has been hypothesized for the North Pacific population (Laurs and Lynn 1991). Albacore released east of 155°W would tend to move eastward and northward as they grew older. By contrast, albacore released west of 155°W would tend to move westward and northward as they grew older. Those that reached the Australian coast might have stayed there, moving up and down along the coast.

The movement patterns hypothesized are in agreement with the results of other studies. Presumably, older albacore move north to spawn, since spawning is believed to take place within latitudes 10—20°S (Ueyanagi 1969). Laurs and Nishimoto (1989) hypothesized that juveniles move eastward across the STCZ during the austral summer and northward during the winter. Jones (1991) made similar inferences on albacore movements based on the prevalence of

didymozoid trematodes in South Pacific albacore. Jones hypothesized that juveniles move south to New Zealand from the tropics and do not return there until the onset of sexual maturity. Jones also noted a reduction in the prevalence of two parasites, *Anisakis simplex* and *Hepatoxylon trichuri*, from New Zealand to the central South Pacific, as would be expected if the albacore had moved eastward from New Zealand as juveniles.

Albacore tagged along the New Zealand coast were not recovered exclusively in coastal areas of New Zealand, as was the case for albacore tagged along the Australian coast. This would indicate that the movement pattern of the latter group is not representative of all albacore found in coastal areas. It is probable that albacore caught along the NSW coast have limited distribution patterns induced by certain environmental conditions, which would have important implications for the management of domestic longline fleets. Hopefully, further tagging by the Australian Game Fish Tagging Programme should help solve this issue.

The programmes conducted so far have revealed that tagging albacore in the STCZ is logistically more difficult and more costly than in the AUNZ. The overall recovery rate of tagged albacore released from troll vessels in the AUNZ was 0.36 per cent, as opposed to 0.24 per cent for STCZ releases, but no significant difference in the recapture to non-recapture ratios was detected between both groups (Chi-square test, $P = 0.281$). These results indicate that tagging costs in the AUNZ would be lower than in the STCZ, but comparable (or higher) recovery rates could be expected under similar conditions of fleet distribution. The cost-effectiveness of the tagging programme could be improved by focusing future efforts in the AUNZ, although little information would be obtained on movement and interception patterns of albacore east of 180°.

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REFERENCES

Bailey, K. (1989). Tagging albacore in New Zealand waters. South Pacific Commission, Noumea, New Caledonia. Second South Pacific Albacore Research Workshop, Suva, Fiji, 14—16 June 1989. WP 22: 7 pp.

Caton, A. E., and P. J. Ward. (1991). Albacore tuna and its fisheries in the Australian fishing zone. *Australian Bureau of Rural Resources.* WP 3/91: 91 pp.

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

Hampton, J., T. Murray and P. Sharples (1989). South Pacific albacore observer programme 1988—1989. South Pacific Commission, Noumea, New Caledonia. *Tuna and Bill. Assess. Progr. Tech. Rep.* 22. 22 pp.

Ito, R.Y., and G. S. Yamasaki. (1988). Status of the American Samoa Foreign Longline Tuna Fishery, 1982—86. *US Nat. Mar. Fish. Serv. S-W Fish. Centr. Adm. Rep.* H-88-19. 30 pp.

Jones, J. B. (1991). Movements of albacore tuna (*Thunnus alalunga*) in the South Pacific: evidence from parasites. *Marine Biology* 111: 1—9.

Kearney, R. E., and R. D. Gillett. (1982). Methods used by the Skipjack Survey and Assessment Programme for tagging skipjack and other tuna. South Pacific Commission, Noumea, New Caledonia. *Tech. Rep. Skip. Surv. Asses. Progr. Rep.* 7: 21—43.

Knox, G. A. (1970). Biological oceanography of the South Pacific. *In* W. S. Wooster (ed.), Scientific Exploration of the South Pacific. National Academy of Sciences, Wash. D. C. USA. pp. 155—182.

Labelle, M. (1993). A review of the South Pacific albacore troll fishery 1985—92. South Pacific Commission, Noumea, New Caledonia. *Tuna and Bill. Assess. Progr. Tech. Rep.* 32: 25 pp.

Labelle, M., and T. Murray. (1992). South Pacific Observer Programme Summary Report, 1988—1991. South Pacific Commission, Noumea, New Caledonia. *Tuna and Bill. Assess. Progr. Tech. Rep.* 26. 22 pp.

Labelle, M., and P. Sharples (1991). South Pacific Albacore Tagging Programme, Summary Report 1990—91. South Pacific Commission, Noumea, New Caledonia. Fourth South Pacific Albacore Research Workshop. Taipei, Republic of China, November 4—8, 1991. WP2. 26 pp.

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. J. Lynn. (1977). Seasonal migration of North Pacific albacore, *Thunnus alalunga*, into the North American coastal waters: Distribution, relative abundance, and association with transition zone waters. *Fish. Bull.* 75(4): 795—355.

Laurs, R. M., and R. J. Lynn. (1991). North Pacific albacore ecology and oceanography. *NOAA Technical Report NMFS.* 105: 69—87.

Laurs, R. M., and R. Nishimoto. (1989). Summary of South Pacific albacore tagging conducted during 1986—1989. *US Nat. Mar. Fish. Serv. S-W Fish. Centr. Adm. Rep.* LJ-89-15.

Laurs, R. M., R. Nishimoto, and J. A. Wetherall. (1985). Frequency of increment formation on sagittae of North Pacific albacore (*Thunnus alalunga*). *Can. J. Fish. Aquat. Sci.* 42(9): 1552—1555.

Lewis, A. (1990). South Pacific albacore stock structure: a review of available information. South Pacific Commission, Noumea, New Caledonia. Third South Pacific Albacore Research Workshop. Noumea, New Caledonia, 9—12 October 1990. WP 5: 13 pp.

Matthews, J., and J. Deguara. (1992). Gamefish tagging 1991—92. *NSW Fisheries Research Institute Annual Report.* 13 pp.

Pepperell, J. G. (1991). A review of tuna and billfish tagging in the eastern Australian fishing zone. Australian Bureau of Rural Resources. WP 17/91: 23—33.

Ricker, W. E. (1979). Growth rates and models. *In* Hoar, W. S., D. J. Randall and J. R. Brett (eds.) *Fish Physiology.* Volume VIII, Bioenergetics and Growth. Academic Press. London.

Roberts, P. E. (1974). Albacore off the north-west coast of New Zealand, February 1972. *N.Z. J. Mar. Fresh. Res.* 8: 455-472.

SPC (1991). South Pacific Commission, Noumea, New Caledonia. Report of the Fourth South Pacific Albacore Research Workshop. Taipei, Republic of China, 4—8 November 1991. 40 pp.

SPC (1992). TBAP Data Catalogue. South Pacific Commission, Noumea, New Caledonia. Standing Committee on Tuna and Billfish. Honolulu, Hawaii, 17—18 June 1992. IP 1: 37 pp.

Ueyanagi, S. (1969). Observations on the distribution of tuna larvae in the Indo-Pacific Ocean with emphasis on the delineation of the spawning areas of albacore, *Thunnus alalunga. Bull. Far Seas Fish. Res. Lab.* 2: 177—256.